University of Alberta

Later Stone Age and Iron Age Human Remains from Mlambalasi, Southern Tanzania

by

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A thesis submitted to the Faculty of Graduate Studies and Research
in partial fulfillment of the requirements for the degree of

Master of Arts

Department of Anthropology

Spring 2012
Edmonton, Alberta

Abstract

The Mlambalasi Rock Shelter in the Iringa Region of southern Tanzania has a rich archaeological record that spans the Later Stone Age (LSA), Iron Age, and historic period. Excavations in 2002, 2006, and 2010 yielded fragmentary, commingled human remains from at least four individuals. There are two adults and a juvenile from the same LSA burial context, and another adult from the Iron Age. One middle-aged adult dated to the terminal Pleistocene LSA is potentially small-bodied, similar to the LSA populations from southern Africa. By comparison, the Iron Age individual appears larger and more robust. The skeletons also exhibit various pathological changes, particularly advanced dental wear and carious lesions. This bioarchaeological study presents the osteological findings on these individuals and interprets their context in the rock shelter. This new skeletal sample has great potential to contribute to studies of human variation in sub-Saharan Africa during the terminal Pleistocene and Holocene.

Acknowledgments

First and foremost, I would like to thank the members of the Iringa Region Archaeological Project, especially Dr. Pamela Willoughby, Dr. Katie Biittner, Ms. Jennifer Miller, Dr. Pastory Bushozi, and Mr. Frank Masele. I am deeply grateful to my supervisor Pam Willoughby for facilitating this research and mentoring me for the past 5 years. Thank you for allowing me to be a part of this wonderful research team. Special thanks also to Jennifer Miller and Katie Biittner, who were my colleagues in the field and are now lifelong friends.

Many thanks to the numerous Tanzanian collaborators who helped with this research, whether at the site or from behind a desk. I would like to thank Dr. Paul Msemwa and Dr. Amandus Kweka at the National Museum and House of Culture, Tanzania for providing access to the skeletal collection from 2002. I would also like to acknowledge the Committee on Science and Technology (COSTECH), the Division of Antiquities of the Government of Tanzania, and Dr. Audax Mabulla at the University of Dar es Salaam for supporting this research.

I owe great thanks to those at the University of Alberta who helped me during this degree and the last. Thank you to Dr. Sandra Garvie-Lok who trained me in osteology and who mentored me throughout this project. I appreciate your work on this skeletal collection and your support in many other ways. Thanks also to Pamela Mayne Correia and Dr. Nancy Lovell who also lent their time and expertise to this project. I appreciated the many small favours from Pamela Mayne Correia, Harvey Friebe, Erin Plume, and Shirley Harpham. I would also like to acknowledge the undergraduate volunteers who helped out in the lab, Caitlin St. Dennis, Lindsey Commandeur, Christopher Olsen, and Catherine Doherty. Thanks as well to the many others in the Department of Anthropology who offered friendship and laughs along the way.

Several others collaborated on this research project. Thanks to Dr. Susan Pfeiffer for providing literature recommendations and thoughtful commentary regarding the possibility of small-bodied humans in East Africa. I am also indebted to Dr. Mary Jackes for her assessment of the dental disease on the B-1 skeleton. Finally, thanks to Dr. Isabelle Crevecoeur who recommended what osteological data to collect.

This research would not be possible without the support, academic and otherwise, of my friends and family. Thanks to fellow graduate students Elspeth Ready, Madeleine Mant, Hillary Sparkes, Erin Jessup, Megan Caldwell, Nicole Burt, Kathryn Waterhouse, Lacey Fleming, and Aaron Perkins, who either read my work or offered their opinions on a fragment. I am also grateful to Krystal McDowell, who did some editing, but was more importantly there for me when I needed it. Many thanks to my family, old and new, who offered love and home-cooked meals throughout the research process. My sister, Dr. Christina Adcock, has been an unparalleled friend in all aspects of my life and career. Thanks also to Dr. Ben Adcock for his brotherly love and scholarly encouragement. My mom and dad contributed to this degree in countless ways, perhaps most significantly by reading this entire thesis! Above all, thanks to my best friend and fiancé, Ben Flanagan. He hasn’t left my side since the day we met in introductory archaeology. My research and my life are inherently enriched by his encouragement, support, and love.

Finally, I would like to acknowledge the people of Iringa, particularly those living around the Mlambalasi site. Thanks to everyone, especially the children, who welcomed us, helped sort artifacts, and listened to our chatter about archaeology. Meeting the people for whom the site holds significance today was one of the most rewarding parts of this entire experience.

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Chapter 1: Introduction

1.1 Introduction

Although *Homo sapiens* fossils appear nearly 200,000 years ago in Africa, little is known about early human populations on this continent until the start of the Holocene 190,000 years later. The incompleteness of the archaeological and fossil records from the Pleistocene is likely due to the effects of ice age cycling between warm and cold phases. Current theories place human evolution in Africa approximately 200,000 years ago when conditions were temperate and cool (Willoughby 2007). Our species then endured several oscillations between warm, wet interglacials and cold, arid glacials that lasted until approximately 12,000 years ago. During glacial periods, the deserts expanded and many regions were rendered inhospitable for human habitation. A lack of diversity in the modern human genome suggests that at some point during these cycles, our species nearly went extinct (Harpending et al. 1993; Ambrose 1998b; Lahr and Foley 1998; Reich and Goldstein 1998). Where human groups did survive, record of their occupations was likely also affected by the poor preservation conditions during the ice ages.

Mitochondrial DNA studies suggest that the human population began to recover near the end of the Pleistocene (Cox et al. 2009). This period is also associated with a shift to the Later Stone Age (LSA), when new technologies, tools, and evidence for symbolic behaviour appears or intensifies (Klein 1992; McBrearty and Brooks 2000; Henshilwood and Marean 2003; Willoughby 2007). Although other biological and cultural explanations have been proposed, this transition may have been triggered by demographic factors related to population increase (Powell et al. 2009). This theory is supported by our species' migration out of Africa, and their colonization of Europe, Asia, and Australia. Archaeological evidence in Europe for the appearance of humans and the subsequent extinction of Neandertals is relatively robust (Bocquet-Appel and Demars 2000). By contrast, the African archaeological record during the Late and terminal Pleistocene is sparse (Crevecoeur et al. 2009). Consequently, it is difficult to study this important chapter in African human history.

The Mlambalasi Rock Shelter (HwJf-02) is a recently discovered site in southern Tanzania with a long sequence of historic, Iron Age, and LSA deposits that date back to the terminal Pleistocene. Middle Stone Age (MSA) artifacts have also been recovered outside the overhang. Inside the main shelter, there is relatively good preservation of organic materials such as wood, bone, and shell. The site was test excavated by Tanzanian and Canadian researchers in 2002 and 2006, respectively. Following the second excavation, I completed a preliminary bioarchaeological study of the human remains from test pit 1 (Sawchuk 2008).

For the present study, I visited the site with the Iringa Region Archaeological Project (IRAP) in 2010 to conduct more intensive excavations. The human remains recovered over the three field seasons represent at least four individuals: two adults and a juvenile from the LSA, and another adult from the Iron Age. One of the LSA skeletons has been indirectly dated to the terminal Pleistocene, 11,170 – 12,940 ± 90 uncalibrated radiocarbon years before present

(BP). Skeletal material of comparable antiquity is extremely rare in sub-Saharan Africa, rendering this an important new find.

The long archaeological sequence at Mlambalasi has great potential to contribute to the discourse on human survival during the ice ages and early Holocene. Finds from this site include abundant lithic material, human and faunal remains, shell fragments, charcoal, and ostrich eggshell beads. The Iron Age and historic occupations also possess iron tools and slag, furnace fragments, decorated and undecorated pottery, rock art, and glass and plastic beads. Preliminary research has focused on the lithic raw material sources (Biittner 2011), projectile point technology and hunting strategies (Bushozi 2011), and zooarchaeological analysis (Collins 2009). Only a small portion of the rock shelter has been excavated to date, and research is scheduled to continue over the coming years. Various patterns of human behaviour can be reconstructed from the diversity of material culture at the site, providing vast opportunities for ongoing research.

1.2 Research Questions

The objectives of this research were to: a) bring together, and holistically interpret, all the skeletal material excavated from the site thus far; and, b) conduct further excavations to determine if additional human remains were present. Prior to this study, the human remains from 2002 were not analyzed while those from 2006 were incomplete. After recovering additional human remains in 2010, the total skeletal material from Mlambalasi was analyzed to gather osteological data on the individuals present, investigate their relationship to one another, and interpret their context within the site.

The two major research questions investigated in this thesis are: a) who are these individuals; and, b) how did they become incorporated into the archaeological deposits in this rock shelter? To answer these questions, my research specifically focused on:

1. *What remains are present?*
2. *What is the Minimum Number of Individuals (MNI)?*
3. *From what context were they recovered?*
4. *With which time period and culture are they associated?*
5. *What relationship (if any) do the individuals have to one another?*
6. *What are the characteristics of these individuals?*
7. *What taphonomic processes affected these individuals after interment in the rock shelter?*
8. *What do these individuals reveal about prehistoric occupations at this site?*

I pursued these questions using a bioarchaeological approach, in which the archaeological human remains were interpreted in the context from which they were derived (Larsen 1997, 2000). This approach involves the description of the archaeological excavations, the creation of osteobiographies, and a consideration of taphonomic processes in the burial environment.

The aim of this research was to holistically interpret how the remains became incorporated into the archaeological record, and what this may reveal about past peoples and societies. This is the first study to present the bioarchaeological data gathered from the Mlambalasi site over the past decade. Although research at the site is ongoing, this thesis reflects the current findings on the LSA and Iron Age individuals that comprise this skeletal sample.

1.3 Summary of Chapters

This document is organized to provide a background on the study, and then describe the recovery, analysis, and interpretation of the archaeological skeletons. Chapter 2 introduces the topic of modern human evolution, and provides the palaeoenvironmental context of our early history. I then discuss the characteristics, appearance, and spread of the LSA in sub-Saharan Africa. I review the literature on the biological affinities of human populations during this period, and introduce the debate regarding the origins of the southern African Khoesan and their contentious link to East Africa.

Chapter 3 provides a brief history of bioarchaeology and research on the archaeological skeleton in North America. This supplies the necessary background for the theory of the Body as Material Culture (Sofaer 2006), which is the framework used in this study. Finally, I describe my field and laboratory methods and collection management. This serves as a record of treatment and a curation guide for the benefit of future researchers using this collection.

Chapter 4 is a complete and comprehensive description of the past three field seasons, the remains recovered therein, and the present extent of the skeletal collection. This chapter is based on field notes and reports from 2002 and 2006, as well as my own observations from the 2010 field season. This chapter is partially influenced by bioarchaeological theory, in which physical anthropologists are encouraged to participate in archaeological excavations, observe the context of any burials, and recover the skeletal remains. However, this is also the first account of all three field seasons at the site. The recovery of human remains from Mlambalasi was exceedingly complex, with two of the individuals recovered over multiple years. This chapter also describes the skeletal elements missing from the identified individuals. These bones may be recovered during upcoming fieldwork.

Chapter 5 presents the osteobiography for the B-1 skeleton. Given the completeness of this individual, it follows the typical osteobiographical format of age, sex, stature, and pathological changes. There is an additional section devoted to the dentition of this individual, which is the most informative component of the fragmentary skeleton.

Chapter 6 consists of the osteobiographies for the three remaining individuals, B-2, B-3, and B-4. These are considerably less detailed given that two of the skeletons are represented by a single bony element, and the other is only marginally more complete. This section also discusses bones of uncertain affiliation. The skeletal remains in the rock shelter were commingled with one another and with fragmentary faunal remains, making it difficult to attribute isolated elements to a specific skeleton. Most of the remains could be confidently assigned to an individual based on context. However, the bones in question were found in the backfill of a former test pit, making their affiliation unclear. In this chapter, I provide an educated guess as to the origin of these particular fragments.

Chapter 7 provides a background on taphonomy and its application to caves and rock shelters. This lays the foundation for the discussion on the post-depositional processes at the site. All of the Mlambalasi remains are highly fragmentary, weathered, and diagenetically altered, which limits osteological interpretation. The skeletons are assessed for articulation in the burial environment, completeness, fragmentation, and stage of weathering. I then discuss the taphonomic agents active at the site, and how they have affected the sample and its interpretation. This chapter also includes a section on pseudopathologies, which are skeletal conditions that result from taphonomic processes but mimic known diseases.

Chapter 8 presents my preliminary interpretation of these remains in the rock shelter. I discuss the known sites and skeletons from this time period in sub-Saharan Africa, as well as the osteometric data available for comparison. I then identify the emerging themes in this research, and what can be deduced from the archaeology of this site thus far.

In my final conclusions, I review the major findings of this study and acknowledge some of the limitations associated with the current research. I then suggest directions for future research based on what is known and not known about these individuals and populations. This information is provided for the benefit of colleagues participating in upcoming field seasons, as well as future researchers who may wish to study and reinterpret this material.

Chapter 2: Human Evolution and the Later Stone Age

According to Stephen Jay Gould (1989: 391), the existence of human beings is a "wildly improbable evolutionary event," that depended on a number of diverse factors including the Cambrian explosion, the demise of the dinosaurs, and a host of other evolutionary triggers. Palaeoanthropology, the biocultural study of human evolution, seeks to recreate our past by amassing evidence from palaeoenvironmental, archaeological, fossil, and genetic records. This chapter reviews the literature on the evolution and early history of *Homo sapiens*. This encompasses the challenges of finding and defining early modern human remains, as well the climatic context of the Pleistocene ice ages that lasted from 2.6 million years until the beginning of the Holocene 12,000 years ago. I then discuss the characteristics and spread of the LSA and the anthropological and biological perspectives on its creators in East Africa. This literature review provides the necessary background for understanding the significance of the Mlambalasi site and where it fits into early modern human history.

2.1 The Evolution of *Homo sapiens*

The origins and evolutionary lineage of our species are some of the most debated topics in palaeoanthropology. The currently accepted oldest *Homo sapiens* remains are from the Omo Kibish Formation in Ethiopia, and are dated to 195,000 ± 5,000 years ago (McDougall et al. 2005). It is uncertain from which species we evolved, although the fossil evidence suggests *Homo heidelbergensis,* sometimes referred to as archaic *Homo sapiens*, is a likely progenitor of both

African modern humans and their Eurasian cousins, the Neandertals. There are several competing models for human origins that fall on a spectrum based on the proposed degree of interspecific reproduction (summarized in Stringer 2002). The Multiregional Hypothesis suggests that admixture between hominin species in different geographic areas led to multiple evolutions of *Homo sapiens* with unique regional affinities. By contrast, the Out of Africa, or Replacement Model, maintains that modern humans evolved late in Africa and then dispersed, systematically replacing other hominin species wherever they were encountered. Two intermediary hypotheses, the Hybridization and Replacement Model and the Assimilation Model, posit an African origin for *Homo sapiens* with a lesser or greater degree of admixture, respectively. Since the 1980s, this debate has been significantly advanced by genetic data from living and fossil populations. Such studies demonstrate that Africans populations are the most genetically diverse, suggesting an African origin for our species (Cann et al. 1987; Ingman et al. 2000; Hammer and Zegura 2002). However, some localized modern groups also possess genetic markers from other hominin species (Green et al. 2010; Reich et al. 2010; Hammer et al. 2011). This evidence supports the two central models, wherein migrating African humans mated with incumbent archaics, and renders the two extreme positions untenable (Stringer 2002).

At the time of our genesis, at least four other hominins were present on the planet: *Homo neandertalensis, Homo erectus,* archaic *Homo sapiens,* and *Homo floresiensis.* Studies of the human genome have revealed the existence of at least one more non-human population that bred with our ancestors, the Denisovans from eastern Siberia (Reich et al. 2010). Genetic data also indicates interbreeding between modern humans and Neandertals in Europe (Green et al. 2010), and with an unknown archaic species in Africa (Hammer et al. 2011). The variety of hominins present in the Late Pleistocene fossil record and the evidence for multiple admixtures render the relationship between these contemporaneous species difficult to reconstruct, in the sense of either taxonomy or behaviour. It is only clear that in our early history, we were neither the sole nor dominant form of humans on the planet.

Investigation of our origins and our ties to other hominins is complicated by the ambiguity surrounding the definition of *Homo sapiens*, and the absence of a type specimen for our own species (Chazan 1995; Stringer 2002; Pearson 2008). This problem dates back to Carolus Linnaeus, the Swedish botanist who developed the binomial nomenclature system for species. In the first edition of his 18th century work, *Systema Naturae*, the only comment on the genus *Homo* is "Nosce te ipsum," which simply translates to "know thyself" (in Tattersall and Schwartz 2008: 49). Although subsequent editions expanded this definition to include physical appearance or race, as well as non-biological traits such as clothing and customs, Linnaeus struggled to relate the variation he saw in humankind to his taxonomic scheme (Chazan 1995). Palaeoanthropologists face the same challenge. The amount of human variation in the Late Pleistocene was likely even greater, with many fossils exhibiting mosaic morphologies that appear transitional between modern and archaic designs (Trinkaus 2005; Bräuer 2008;

Rightmire 2009). This diversity makes it difficult to classify individual fossils and determine the number of species that were in existence.

Just as Linnaeus used culture as an indicator of human sub-species, palaeoanthropologists tend to associate major changes in the archaeological record with the appearance of a new hominin. This approach works well in some contexts, such as the appearance of *Homo erectus* with the Acheulean, and the incursion of *Homo sapiens* into Europe bearing Aurignacian technology that was quite unlike that of the Neandertals. However, the application of this approach to early modern humans in Africa is highly controversial. There is no evidence in the archaeological record for sweeping changes around 200,000 years ago when the first human fossils appear. Instead, such shifts happen earlier and later, at the beginning of the MSA 50,000 years earlier, and at the transition to the LSA 150,000 years later.

Since there is no reliable correlation between early modern humans and a specific techno-complex, most researchers favour statistical and biological criteria for attributing fossils to *Homo sapiens* (Lieberman 2008; Pearson 2008). Human morphology is recognized by a large cranial capacity typically over 1350 cc; a globular, or brachycephalic, cranium that widens at the parietal bosses; a relatively flat face tucked beneath the braincase; and a robust mandible with a distinct chin. The postcranial criteria include long limb bones relative to the trunk, particularly the distal segments, and other adaptations that reflect a recent tropical origin (summarized in Klein 2009: 622-626). Many of these early traits were defined in opposition to the best-known contemporaneous hominin species, the Neandertals.

Unfortunately, the evolution and stability of the modern human design are poorly understood due to the near-complete lack of fossils from 80,000-20,000 years ago in Africa. Several morphologically distinct populations can be distinguished following this gap, suggesting that population bottlenecks and other demographic events influenced the evolution of human biological patterns (Pearson 2008). Although they belong to the same species, Holocene *Homo sapiens* tend to be smaller, more gracile, and have more pronounced chins when compared to their Pleistocene predecessors (Pearson 2008).

The search for the origins and early members of our species is complicated by several factors, such as the number of interrelated and interbreeding hominin species present in the Late Pleistocene, the unknown extent of variation in early human populations, and the difficulty in defining *Homo sapiens*. Biological and morphometric approaches have become the paramount means to classify fossils. However, palaeoanthropologists are still working on the criteria that encompass all the traits found in living humans, while still distinguishing our ancestors from other species. This process is limited by the lack of fossil evidence from a 60,000-year time span in the Pleistocene. Understanding this gap in the fossil record, as well as the broader context of human evolution, requires a review of the environmental circumstances of the Pleistocene ice ages.

2.2. The Palaeoenvironmental Context of Human Evolution

The earth’s climate has been consistently inconsistent throughout the entirety of human evolution. Although the planet has been warm with little ice throughout most of its history, sporadic ice ages have occurred over the past 3 billion years (Macdougall 2004). The earliest members of our genus, *Homo,* appeared approximately 2.6 million years ago at roughly the same time that the Pleistocene cycles of cooling and warming commenced. Perhaps as a response to this climatic instability, the rate of hominin evolution drastically accelerated. Most significantly, brain size increased by more than a factor of three in the less than 3 million years. The relationship between hominin evolution and palaeoenvironments can be summed up by the question, “Would we be here at all if not for the Pleistocene Ice Age?” (MacDougall 2004: 188).

Global climate is influenced by several factors operating on cosmic, global, and regional levels. On the cosmic level, the earth’s climate is influenced by where and during what season sunlight is received. In the early 20th century, Milutin Milankovitch proposed three factors that regulate the frequency of ice advance and retreat: obliquity, eccentricity, and precession. These processes describe how the earth moves through the solar system in interrelated 41,000 year, 100,000 year, and 19,000-23,000 year cycles. They combine to influence the strength of summer on an annual basis; the development of an ice age only requires one weak summer during which not all the winter snow or ice melts (Alley 2000a; Willoughby 2007).

On a global level, the planet's climate is controlled by thermohaline circulation, a system of ocean currents that redistributes solar energy to minimize the temperature differences between the equator and the poles (Alley 2000a). Warm ocean currents travel north near the surface of the ocean and heat landmasses, then sink and return at a greater depth. This system depends on ocean salinity, which allows the cold water to sink at several "flushing" sites around Greenland so warm water can continue to flow (Alley 2000a: 153). An influx of fresh water has the potential to "jam" the pump, causing widespread changes to the earth's climate (Alley 2000a: 148).

During the Pleistocene, this occurred as the result of interrelated phenomena known as Dansgaard-Oeschger and Heinrich events. Dansgaard-Oeschger warming cycles caused the ice around Hudson Bay to periodically slide into the North Atlantic. Such occurrences, termed Heinrich events, produced a sudden influx of fresh water, interfering with oceanic salinity and preventing the cold water from sinking (Alley 2000a: 122-125). Disruption of thermohaline circulation resulted in catastrophic global cooling. On their own, Dansgaard-Oeschger cycles routinely shut down one of the flushing sites in the North Atlantic. Heinrich events shut down the remainder, with global ramifications for climate.

There were 20 Dansgaard-Oeschger cycles and 6 Heinrich events between 75,000-15,000 years ago (Burroughs 2005: 71). After each Heinrich event, the subsequent Dansgaard-Oeschger warming was more pronounced, with cycles becoming progressively milder until next the Heinrich event. Against the background of Milankovitch cycles and global heat redistribution, these oscillations caused global cooling and drying on a shorter timeline. Although there are other agents of climate change, these processes were the major factors impacting the Pleistocene ice ages.

Three types of palaeoenvironmental records are important for studying the time span of modern human evolution: marine sediments, ice cores, and lake sediments. Marine sediments accumulate on the magnitude of 6-11 billion metric tonnes per year, and reveal climatic conditions near the ocean surface and on adjacent continents (Bradley 1985: 171). Isotopic analysis of calcium carbonate shells in the sediments provides a record of global sea temperature from when the organisms were alive. Greater ^{18}O indicates colder atmospheric temperatures incapable of evaporating heavier molecules, and greater ^{16}O indicates warmer temperatures in which oxygen isotopes evaporated more equitably. These oscillations between cool and warm constitute a series of Marine Isotope Stages (MIS). Marine sediments can be used to reconstruct climate as far back as 1 million years, but cannot usually elucidate intervals shorter than 1,000 years (Bradley 1985: 6).

Ice cores from the continental ice sheets of Greenland and Antarctica can also be used to reconstruct global climate by analyzing the chemical signature of trapped gas bubbles (Alley 2000b). Although ice core records only encompass the past 100,000 years, one-tenth the range of marine sediments, they are often able to date events to within a decade (Bradley 1985: 6). Consequently, they are useful for investigating shorter-duration climate oscillations. This type of record is also used to correlate and measure global climate events represented at the different poles. Ice cores represent one of the most detailed and accurate accounts of the past 100,000 years, a time period that is intensely important for the study of modern humans.

One of the drawbacks of marine sediments and ice cores is that they reveal climate change on a global level without offering details on continental and local responses. By comparison, lacustrine, or lakebed, deposits from low latitudes represent the longest continuous record of recent climate change in Africa. Foraminifera are primarily used to interpret this record, but pollen, charcoal, and terrestrial deposit samples may reveal additional information on temperature-sensitive vegetation patterns and periods of drought. Although these records are usually geologically short in duration and have low stratigraphic resolution, they provide the best record of regional climate change. The sediments of Lake Malawi, Lake Tanganyika, and Lake Bosumtwi have provided great insight on the aridity of East Africa during the Pleistocene (Cohen et al. 2007; Scholz et al 2007).

Glacial cycling determined from these palaeoclimatic proxies is usually represented as a series of Marine Isotope Stages (MIS) (summary provided in Table 2.1). The last several hundred thousand years were divided into glacials (cold periods) and interglacials (warm periods), with smaller stadials (cold periods) and interstadials (warm periods) within larger phases. However, there were also smaller oscillations, sometimes representing significant and rapid change, within any one stage.

Marine Isotope Stages and Sub-stages	Approximate Time Range	Environmental Context in Africa	African Cultural Phases
1	13,000 BP to present	Holocene; warm conditions	Epipalaeolithic, Mesolithic, and all later cultural periods
2	32,000 to 13,000 BP	Last Glacial Maximum (LGM); extremely cold and dry	North Africa: no occupation? Sub-Saharan Africa: Middle/Later Stone Age transition in some localities?
3	64,000 to 32,000 BP	Interstadial; unstable climate with rapid fluctuations	Sub-Saharan Africa: Middle/Later Stone Age transition?
4	75,000 to 64,000 BP	Stadial; intense cold; vegetation in Africa similar to LGM; expanded North African desert; sea level about 75 m below present	Middle Palaeolithic in North Africa/Middle stone Age in sub-Saharan Africa
5a	85,000 to 75,000 BP	Warmer	Middle Palaeolithic/Middle Stone Age
5b	95,000 to 85,000 BP	Cooler	Middle Palaeolithic/Middle Stone Age
5c	105,000 to 95,000 BP	Warmer	Middle Palaeolithic/Middle Stone Age
5d	116,000 to 105,000 BP	Cooler	Middle Palaeolithic/Middle Stone Age
5e	130,000 to 116,000 BP	Last Interglacial; African environments spread into Middle East	Middle Palaeolithic/Middle Stone Age
6	195,000 to 130,000 BP	Glacial; drier than now	Middle Palaeolithic/Middle Stone Age
7	251,000 to 195,000 BP	Temperate or cool	Middle Palaeolithic/Middle Stone Age

Table 2.1: MIS stages 7-1 (adapted from Willoughby 2007: 73; Finlayson 2004: 136)

For example, MIS 3 was not homogenously warm but rather variable with some of the most pronounced and abrupt climate changes seen in the proxy records (Lahr and Foley 2003).

In Africa, glacial periods produced cold, dry conditions while interglacials were warmer and wetter (Lahr and Foley 2003: 243). Cooling often occurred in steps while warming was abrupt, but in both cases, the period before the transition was marked by enhanced variability, or “flickering,” as the climate bounced between warmer and colder conditions before settling on one (Alley 2000b: 33; Burroughs 2005: 6). These smaller oscillations were significant. Heinrich events and Dansgaard-Oeschger cycles appear to have caused 5-10° C jumps in a matter of years, with the effects lasting up to 500 years (Burroughs 2005: 101; Carto et al. 2008: 145). Within a single stage, changes in rainfall could be as great as 50% annually (Mellars 2006: 9284). Ambient temperature could fluctuate up to 8°C within two decades (Mellars 1998: 494). During the coldest phases, sea level was approximately 135 meters lower than present, exposing vast continental shelves as ocean water became trapped in northern ice sheets (Carto et al. 2008: 149).

Based on the analysis of lakebeds, Africa was characterized by extreme aridity between 135,000-127,000 and 115,000-95,000 years ago. This reduced the volume of Lake Malawi by 95% and caused Lake Victoria to dry up entirely (Cohen et al. 2007; Scholz et al. 2007). These periods of aridity were even more severe than during the Last Glacial Maximum (LGM). As a result of this dryness, shifting vegetation zones, and pervasive climatic instability, significant numbers of humans and animals withdrew to continental refugia during glacial and stadial periods. By sampling sediments from the Dama Swamp in the Uluguru Mountains, J. Finch and colleagues (2009) determined that the Eastern Arc forest of Tanzania would have been habitable throughout the Pleistocene due to its elevated topography and consistent rainfall from the Indian Ocean. Other potential refugia have been proposed in far west Africa, west-central Africa, the montane eastern margin of the Congo basin, as well as places like South Africa, highland Ethiopia, the Nile Valley, and the Atlas Mountains (Ambrose 1998b: 639). The high productivity of exposed continental shelves, in conjunction with low productivity and shifting vegetation in continental regions, may have rendered coastlines another type of refugia (Hetherington et al. 2008). In fact, continental shelves may have acted as coastal oases during all cold phases of the last glacial cycle (Carto et al. 2008). All refugia had sustained annual rainfall, usually greater than 2000 mm, and may have represented contiguous expanses of steppe, woodland, and savannah conditions in isolated places throughout the tropics (Ambrose 1998b; McBrearty and Brooks 2000). Although some researchers suggest they would have repeatedly expanded and collapsed during periods of heightened climatic variability (Scholz et al. 2007), it is likely that occupying shifting refugia allowed human populations to survive during times of resource scarcity.

Earth’s climate is a complex system that depends on the integrated functioning of several smaller systems, and can be agitated into change by catastrophic events. As Richard Alley explains it: “You might think of the climate as a drunk: When left alone, it sits; when forced to move, it staggers” (2000a: 83).

Palaeoenvironmental reconstruction is complicated by the lack of direct evidence, and must instead incorporate a variety of proxy records that reveal different types of information about different time periods. However, their resolution for the past 200,000 years is comparatively good. This palaeoenvironmental evidence suggests that abrupt and significant climatic oscillations characterized the environment in which our species emerged and flourished.

2.3 Characteristics and Spread of the LSA in East Africa

Between 50,000-40,000 years ago, the archaeological records in Africa, the Levant, and Europe reveal a shift in tool technologies representing a transition from mode 3 to mode 4 industries, or from flakes and prepared cores to blades (summary of the mode system of classification in Clark 1969: 31). In addition to blade technology, other technological advances and cultural behaviours seem to appear or increase. This is also the period when our species first successfully migrated out of Africa to colonize Europe, Asia, and Australia. The numerous characteristics that mark this transition are summarized in Table 2.2.

The appearance of these traits defines the Middle to Later Stone Age transition in sub-Saharan Africa, and the Middle to Upper Palaeolithic transition in the Middle East and Europe. The Human Revolution model attributes these innovations to “the most dramatic behavioural shift that archaeologists will ever detect... [one that] almost certainly marks the advent of the fully modern way of doing things or, more precisely, of the fully modern ability to manipulate culture” (Klein 1992: 5).

Category of Innovation	**Innovation**
Ecology	Range extension to previously unoccupied regions (tropical lowland forest, islands, the far north in Europe and Asia)
	Increased diet breadth
Technology	New lithic technologies: blades, microblades, backing
	Standardization within formal tool categories
	Hafting and composite tools
	Tools in novel materials, e.g., bone, antler
	Special purpose tools, e.g., projectiles, geometrics
	Increased numbers of tool categories
	Geographic variation in formal categories
	Temporal variation in formal categories
	Greater control of fire
Economy and social organization	Long-distance procurement and exchange of raw materials
	Curation of exotic raw materials
	Specialized hunting of large, dangerous animals
	Scheduling and seasonality in resource exploitation
	Site reoccupation
	Intensification of resource extraction, especially aquatic and vegetable resources
	Long-distance exchange networks
	Group and individual self-identification through artefact style
	Structured use of domestic space
Symbolic behaviour	Regional artefact styles
	Self adornment, e.g., beads and ornaments
	Use of pigment
	Notched and incised objects (bone, egg shell, ochre, stone)
	Image and representation
	Burials with grave goods, ochre, ritual objects

Table 2.2: Archaeological signatures of modern human behaviour (McBrearty and Brooks 2000: 492, table 3)

Its proponents believe human biology changed 50,000 years ago, and that MSA humans were only “anatomically modern” while succeeding LSA groups were also behaviourally modern (Klein 1992, 1995, 2000, 2008).

In response to this position, S. McBrearty and A. Brooks (2000) compiled an exhaustive list of putative LSA traits found in the African archaeological record prior to 50,000 years ago. Supporters of this earlier chronology attribute MSA-LSA changes to population successions, migrations, isolations, and adaptations. They also deny the existence of a “Human Revolution,” insisting that the shift was gradual, accretionary, and in no way dramatic enough to warrant the term. The perspectives held by Klein and McBrearty and Brooks differ based on the medium of the change at the MSA-LSA boundary, and whether it was biological or cultural.

Although most researchers now gravitate toward a cultural impetus for the MSA-LSA transition, studying this prehistoric process continues to present challenges. There is substantial disagreement regarding which criteria define the LSA. When A.J.H. Goodwin and C. Van Riet Lowe introduced the term in the 1920s, it referred to several industries with no MSA tools, and was associated with the appearance of biologically and behaviourally modern *Homo sapiens* (Wadley 1993). Since fossil evidence now places the evolution of our species earlier, the only remaining qualifier of LSA industries is that they should lack MSA artifacts (Wadley 1993: 244). Consequently, the presence of microliths, bladelets, microblade cores and backed geometrics, and the absence of MSA points or other tool types, is variably employed to identify the earliest LSA

(McBrearty and Brooks 2000: 290). This leads to the classification of LSA assemblages based on discrete traits, as opposed to a more holistic understanding of the material culture present (McBrearty and Brooks 2000: 490). Basing identification on stone tools is flawed because modes 3, 4, and 5 are all technically present in the preceding African MSA (McBrearty and Brooks 2000: 530). LSA industries also tend to exhibit a vast degree of regional and temporal variability (Ambrose 2002: 10). Another issue is the proximity of the MSA-LSA boundary to the limit of radiocarbon dating, which vastly decreases the certainty of chronometric dates.

The inconsistent association of the LSA with modern human behaviour is also problematic. Shifts in technology may reflect behavioural change, such as the invention of projectile technology to hunt more dangerous game and the creation of art and personal ornamentation to externally store abstract thought. However, it is difficult to place a definitive boundary between modern and non-modern behaviour in prehistory because the conditions under which novelties emerge and become encoded in the archaeological record are not readily apparent. Assuming that the transition to the LSA was not biologically driven, it is possible that disparate habitats, population dynamics, and fluctuations in resource availability account for the mosaic pattern of LSA traits observed in sub-Saharan Africa. Furthermore, the appearance of a novel trait must post-date the capacity for that behaviour, and thus observing the first archaeological evidence for something is not the same as pinpointing when the necessary capacity evolved. Consequently, the LSA is not analogous to modern human behaviour, and its appearance and spread cannot be used as a direct marker of behaviourally modern humans.

Compounding issues of definition, archaeological sites spanning the MSA-LSA transition are virtually non-existent. The transition appears to originate in eastern Africa, but the diversity in early LSA industries across the continent is substantial, making it difficult to track (Ambrose 2002: 16). The LSA first appears with transitional industries at the Nasera and Mumba sites in Tanzania, dated to 65,000-23,000 years ago (Ambrose 1998a). Such industries are recognized based on an admixture of traits, with increased frequencies of LSA tool types and decreased frequencies of MSA ones. However, such assemblages are highly variable. The Sakutiek industry at the Enkapune Ya Muto rock shelter in Tanzania fits the same criteria but is dated significantly later than the MSA/LSA boundary (Ambrose 1998a: 388).

Enkapune Ya Muto also possesses the oldest LSA technology, represented by the Nasampolai industry dated between 50,000-40,000 years ago, and the earliest-known ostrich eggshell beads, dated to 39,900 years BP (Ambrose 1998a, 2002). Other sites in East Africa, including Prospect Farm, Kakwa Lelash, Ntuka River 3, Olduvai Gorge, and Norikiushin, also contain transitional or early LSA industries all dated to before 40,000 years BP (Ambrose 2002; Willoughby 2007).

In general, LSA archaeological assemblages are defined by the appearance or increase of geometric microliths, backed pieces, endscrapers, burins, borers, and blades (Willoughby 2007: 204). Geometric microliths are a well-known hallmark of the LSA and become more common in Holocene assemblages

(McBrearty and Brooks 2000). Many of these pieces are blunted on one side, which supports the hypothesis that they were hafted (Phillipson 2005). The shift from larger flake tools to blades and geometric pieces supposedly reflects a preference for more standardized types, perhaps for consistent use in composite tools. This is also suggested by the use of higher quality, exotic raw materials at LSA sites when compared to MSA ones (Willoughby 2007). Other common signifiers of LSA assemblages include organic artifacts such as bone tools and shell beads. The struggle to classify the LSA, combined with the evidence for high regional variability, necessitates detailed attention to and holistic understanding of each Late Pleistocene and early Holocene assemblage prior to interpretation.

Research conducted on the Mlambalasi site thus far is consistent with other findings regarding the LSA. The lithic artifacts from test pit 1 were analyzed by P. Willoughby who found a high proportion of retouched tools (64.6%), most of which are backed pieces and scrapers. The assemblage also contains points, burins, bifacially modified pieces, becs, composite tools, *outils écaillès* or scalar pieces, core tools, and prismatic blades and bladelet cores (Willoughby 2011, personal communication). The combination of blades, backed pieces, and overall small tools classify the assemblage as LSA. There is some indication that the size of the artifacts increases with depth, particularly among the artifacts associated with the B-1 skeleton (Willoughby 2011, personal communication). P. Bushozi (2011) found very few points in this LSA assemblage. Backed pieces are more common, which may indicate a preference for producing spears and arrows

(Biittner 2011; Bushozi 2011). Lithic raw material analysis by K. Biittner and P. Willoughby revealed that 93% of the assemblage is composed of quartz, quartzite, or rock crystal, and that the proportion of exotic raw material was small and from a mixed context (Biittner 2011: 304). The low frequency of crypto-crystalline silica such as chert, that was available but difficult to access in the surrounding landscape, suggests that these groups were not highly mobile (Biittner 2011).

Other materials from this assemblage include multiple plastic, glass, and ostrich eggshell beads from historic, Iron Age, and LSA contexts; abundant faunal remains; giant land snail shells; pottery; tuyere fragments; and iron tools and slag. Preliminary zooarchaeological analyses of test pit 1 revealed some evidence for differential treatment of small and large animals, as well as carnivore activity in the Iron Age levels. The LSA deposits were considered to be too temporally variable and culturally mixed to offer insight into subsistence patterns (Collins 2009). J. Miller (2011, in preparation) is currently analyzing 69 ostrich eggshell beads excavated from Mlambalasi in 2010. Preliminary analysis suggests a decrease in bead size with greater depth, which has also been observed in southern African LSA assemblages. She has also identified multiple stages of production, indicating the beads were manufactured *in situ*. Other ongoing analysis on the Mlambalasi site focuses on the materials excavated in 2010, which are discussed in detail in Chapter 4.

The dearth of archaeological sites and a lack of consensus regarding the definition of the LSA complicate study of this purportedly monumental shift. Nevertheless, the available archaeological evidence suggests the LSA first appeared in East Africa around 50,000 and subsequently spread, taking on highly variable, regional characteristics. Continued research at the Mlambalasi site and other East African locales is critical to expanding our knowledge of this cultural process. The Mlambalasi site is also significant due to the presence of LSA human remains, which are considerably more rare than other remnants of past human activity. The combination of LSA artifacts and remains is significant; in addition to the debate on the artifactual characteristics of this period, there is also some disagreement about its makers.

2.4 The Biological Affinities of LSA Populations

Like the archaeological record, the fossil record from the Late Pleistocene is sparse, rendering it difficult to study the human populations responsible for the LSA (Rightmire 1984; Harpending et al. 1993; Gringe et al. 2007; Crevecoeur et al. 2009; Pfeiffer and Harrington 2011). Palaeoanthropologists have focused on two periods: MIS 6-4, from 190,000-70,000 years ago, and MIS 2-1, dating after 25,000 years ago. This is due to the near absence of human fossil remains between 65,000-25,000 years ago in Africa (Crevecoeur et al. 2009). Most discoveries are of early *Homo sapiens* from prior to 100,000 years BP, or late LSA populations from the terminal Pleistocene or early Holocene.

The dearth of skeletal remains is likely due to a bottleneck, or population crash, among ancestral human populations in Africa. Genetic studies of living humans reveal a significant lack of diversity when compared to other primates (Harpending et al. 1993; Ambrose 1998b; Lahr and Foley 1998; Reich and

Goldstein 1998). Based on genetic data, M. Lahr and R. Foley (1998) estimate that human populations may have been reduced to as few as 10,000 individuals, possibly representing a 75-90% population decrease at the time. Their demographic simulations suggest that these surviving humans represented a single ancestral group, while all other MSA populations went extinct. Our species began to recover around 70,000-50,000 years ago, with subsequent population expansions, contractions, and bottlenecks leading to regional diversification. These repeated fluctuations facilitated rapid change through genetic drift, as well as biological and cultural selection for more efficient bodies and tools to combat times of scarcity.

Based on cranial morphometrics of remains from Egypt, South Africa, and Romania, I. Crevecoeur and colleagues (2009) argue for enhanced diversity and presence of unique traits prior to the population crash. MSA humans also show considerable diversity in their postcranial remains. A left proximal radius fragment from the MSA at Klasies river mouth dated to about 115,000 years ago appears to belong to a small, lightly built individual (Pearson and Grine 1997, Pfeiffer and Harrington 2011). However, other remains from this time period are quite large and robust, with some overlapping traits with archaic *H. sapiens* (Allsworth-Jones 1993). This supports the conclusion that present-day human variation only represents a portion of former diversity, or the traits present in the surviving bottleneck population.

Although many early human traits were lost, there is still considerable diversity in terminal Pleistocene and early Holocene populations. Based on archaeological visibility in South Africa, L. Wadley (1993) believes that human populations were slow to recover after the LGM, and that significant population increase did not occur until after 13,000 years ago. This agrees with genetic data indicating population growth in the Late Pleistocene that began with hunter-gatherer groups and continued into the Neolithic (Cox et al. 2009). This expanding population shows considerable variation in robusticity and dimorphism, with some very large individuals appearing in southern Africa (Pfeiffer and Harrington 2011). Most of the available remains date to the Late Pleistocene and early Holocene and are associated with LSA industries. Even then, pre-Holocene skeletons are rare compared to late LSA populations.

D.R. Brothwell (1963: 101) identifies three major challenges in analyzing Pleistocene skeletal remains in Africa: inadequate dating evidence; fragmentary remains and a small sample size; and difficulty determining racial or ethnic affiliations based on subjective morphological features. He considers the fragmentary condition and small sample size of the Pleistocene fossil record the biggest barriers, since the evolutionary trajectory and interrelationships of modern humans is difficult to determine without ancestral specimens. Several researchers believe that East Africa, encompassing Tanzania, Kenya, and Uganda (and occasionally Somalia, Ethiopia, Malawi, and Zambia), may be the ideal place to conduct palaeoanthropological research due to the evidence of refugia (Gramly and Rightmire 1973; Ambrose 1984, 1998a; Klein 1992; Lahr 1996; Kusimba 2001). Furthermore, it is considered one of the most ecologically rich and diverse places in the world, both in prehistory and modern times. East Africa is believed to be the place where *H. sapiens* evolved, survived a bottleneck event, and dispersed outward out of Africa, due to the sustaining characteristics of the environment therein.

Despite this immense potential, our knowledge of LSA populations is largely based on the better-preserved Late Pleistocene and early Holocene records in southern Africa. The numerous LSA remains from this region and time period are thought to be the ancestors of present-day indigenous southern Africans, the Bushman or Khoesan. These hunter-gatherers have been the focus of extensive ethnographic study since the 18th century, and exhibit distinctive physical characteristics including yellow-brown skin, tightly spiraled or “peppercorn” hair, flat noses, strong cheek bones, epicanthic eye folds, and accumulations of fat on their buttocks and thighs, known as steatopygia and steatomeria respectively (Tobias 1965, 1978). The Khoesan are also well known for their short stature and diminutive body size. San studied by R. Dart in the 1930s averaged 155.8 cm for males and 146.1 cm for females. Several decades later, a Harvard study raised this to 160.9 cm for males and 150 cm for females (summarized in Sealy and Pfeiffer 2000: 643). The most frequently cited averages for the San derive from a medical study by A.S. Truswell and J.D.L. Hanson (1976): 161 cm and 48 kg for males, and 150 cm and 40 kg for males. Other than some evidence of a secular trend in the 20th century, the San small body size has remained fairly consistent, indicating a genetic basis for this design (Sealy and Pfeiffer 2000).

Myriad evidence connects southern African LSA populations with the Khoesan, including continuity of archaeological and ethnographic sites, a similar tool kit and technologies, and the style and symbolism of rock art and open-air engravings (Inskeep 1978; Sealy and Pfeiffer 2000; Pfeiffer and Sealy 2006; Pfeiffer and Harrington 2010; Pfeiffer n.d.) They also share many morphological characteristics, including a small body size. The physical and cultural similarities between the LSA burials in southern Africa, particularly the Southern Cape, suggest a homogenous population occupied the region during the Holocene (Pfeiffer 2007; Pfeiffer and Harrington 2011).

Research on this LSA population has focused on the stability of small body size over time, as well as the health and growth of individual members. All burials show a consistently small stature that at no point exceeded historical Khoesan averages. However, during a more variable and possibly stressful period 4,000-2,000 years BP, some individuals were even smaller (Pfeiffer and Sealy 2006). Evidence of diet and development from juvenile and adult remains indicates this pattern was not the result of nutritional deficiencies, disease, or stunted childhood growth, but of a selective adaptation that favoured small adult size (Sealy and Pfeiffer 2000; Pfeiffer and Sealy 2006; Pfeiffer 2007; Harrington and Pfeiffer 2008; Pfeiffer and Herrington 2010, 2011; Pfeiffer n.d.). The evolution of small body size in this population is supported by other morphological correlates such as a distinctive pelvic shape that is proposed to be an allometric adaptation to facilitate childbirth in females (Kurki 2007). The LSA hunter-gatherers from southern Africa represent one of the most abundant skeletal population samples in African archaeological studies, and provide rare insight into human populations at this time.

Starting in the mid-20th century, discoveries of “Khoisanoid” remains in East Africa fuelled theories that the Khoesan evolved there and migrated south, or, alternatively, that the proto-Khoesan range extended up the eastern side of the continent from South Africa to Egypt (Galloway 1933; Brothwell 1963; Tobias 1965, 1972, 1978; Nurse et al. 1985). Existence of an East African Khoesan is argued based on archaeological, osteological, linguistic, and genetic evidence. Certain LSA assemblages found throughout rock shelters in East Africa have been described as similar to the Wilton industry in South Africa that is associated with the ancestral Khoesan. These East African lithic assemblages possess Wilton-like microliths, especially thumb nail scrapers, and ostrich eggshell beads (Schepartz 1988). However, as discussed, LSA assemblages in East Africa show a high degree of regional and temporal variation in characteristics such as raw material and tool types, which makes it difficult to broadly apply cultural labels.

It is also argued that Late Pleistocene and early Holocene rock art and petroglyphs in East Africa are similar to the well-established Khoesan tradition, and depict Bushman-like figures in a hunter-gatherer lifestyle (Schepartz 1988). Yet, since there is no link between modern groups and this custom (as there is in South Africa), it is difficult to determine if the symbolism and folklore behind the rock art is comparable. Any resemblance may be due to a shared subsistence strategy, as opposed to ethnic or cultural affinity. In her analysis of Tanzanian rock art, M.D. Leakey (1983: 41-44) divided the human figures into three styles: “Kolo,” depicting tall, linear people; “Bushman” showing short, stocky people; and a third, irregular type that may represent supernatural beings. This is a significant departure from South Africa, where human depictions follow a strict stylistic cannon that broadly mimics Bushmen morphology. The duality of human forms in East African rock art may reflect human variation during the Late Pleistocene. However, most of the postcranial skeletal remains from this period appear to conform to the tall Kolo pattern while putative Bushman remains are largely unknown (Schepartz 1988).

Finally, a select number of archaeological human remains from East Africa are argued to have Khoisanoid morphology. Such traits include paedomorphic, or child-like, crania with smooth, rounded vaults and proportionally small faces (Tobias 1972, 1978; Schepartz 1988). A. Galloway (1933) identified the first specimen at the Nebarara site in northern Tanzania, with subsequent specimens identified from Lake Malawi, Homa in Kenya, Elmenteita in the Great Rift Valley, and Singa in Sudan (summary of relevant remains in Rightmire 1984; Schepartz 1988; Morris 2002, 2003). In contrast to the small body size of the Khoesan, many of the postcranial remains associated with these skeletons are robust or otherwise large. It was proposed that some of the skeletons belonged to the Boskop race, a large or “unreduced” proto-Bushman population (Galloway 1933; Keith 1933; Cole 1965; Schepartz 1988; Morris 2002, 2003; Pfeiffer n.d.). This idea was later refuted based on cranial evidence (Singer 1958).

The isolated use of cranial morphology to determine race, Khoesan or otherwise, is criticized by a number of researchers since key traits are often highly subjective and considered separately from the rest of the skeleton (Brothwell 1963; Schepartz 1988; Morris 2002, 2003). Other skeletons were only presumed

Khoisanoid due to their affiliation with Wilton-like archaeological assemblages. These analytical fallacies have caused most of the archaeological evidence for an East African Khoesan to be questioned or outright dismissed. However, this topic would benefit from re-examination. Many of these finds were discovered over 50 years ago and the postcranial remains were only fleetingly assessed due to their fragmentary condition (Brothwell 1963; Rightmire 1984). Additional skeletal discoveries and better techniques for assessing fragmentary material are now available. Consideration of new material, along with re-analysis of older finds, could resolve the ambiguity surrounding the existence of Khoesan-like people in East Africa during the LSA.

The most compelling evidence for a link between the East and South African LSA records does not derive from archaeology, but rather two living groups in Tanzania, the Hadza and Sandawe. These hunter-gatherers speak languages that were classified in the Khoesan family based solely on their distinctive click noises, consonants pronounced using a velaric ingressive airstream (Bleek 1931; Greenberg 1963). However, L.A. Schepartz (1988) questions whether or not this single phonetic feature could have arisen in more than one population, potentially eliminating the ethnolinguistic connection.

Modern genetic evidence may provide a stronger link. The Hadza and Sandawe share a number of unique genetic markers with the Khoesan that are absent in other humans (Excoffier et al. 1987; Tishkoff et al. 1996, 2009; Semino et al. 2002; Scheinfeldt et al. 2010). These commonalities are found in nuclear, mtDNA, and Y chromosome DNA, as well as several indicators in the blood. At least some of this evidence could potentially represent a deeper history of all humans. The effects of recent interbreeding with contemporary populations in East Africa are also apparent (Schepartz 1988; Morris 2002, 2003). However, the number and strength of the genetic similarities between the Hadza, Sandawe, and Khoesan are nevertheless persuasive.

Of the two East African groups, only the Hadza have undergone recent medical study that included body size. J. Hiernaux and D. Boedhi Hartono (1980) recorded mean stature and weight as 160.95 cm and 54.26 kg for males and 150.37 and 48.26 kg for females. This is broadly comparable to 20th century measurements for the Khoesan, although the plasticity of body size makes it difficult to presume a biological relationship on this basis. Earlier osteological data for this group was destroyed in the Second World War, so it is also impossible to determine the effects of a secular trend (Morris 2002). The Hadza, Sandawe, and a few other groups such as the Boni, Dorobo, and Ik, are said to resemble the Khoesan in other traits. However, the criteria used to define traits like light skin and steatopygia are somewhat subjective (Schepartz 1988). Inconsistent data collection and the effects of population admixture hinder modern biological studies of these groups and their similarities to the Khoesan, which makes it difficult to determine biological distance.

In addition to ambiguous evidence, the notion of East African Khoesan is criticized on the grounds of pervasive theoretical bias (Keith 1933; Schepartz 1987, 1988; Morris 2002, 2003). The theory originated during a time when surveys of East African prehistory, and physical anthropology in general, were concerned with the racial affinities of various human populations. This focus produced an undue emphasis on the relationship between LSA humans, and impeded holistic interpretation of sites in their temporal, regional, and cultural contexts.

According to L.A. Schepartz (1988), this debate is plagued by two additional biases. First of all, the Khoesan are considered by some to be the archetypal African hunter-gatherer from which modern foragers must have descended. This is a continuation of the trend discussed throughout this chapter wherein culture and biological type are conflated. Due to their retention of a hunter-gatherer lifestyle in the modern world, it has even been proposed that the Khoesan are a relict Palaeolithic population that can be used to analogize prehistoric groups outside of Africa. The hypothesis that the voluptuous “Venus Figurines” found throughout the European Aurignacian represent steatopygic Bushmen women is a direct outgrowth of this notion (Inskeep 1978).

Secondly, the better-known South African archaeological and paleontological records have been misused as models for other geographical areas of Africa. This is observable in the extenuation of the Wilton techno-complex to vastly different microlithic industries in East Africa. Given this association, it naturally followed that the makers of the South African LSA record were also present in the East. These evidentiary and theoretical issues have led to the condemnation of this debate, causing it to stagnate over the past decade. As there is no conclusive link between East African LSA populations and modern

Khoesan, as is the case in southern Africa, a hypothetical relationship across millennia is considered by some to be spurious.

If the Khoesan did not exist north of the Zambezi River (as is postulated by Morris 2002, 2003), then who were the LSA East Africans? The human remains from the Mlambalasi site have the potential to renew discussion on the presence of small-bodied people in East Africa. Similarities between the East and South African LSA populations, as well as the Hadza, Sandawe, and Khoesan, suggests that click languages and Khoesan morphology may have been more widespread, or even ubiquitous, prior to the expansion of “black Africans” associated with the Bantu migration. The broader extent and evolutionary implications of small body size in Africa are largely unexplored. Examining the incidence and scope of this pattern in East Africa will build on existing research by determining if small body size was also typical of those populations and, if so, what that suggests about the nature of LSA humans.

Many extinct hominids were small bodied, and the pattern intermittently recurs both in the fossil record and in present-day groups such as the Khoesan, Filipino “Negritos,” African pygmies, and the Andaman Islanders (McHenry 1992; Ruff 1994; Bernstein 2010; Kurki et al. 2010). Hypotheses for why small size develops include the need for thermoregulation, limited food supply, enhanced mobility, and high mortality influencing early reproduction (Perry and Dominy 2009; Pfeiffer and Harrington 2011; Pfeiffer n.d.). Small and pygmy populations are found in a variety of environments, but are often associated with deserts, islands, and dense tropical forests where small size has a series of advantages (Kurki et al. 2008; Bernstein 2010). The Khoesan were once thought to represent a “desert ecotype,” although the idea was dismissed following evidence that their range formerly extended well beyond the Kalahari (Tobias 1978).

It is more plausible that the Khoesan small body size is linked to energetics and accident avoidance (Pfeiffer n.d.). The rate of injury among the South African LSA populations is lower than other mobile hunter-gatherer groups, which S. Pfeiffer (2007) interprets to be related to reduced body mass. Furthermore, ethnographic studies of modern Khoesan emphasize the centrality of the bow and arrow and persistence hunting, in which small, energetically efficient bodies prove advantageous (Tobias 1978). G. Silberbauer, an officer in charge of the Bushman survey in the Bechuanaland protectorate, once noted that taller Bushmen were invariably poor hunters, clumsy, and enjoyed little prestige (in Tobias 1965: 75).

Cultural shaping and sexual selection may have been a major factor in the development and sustainment of small body size amongst the Khoesan. Although sexual selection in many species favours larger individuals due to real or perceived fecundity, larger bodies require more resources to maintain (Bernstein 2010). Small body size could become dominant through sexual selection if the pattern were better adapted to resource availability or sustained cultural practices. S. Pfeiffer (n.d.: 19) argues: “The population history of KhoeSan people suggests that there need not be strong factors selecting for smallness, if there is an absence of factors selecting for largeness.” There is no reason why this pattern could not be replicated in similarly isolated conditions, perhaps amidst the low population densities and regional diversification evident in the LSA archaeological record. Given that early modern humans endured a population crisis, and that there is some evidence for increased diversity among earlier populations (Crevecoeur et al. 2009), one characteristic of some terminal Pleistocene and early Holocene groups may have been a small body size.

There are problems with the debate on the presence of Khoesan-like people in East Africa. However, these challenges should not be enough to damn further investigation into the biology and variation of LSA populations. New discoveries of skeletal material from this period, such as from Mlambalasi, will be instrumental in advancing this debate and exploring broader evolutionary patterns of human morphology. Both the LSA archaeological and fossil records will continue to garner attention given the mystery and potential significance of this period to the rest of human history.

2.5 Conclusions

The study of modern human evolution suffers from a series of classificatory issues. To begin with, is it difficult to recognize and define humans amidst the plethora of Late Pleistocene hominins, and to isolate their contributions to the archaeological and fossil records. Consequently, it is difficult to track the origins and spread of *Homo sapiens,* as well as their relationships with other human-like groups. Secondly, it is challenging to define human material culture, particularly LSA assemblages, due to the diversity and breadth of artifacts.

Despite allegations that the MSA-LSA transition represented a revolutionary shift, the highly regionalized and specific character of the new technocomplexes renders them difficult to classify and trace. The inconsistent inclusion of behavioural traits into this schema is also problematic since evidence of behaviour cannot be used as a proxy for when related cognitive capacities evolved. Therefore, when studying early humans, it is often impossible to confidently apply fossils and artifacts to the research question. Instead, palaeoanthropologists must carefully rely on the context of archaeological finds in order to interpret the significance of each individual discovery.

Many of the problems with investigating modern humans and the spread of the LSA are due to poor preservation and small sample size. This is because there were fewer people in the Pleistocene, probably due to bottleneck events and a low carrying capacity of the environment. Furthermore, the scant evidence left by these humans was then subjected to climatic oscillations and the effects of shifting coastlines that likely obliterated a number of sites. These problems are directly related to climate change associated with the Pleistocene ice ages, and the challenges it undoubtedly posed to human survival. Our genus *Homo* evolved against a backdrop of ice age cycling, and the effects on our species in particular appear to have been profound.

Despite interest in the LSA and the development of anatomical and behavioural modernity, relatively little is known about humans at the time. The largest skeletal population derives from the Late Pleistocene and early Holocene of southern Africa, and is biologically and culturally linked to the present-day

Khoesan. This population has very distinctive morphological traits that are allegedly also found in some LSA remains from East Africa. In addition to archaeological and osteological comparisons, two living groups in Tanzania, the Hadza and Sandawe, speak a similar click language and share a suite of genetic markers with the Khoesan that are absent from other Africans. However, it is apparent that at least some of the similarities between these groups are the result of misplaced analogies, a shared hunter-gatherer lifestyle, and evidence of a deeper African ancestry. Nevertheless, the nature of the LSA East Africans and their connection to other early human populations deserves further enquiry.

A present focus in human origins research involves finding new sites and skeletal samples to improve our understanding of human variation and population characteristics at this time. Overall, LSA research is moving in the direction of studying patterns of regionalization, cultural diffusion of technologies, and changing patterns of subsistence. Although the search for the MSA-LSA transition still commands great attention, there is renewed interest in the character of humans before and after the transition as well. Humans nearly went extinct at one point during the Pleistocene, and there is growing curiosity about the traits and factors that allowed our ancestors to persist. Ultimately, the question can only be answered by finding the biological and cultural remains of those early survivors.

Chapter 3: Bioarchaeological Theory and Methods

The human body is a focus in many disciplines, from philosophy and the social sciences to the natural and physical sciences. Simply put, “we have much to learn from the dead” (Larsen 2000: 11). This chapter briefly describes the history of archaeological skeletons in North American scholarship in order to provide a background on bioarchaeology. J. Sofaer (2006) views this trajectory as several successive phases, from described bodies to behaved and manipulated bodies. These stages roughly correspond to the growth of anthropology as a discipline, from the classificatory period through processualism and post-processualism. The Body as Material Culture refers to a specific theoretical approach within bioarchaeology in which bodies are interpreted as another type of artifact. This describes the theoretical framework I applied to my analysis of the Mlambalasi skeletal sample. I then discuss the principle methods of bioarchaeological analysis, centered on the creation of osteobiographies, and describe the recovery and curation of this collection in the field and laboratory. This chapter illustrates the dual nature of this study as archaeological and osteological, and provides the necessary context to evaluate my analysis and interpretation.

3.1 Bioarchaeology and the Archaeological Skeleton

Sofaer’s (2006:13) phase of “described bodies” refers to 19th and early 20th century archaeology and physical anthropology in which skeletons were regarded as curiosities that were largely auxiliary to antiquarian research. Two commonly held misconceptions affected early excavations: that skeletons provided little information on the past; and, that physical anthropologists were extraneous to the excavation process. During this period, archaeological skeletons were either completely discarded (Saul 1972), or only selectively collected, more for the sake of interest (Ubelaker 1989; Robbins 1977). When well-preserved skeletons were collected, often only the skulls were retained. Broken, incomplete, or deteriorated bones were always thrown away (Ubelaker 1989: 1). Such practices significantly impacted the materials available for study, limiting most skeletal analyses to descriptive observations and cranial typologies.

Many early physical anthropologists advocated for a reversal of these practices. In a 1935 paper in *American Anthropologist*, W.M. Krogman wrote:

> The real import of the present study is to drive home to the archaeologist that skeletal material – even “mere bones” – can no longer be totally disregarded in their work. No matter how fragmentary the skeleton, how incompletely it is present, each part tells its own story in the recording of the age and health and physical history of the individual (1935: 103).

Krogman considered the lack of communication between archaeologists and physical anthropologists to be detrimental to reconstructing the past. Unfortunately, his attempt to foster collaboration went largely unnoticed. Decades later, archaeological skeletons were still routinely delivered to laboratories throughout North America with minimal record of context. Subsequent findings were almost always relegated to the appendix of a site monograph. This reinforced the separation between skeletons and the rest of the archaeological site (Larsen 2006).

The New Archaeology and New Physical Anthropology of the post-war period ushered in the phase of “behaved bodies” (Sofaer 2006: 14). The processual movement grew out of scientific and technological advancements of the mid-20th century, and emphasized hypothesis-based research strategies, meticulous data collection and recording, analysis and processing of evidence for interpretation, and commitment to publication of results (Renfrew and Bahn 2004; Armelagos and Van Gerven 2003). It was thought that universal laws of human behaviour could be found by applying anthropological views on human culture to data derived from archaeological contexts (Binford 1971; Gosden 1999).

In contrast to early attitudes towards the body, processual archaeologists neither dismissed, nor simply described, the archaeological skeleton. The focus on mortuary sites as a means to reconstruct social relationships placed the body at the centre of archaeological inquiry. After all, "a human burial contains more anthropological information per cubic meter of deposit than any other type of archaeological feature" (Peebles 1977: 124). During this period, F. Saul (1972) created the term "osteobiography" to argue that skeletal features can be used to recreate the life of the individual to whom they belonged. This method of creating a biography using biological traits is still the dominant method used by physical anthropologists to analyze skeletal material.

Post-processual theories developed in reaction to the large-scale, reductionist, and universal elements of processual thinking. In the phase of "manipulated bodies" (Sofaer 2006: 18), archaeologists and anthropologists focused on questions ignored by processualists, such as gender, age, and individual agency in past societies. Researchers also became interested in embodiment and the experiences of the lived body in antiquity (Joyce 2005). The post-processual movement incorporated notions of the social body, the interior versus the exterior, and subjectivity found in contemporary socio-cultural anthropology, sociology, psychology, and philosophy (Frank 1990; Sofaer Derevenski 1997; Meskell 1998; Arwill-Nordbladh 2002; Latour 2004; Chapman 2005). Archaeological skeletons and the osteobiographies generated from them were still considered a means for understanding culture and social meaning. This time, however, study occurred at the level of the individual and with greater attention paid to the body as the site of inscription.

Bioarchaeology developed against the background of processualism and post-processualism, and yet does not conform to either approach. Bioarchaeology refers to the study of human biological remains from archaeological sites, with a focus on what these tissues can reveal about life histories at the individual and population levels (Larsen 1997, 2000). This specialization originated in the mid-20th century with the creation of the biocultural approach that stressed interpreting human remains as the adaptive product of both biology and culture (Blakely 1977). J. Lawrence Angel (1946) pioneered an early biocultural approach in his analysis of migration trends in ancient Greece. Although Angel’s work was inspired by other physical anthropologists like E.A. Hooten (Saul and Saul 1989), “Social Biology of Greek Culture Growth” was the first study in which environmental changes, ecology, ethnic groups, population, racial types, physical changes in environment, and physical changes in social biology were holistically evaluated using a skeletal population. It was also the first to explicitly conjoin archaeology and human osteology in a study of the past (Buikstra 2006).

At a 1977 symposium, R. Blakely defined the objectives of the biocultural approach: to document how biological anthropologists can contribute to the study of cultural processes; to illustrate adaptiveness or maladaptiveness in prehistoric populations through environmental, cultural, and biological variables; and to reinforce the need for cooperation among biological anthropologists, archaeologists, ethnologists, and others investigating problems in behavioural anthropology (1977: 3). This movement stressed the integrated nature of ecological, cultural, and biological factors contributing to human behaviour. J.E. Buikstra (1977) coined the term bioarchaeology at the same symposium. Around the same time in Britain, similar developments culminated in the creation of osteoarchaeology (Sofaer 2006). Both bioarchaeology and osteoarchaeology refer to the biocultural approach, and refine its application to an archaeological context (Buikstra 1991, 2006; Larsen 2006; Sofaer 2006).

Bioarchaeology was created to reinforce the role of skeletal analysis in archaeological research and create a canon of literature specifically related to problems surrounding the archaeological skeleton. As a result of this specialization, bioarchaeology is criticized as excessively focused on methodology and unwilling to engage with theoretical developments in the broader discipline of anthropology (Buikstra and Ubelaker 1994; Sofaer 2006; Goldstein 2006; Mays 2008). This isolation has only increased with the development of new techniques and methodologies, and the emergence of new foci such as the biological relatedness (biodistance) of populations (Larsen 2006). Allegations of introversion contradict the philosophy of bioarchaeology, which seeks to be an integrative and interdisciplinary approach. Like many other specialists in physical anthropology, bioarchaeologists are also accused of being atheoretical. A lack of explicit theory in bioarchaeology and osteoarchaeology was a major motivating factor in the creation of the Body as Material Culture, and the push toward developing "archaeologies of the body" (Sofaer 2006: 21).

3.2 The Body as Material Culture

In her book *The Body as Material Culture*, Sofaer (2006) outlines an explicit theory for bioarchaeology that seeks to address and resolve the theoretical void. Her theory proposes that archaeological skeletons be analyzed as another component of material culture as part of holistic site interpretation. Human remains have always been placed apart from other archaeological artifacts due to Cartesian and other philosophical traditions that separate humans from the natural world. This contributes to the fragmentation of archaeological sites, in which various specialists conduct independent analyses that are then separated into discrete chapters in the site monograph (Jones 2002). Those studying humans are also divided between the living and the dead. The living body is a cultural subject, while the dead body is a biological object (Sofaer 2006: 46). The splits between humans and nature, as well as biology and culture, have created a number of fragmented discourses on the meaning of the human body. Sofaer (2006: 9) considers the archaeological body to be the nexus between biology and culture, and believes it is useful in addressing this epistemological divide.

Contrary to the notion that the opposite of the body is death (Latour 2004), archaeological skeletons are both alive and dead because they combine the embodied experience of life and the physical processes of death. This is relevant to the study of human history precisely because humans are both biological and cultural organisms (Ingold 1990; Hinde 1991). The paradoxical quality of the human skeleton served as the inspiration for the Body as Material Culture. This theory revolves around three central concepts: the plasticity of the human body, the materiality of the body, and the need for holistic interpretation of archaeological sites.

An individual's lived experiences are recorded on the skeleton as the result of bone plasticity. Bones are largely mineral, but they contain living tissue which remodels throughout life in order for the bone to grow, repair trauma and disease, and respond to habitual stress. The methods and techniques of physical anthropology draw on this phenomenon of plasticity to recreate the conditions of life from skeletal material. The dynamic nature of the skeleton creates a link between an individual's life and their remains after death, providing an opportunity to infer the conditions of one from the other. Regarding the study of objects, D. Charles and J. Buikstra (2002: 16) state that "the physical activities of making and modifying are our portals to the prehistoric past," but the same is just as true of the object makers. Patterns of bone growth permit the creation of osteobiographies, an interpretation of an individual's life from markers on their skeleton (Saul 1972). This biological phenomenon also links the humanities and science, bridging the gap between embodied experience and biological indicators.

Bone plasticity is a common trait for all humans, and yet the outcome is individualizing (Sofaer 2006).

The importance of creating life histories from bones in this theoretical perspective is heavily influenced by writings on materiality. Materiality is defined as the study of the characteristics of objects, “but also the more general notion that humans engage with the things of the world as conscious agents and are themselves shaped by those experiences” (DeMarrais et al. 2004: 2). In short, materiality theorists engage in a dialectic of people and things, where both objects and subjects are agents in the construction of meaning. Regarding the archaeological body, materiality is understood as “the material outcomes of human plasticity at a given point in time... The materiality of each body is context dependent, temporally described, produced, and unique” (Sofaer 2006: 75). Along with objects, human bodies are considered to be in a recursive relationship with the environment, material culture, and social interaction. This process is never finished; the materiality of the body is the materiality of process, one that lasts from birth to death (Sofaer 2006: 77). This approach differs from theories on agency because it does not stipulate that the actions that produce the body have to be intentional. Instead, both humans and their objects are affected by the “reality of matter”; to exist means to be transformed (Nakamura 2005: 22). In this perspective, no element found in an archaeological context can be studied to the exclusion of all other elements because they are all inextricably intertwined.

The link between embodied experience and the skeleton, combined with the recursive nature of materiality, inform the theory and method outlined in the

Body as Material Culture. Body and mind, and cultural and material, are not distinct phenomena, but must be studied in conjunction. Therefore, Sofaer's theory advocates that bodies be reintegrated into archaeological sites as another category of material culture. This is accomplished by reclassifying the body as material. Bodies can no longer be seen as exclusively somatic and objects as extra-somatic because they create and are created by one another. Furthermore, they become part of the same archaeological domain (Sofaer 2006). Bioarchaeology is therefore the study of a particular type of material that falls in line with studies of pots, flints, soils, and animal bones (Sofaer 2006). Likewise, living and dead bodies are no longer irreconcilable because they represent points on the same continuum that is grounded in material existence.

This theory advocates a philosophical paradigm shift, as opposed to a methodological one. The Body as Material Culture is an attempt to reconcile the legacy of methodological developments in archaeology and physical anthropology with a need for an explicit theory of archaeological human remains. It vocalizes assumptions that have always implicitly accompanied bioarchaeological research but were de-emphasized by the focus on methodology. Other authors have discussed the body as an element of material culture (Saul 1972; Gosden 1999; Pluciennik 2002), but Sofaer (2006) is the first researcher to systematize how this approach should be applied to the bioarchaeological framework. By reintegrating skeletons into the archaeological context from which they were derived, this theory has immense potential to connect various discourses in archaeology, physical anthropology, and philosophy, and to facilitate the interpretation of the past in a holistic manner.

3.3 Bioarchaeological Methods

The creation of bioarchaeology was partly predicated on the need to involve physical anthropologists in the excavation of archaeological sites, as opposed to analyzing decontextualized skeletal remains afterward. It is now commonplace for bioarchaeologists to be present on-site and conduct or supervise the excavation of remains (Larsen 2006). This practice not only increases the efficacy of recovery, since skeletal specialists are more familiar with the human body and its structures, but also creates opportunities for better interdisciplinary collaboration. Instead of working on the remains in isolation, bioarchaeologists in the field can assess the context of the remains, as well as the nature and findings of the entire archaeological site. This permits more holistic interpretation of the population from which the individual may have derived, as well as the mortuary and cultural associations of the burial. By participating in the excavation, bioarchaeologists are better poised to reintegrate skeletons into archaeological sites as another type of material culture, as per Sofaer's petition (2006).

Osteobiographies are created for individual skeletons following excavation, either in the field or in the laboratory. F. Saul (1972: 8) first employed the term in his study of Mayan remains from the Altar de Sacrificios: "Rather than talk about measuring "sexing," "ageing," sickening," and so on, the term osteobiography has been used to indicate in a single word that this study is concerned with all the foregoing aspects of skeletal analysis.” Saul’s osteobiographies included demographic characteristics such as age and sex, health status by means of pathology, and physical characteristics such as estimates of stature (1972: 8). Contemporary osteobiographies, generated by both forensic anthropologists and bioarchaeologists, also encompass other lines of research such as: time since death; the minimum number of individuals in commingled remains; ante-, peri-, and postmortem trauma; and any individualizing features whether benign, such as non-metric traits, or health related, such as trauma or disease (Buikstra and Ubelaker 1994; Bass 2005; White and Folkens 2005).

In forensic cases, the aim of the osteobiography is to find the identity of the individual. By contrast, in bioarchaeological research, osteobiographies provide the foundational data for secondary research. Topics of research include quality of life, which encompasses diet, disease, and growth and development, behaviour and lifestyle, and population histories, including biological relationships and past migrations (Larsen 2006). However, such research often requires large skeletal samples from the same group, region, and time period, similar to what would be found in a cemetery. In cases where only a few individuals are present, such as the Mlambalasi sample, data from individual osteobiographies are often used for comparisons between populations. This is a common practice in Stone Age and palaeoanthropological research where the antiquity of the finds often precludes mass preservation of remains, and therefore interpretation at the population level.

Osteobiographical data can be compiled in two ways: macroscopic or osteoscopic analyses, which refer to visual assessment of morphological traits, and osteometric analysis, which involves qualitative and quantitative bone measurements. These methods are commonly used in conjunction to provide greater accuracy to the estimations. It is also common to use a combination of methods to determine single attributes, such as sex and age. This is partly due to variable preservation; osteobiographical analysis is heavily contingent on the elements recovered and intact. For example, traditional methods for sex estimation focus on the skull and pelvis, while age and stature are often calculated from the long bones. However, in the Mlambalasi sample, the pelves, long bones, and skulls were either not recovered or shattered beyond reconstruction. Consequently, I relied on secondary methods for estimation such as the metacarpals and mandible for sexing, dental development and pathology for aging, and the metacarpals and femoral head for stature. The confidence level of these methods is slightly lower, as is the overall accuracy of the osteobiographical data as it could not be verified using a larger variety of skeletal elements and methods. However, given the circumstances, this data still permits preliminary comparison of this collection to other (often poorly preserved) skeletal remains from this time period.

3.4 Field and Laboratory Methods and Collection Management

The Mlambalasi skeletal collection was studied according to the bioarchaeological methods discussed above. This description of my laboratory methods and collection management serves as a specific guide to the history and treatment of the collection for use by future researchers. It also outlines my cataloguing system, which may assist with the physical recall and examination of certain fragments and skeletal elements mentioned throughout this thesis.

Skeletal recovery during the 2010 excavation proceeded according to the standards dictated in bioarchaeological and forensic anthropological literature. The recommended sequence we observed was as follows (compiled from Skinner and Lazenby 1983; Krogman and Işcan 1986):

1. Planning – identifying constraints on recovery including personnel, equipment, other resources, environment, location remoteness, etc.
2. Survey and search – finding and identifying the site of human remains, collecting data on surface finds and site formation processes
3. Establishment of spatial controls – establishing a datum point, excavation grid, etc.
4. Excavation to expose remains
5. Excavation to remove remains
6. Cataloguing, packing, and transportation – moving remains to an approved laboratory or other facility

Based on test pit surveying from 2002 and 2006, we were able to conduct most of the planning in the months preceding the excavation. After our arrival in Tanzania, we gained spatial control of the site by establishing a site datum, the point from which the provenienced artifacts and remains were recorded in three dimensions, and an excavation grid. We also mapped the rock shelter complex using a total station. For the *in situ* remains, my colleagues and I excavated to expose the surface of the burial, mapped the feature, and then removed it. The other remains were randomly distributed throughout the eastern side of the trench in a disturbed context. These were collected over the course of the excavation but not provenienced. The cataloguing and packing was completed at our field laboratory at the Isimila Hotel, and the remains were transported (on loan) to the University of Alberta for further study. We documented the entire process of finding and recovering human remains through photographs; standardized data collection forms for each feature, unit, and level; and personal field journals of our daily activities at the site. These materials are available through IRAP at the University of Alberta.

During the excavation, bones were collected from each unit, level, and quadrant separately from the other artifacts in order to minimize further damage from compression. The *in situ* remains were removed *en bloc* in their surrounding matrix and wrapped in tin foil in order to preserve the condition and relationship of the fragmentary bones (Roberts 2009: 92). We washed and inventoried all the collected artifacts in our field laboratory, where I also counted, photographed, and re-bagged the bones. None of the human or faunal bone fragments were washed. This was done to prevent contamination for future chemical testing (Bollogino et al. 2008; Fortea et al. 2008) and because the fragments were determined to be at risk for disintegration (Roberts 2009). The remains from the 2006 excavation were immersed in water and washed with brushes, but it does not appear that they sustained any damage. There is no record of whether the remains from the 2002 excavation were cleaned, but they appear to be in similar condition to those from 2006. Human bone fragments were most often identified and separated during excavation. However, I collected and photographed additional small fragments from the faunal bone bags during the field inventory process. I also separated a series of fragments for later comparison to osteological, zooarchaeological, and primatological reference collections. The human remains collected in the field were bagged separately according to their individual proveniences, packed in cardboard boxes with newspaper, and transported from the field separately from the other artifacts. The human remains from the 2002 excavation, which are on loan from the National Museum and House of Culture, Tanzania, were similarly transported.

The Mlambalasi collection is temporarily curated at the University of Alberta in Edmonton, Canada but will be returned to the Division of Antiquities, Government of Tanzania. I analyzed the material between September 2010 and September 2011 using the University of Alberta skeletal reference collection for comparison. The *en bloc* remains from the 2010 excavation were removed from their sediment within 30 days of collection to prevent cementation of the matrix. Each package was photographed unwrapped, and then the fragments were collected using paintbrushes and tweezers. All remains were only handled with latex gloves following modern museum standards (Cassman and Odegaard 2007). This was done to minimize contamination and further degradation of the bone. The sediment from each package was transferred into sterile plastic graduated cylinders using plastic funnels rinsed with distilled water. This sediment is organized by provenience and is available at the University of Alberta for future sampling and study. After transfer from their matrix, the individual bone fragments were placed in cardboard trays and eventually transferred into plastic bags with paper labels identifying their provenience. Although it is common practice to directly label bones with their provenience using indelible ink, the weathered surface and fragile nature of the 2010 remains precluded this option. The bones from 2002 are unlabeled, but the ones excavated in 2006 are labeled.

Given the degree of fragmentation of the skeletons, as well as their commingled context with faunal bone, it was important to identify as many fragments as possible to a specific bone to confidently assess the amount of human material. I compared the material with the faunal and human reference collections, and consulted with experts in zooarchaeology, bioarchaeology, and palaeopathology. Identifying small fragments aided with the reconstruction of larger skeletal elements as well as the assessment of MNI. Where possible, the identified fragments were scored for completeness and osteometric data was collected following the methods outlined in *Standards for Data Collection From Human Skeletal Remains* (Buikstra and Ubelaker 1994) and *Human Osteology: A Laboratory and Field Manual, 5th edition* (Bass 2005). This information is in Appendices A and B.

In the laboratory setting, each bone fragment was cleaned non-invasively using a dry, stiff paintbrush to dislodge sediment. During this process, the remains were visually assessed for additional conservation needs. To address pathological and taphonomic changes to the teeth and several elements of the spine in the B-1 skeleton, it was necessary to remove additional sediment from a series of lesions. Invasive action to archaeological skeletons, or any treatment that makes a permanent change, must be carefully weighed against the effect on possible future research. V. Cassman and N. Odegaard (2007: 78) stipulate that any cleaning should be a “conscious, conscientious, and well-thought-out process and always recorded with information on and materials and techniques used.” In this case, aqueous cleaning was necessary to remove concreted sediment to view the dental pathologies and determine whether or not “lesions” on the ribs and vertebrae were pathological or pseudopathological. The crowns and caries of the teeth and the unidentified spinal lesions were “spot cleaned” using cotton swabs, paintbrushes and distilled water and then allowed to dry naturally away from sunlight (Cassman and Odegaard 2007: 80). I photographed the affected bones before and after the treatment to document the change in condition. The removal of sediment from the tooth enamel and the affected ribs and vertebrae made their features more visible, and no negative effects were observed.

In 2008, I photographed the skeletal collection using a professional light table and a Canon Rebel single lens reflex (SLR) camera using the standard lens. Digital copies of the photographs were provided to the project for future use after the collection is returned to Tanzania. The remains from 2002 and 2010 were photographed using the same light table and a Canon 50 D SLR camera with a standard lens. Copies of these photographs will also be retained by the project. Digital photos of the complete skeletal collection from all three years will be sent to Tanzania along with the remains.

The challenge of organizing thousands of fragments necessitated the creation of a catalogue system. In museum practice, unique accession numbers are assigned to new items of the museum collection to link the object with its related documentation. Tripartite systems typically express the year, accession of that year, and object number in the format 2011.01.01. This number usually also becomes the object's catalogue number when it is subsequently described and categorized. The purpose of cataloguing museum collections is to ensure information about the objects is easily accessible and retrievable, and so the museum can maintain intellectual control over its holdings (Hayward 2005: 183).

Following collection management standards (Hayward 2005), I adapted this system to create catalogue numbers for each fragment or series of related fragments belonging to the same bone with the same provenience. The accession numbers follow the format: year of excavation, bone number. For example, the number 2010.71 refers to a complete right trapezium from the B-3 skeleton collected from unit I-09, Level 1, northwest quadrant on July 10, 2010. For provenienced elements of feature B-1, I adapted the tripartite system to reflect burial provenience instead of accession number. For example, the number 2010.26.01 refers to the left clavicle of B-1 excavated from the B-1 grid at provenience #26 (93 cm north, 106 cm east, and 32 cm below datum) on August 11, 2010. Exact proveniences are not available for the remains from 2002 and 2006, so they follow the same bipartite format as the unprovenienced fragments from 2010. The entire skeletal collection, organized by catalogue number, is available in Appendix C.

The catalogue numbers link the fragments to their photographs and provenience information, which may be useful to future scholars accessing this collection. The records and photographs may also be used to digitize the collection. Given the possible antiquity of the skeletons and the dearth of human remains from that time period in East Africa, it is of paramount importance that the collection is properly documented, accessible, and conserved for future researchers.

3.5 Conclusions

This study of the Mlambalasi skeletal population was conducted using the theoretical framework and methods of bioarchaeology. This involved participation in the excavation of the rock shelter, the creation of osteobiographies for the individuals recovered, and my interpretation of remains in the context of the broader archaeological site. However, traditional bioarchaeology has become increasingly focused on methodological advancements that are often rooted in the natural sciences, as opposed to theoretical development. Consequently, I incorporated Sofaer's theory of the Body as Material Culture into my research design through my role as excavator and subsequent interpretation of the osteobiographies.

Following recovery, the remains were transported on loan to the University of Alberta where I removed the skeletal elements from their *en bloc* packages, individually identified the fragments, completed minor conservation, and assigned discrete catalogue numbers. Furthermore, the entire collection was photographed to conform to bioarchaeological recording standards (Buikstra and Ubelaker 1994).

In addition to the field and laboratory methods discussed here, the bioarchaeological framework also informs the organization of this thesis. The next chapter provides a detailed review of the context and recovery of the remains in order to provide a complete background for interpretation. This constitutes the archaeological element of this bioarchaeological study. Following discussion of the field procedures, I provide the current osteobiographies for the individuals recovered: the nearly complete B-1 skeleton, followed by the incomplete B-2, B-3, and B-4 skeletons. I then discuss the effects of the burial environment on the remains. Taphonomy should be considered separate from the osteobiographies, which only reflect the conditions during an individual’s life, and yet taphonomic changes affect both archaeological and osteological analyses. Holistic interpretation of these skeletons in the rock shelter can only proceed after discussion and consideration of the archaeological context, osteobiographical data, and taphonomic bias. This reflects the central notion of bioarchaeology; that the archaeological body cannot be divorced from the context from which it was derived.

Chapter 4 – Excavations at the Mlambalasi Rock Shelter

The skeletal remains from the Mlambalasi rock shelter were excavated over three field seasons by Tanzanian and Canadian researchers. Fragmentary, commingled human remains were recovered during each excavation, representing a minimum of four individuals. This review focuses on the site and its regional surroundings, including the geological and environmental setting, as well as the method and results of the various excavations. Multiple excavation seasons, diverse taphonomic agents, and thousands of years of occupation complicate archaeological interpretation of this site. Therefore, this bioarchaeological study relies heavily on the context in which the skeletal remains were found in order to analyze the material and situate it in the culture history of the region. This also represents the first comprehensive review and description of all three excavations at the Mlambalasi site. This review provides a background for subsequent osteological and archaeological interpretation.

4.1 Geology and Environment of the Iringa Region

The Mlambalasi site is located in the Iringa Region of southern Tanzania. This area is found in the Dodoman System, the largest section of the Tanzania craton defined by a schist belt and surrounding granitoid rocks (Schlüter 1997). The geology of this area is Precambrian in origin, and is considerably more ancient than the nearby rift valley systems, which began forming in the Miocene. It lies in the catchment area of the Rufiji River basin and the Little Ruaha River, and is also cut through by ephemeral streams. The region also has a number of erosional gullies, known as *makorongo,* many of which bear evidence of archaeological sites.

The most distinctive topographic features of Iringa are the large granite boulders that dominate the landscape. These dome shaped hills of crystalline rock are termed inselbergs, and can form either bornhardts or castle kopjes depending on their erosional history and the space of the joints (Buckle 1978). The Tanzanian central plateau is well known for granite inselberg assemblages, including the Uhambingetu bornhardt located 30 km northeast of Iringa that rises more than 450 m above the plain (Buckle 1997: 148). The Mlambalasi site is located on an escarpment with multiple castle kopjes, one of which forms the structure of the main rock shelter.

The vegetation in Iringa is classified as moist savanna, characterized by strata of densely spaced leafy trees and tall, narrow-leaved grasses. Moist savannas are found in areas with less effective precipitation than forest zones, and tend to have yellow or red sandy soils (Hamilton 1982: 16). The specific moist savanna vegetation type around Iringa is known as *miombo woodland* and is dominated by fairly tall (20 m) and densely spaced leguminous trees belonging to genera such as *Brachystegia, Isoberlinia,* and *Julbernardia.* This vegetation type is found throughout Tanzania as well as in Zambia, Angola, and the Katanga region of southern Congo, in areas with an annual rainfall between 750-1,000 mm and a long dry season (Hamilton 1982: 19).

Most of tropical and sub-tropical Africa has a sub-humid or semi-arid climate affected by the Inter-Tropical Convergence Zone (ITCZ). This phenomenon produces bimodal rainy seasons between March-May and October-December (Hamilton 1982; Street-Perrott and Perrott 1994; Barker and Gasse 2003). The highest amount of rainfall is usually in highland areas. However, the pattern of precipitation is complex, varies between regions, and is affected by bodies of water such as lakes (Hamilton 1982). In general, this climate zone is arid and subject to water deficits.

Despite modern day aridity, this area is suspected of containing some of the proposed Pleistocene refugia. Diatom analysis of Lake Rukwa, Lake Malawi, and Lake Massoko suggests that not all bodies of water dried up during glacial phases (Barker et al. 2002, Barker and Gasse 2003). Although many lowland lakes did disappear, some in the highlands appear to have persisted. Additionally, sediment cores from the Dama and Deva Deva swamps indicate that parts of the Eastern Arc mountains have been stable grasslands for at least 13,000 years, and potentially as long as 48,000 years (Finch et al. 2009; Finch and Marchant 2011). This long-term stability provides a possible explanation for the great biodiversity and endemism of the Uluguru Mountains. It would have also contributed to the survival of human populations in the region and the preservation of archaeological sites.

4.2 Introduction to Research at the Mlambalasi Rock Shelter

The Mlambalasi site is located 50 km west of Iringa town and partway up a large escarpment (Figure 4.1). The rock shelter complex consists of three sites with the SASES (Standard African Site Enumeration System) numbers HwJf-01, HwJf-02, and HwJf-02 RA. HwJf-01 is the burial place of Chief Mkwawa, a Hehe leader who killed himself and his one remaining servant at Mlambalasi in 1898 rather than submitting to German colonial forces. In 1998, a national Uhuru (or Freedom) Monument was erected next to a tomb housing Mkwawa's skeleton (except the skull, which is on exhibit at the Kalenga Museum). The main rock shelter is located several hundred meters uphill from the monument and is designated HwJf-02. HwJf-02 RA is a large granite outcrop just outside the main shelter with rock art featuring anthropomorphic, abstract images in red pigment. Granitic kopjes, many of which have small overhangs, populate the entire escarpment. It should therefore be considered a larger, continuous rock shelter complex that past peoples likely used in an integrated fashion. The slope around the rock shelters has significant archaeological surface scatter that supports this notion.

The main rock shelter (HwJf-02) is located at 7°35.460'S, 35°30.027'E, at an elevation of 1,029 m. The shelter is divided into two interconnected rooms. The main overhang, room 1, is approximately 12 m east to west and 7.8 m north to south (Figure 4.2). The roof of the room is several meters high creating open, comfortable space for standing. There are east and southwest entrances, with a granite boulder measuring several meters across and wide situated between them. The boulder is probably roof fall that dislodged from the main shelter thousands of years ago. In its current position, it forms a partial fourth wall to room 1 that shields the interior from wind and conceals it on the landscape.

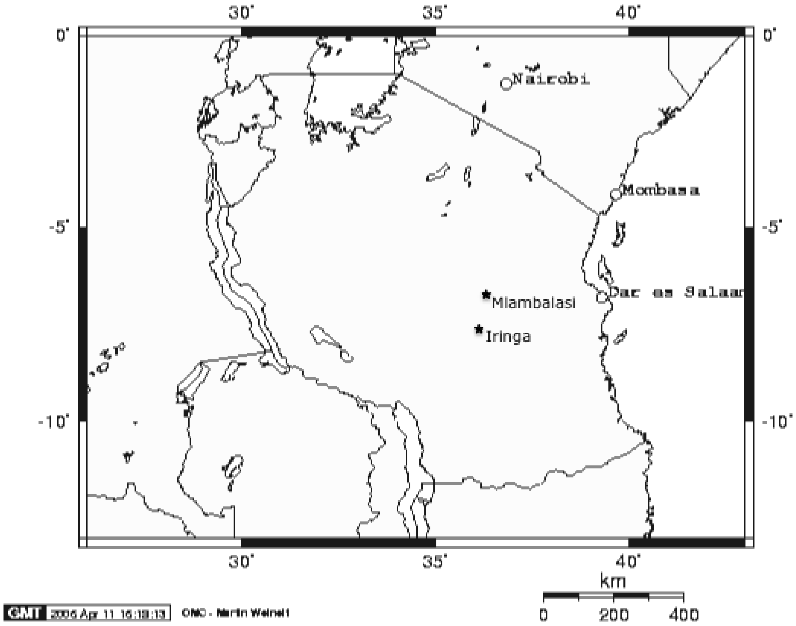

Figure 4.1: Map of Tanzania showing the Mlambalasi Rock Shelter

Figure 4.2: Interior view of room 1 of Mlambalasi (photo by P. Willoughby)

The hidden, sheltered nature of this space makes it attractive for human use. This is evidenced by the long archaeological sequence, as well as recent charcoal graffiti on the shelter walls and evidence of animal tending. The contemporary peoples living around the site are predominantly Hehe and Maasai. However, the latter group only migrated to the area in the 20th century from their traditional territory in northern Tanzania and Kenya (Cole 1965).

Room 2 of the rock shelter lies directly northwest of room 1 and can be accessed through a small crawl space or from its own entrance around back. It is significantly smaller measuring about 4 m east to west and another 4 m north to south. It is more exposed and delineated by a natural boundary of boulders to the west, marking the slope downwards. Although the second room is smaller and less sheltered, we found abundant surface scatter including lithics, bone, iron, and pottery, as well as several large grindstones. We also frequently witnessed local Maasai children using the space as a natural corral for goats, perhaps in lieu of the main room where we were excavating. Room 2 of Mlambalasi has not been excavated although, based on surface artifacts, it almost certainly has archaeological potential.

The rock shelter complex is well known in the region through both its association with Chief Mkwawa and its prominence and continued use on the landscape. Consequently, it had been previously reported as a possible archaeological site when it was first excavated in 2002. The following review of the 2002, 2006 and 2010 excavations is intended to describe the human remains recovered to date and provide a record of the archaeological research at the site.

4.3 2002 Excavations

Paul Msemwa, the current director of the National Museum of Tanzania and an expert on Iron Age archaeology, conducted the initial work at the site. Mlambalasi and another open air site, Utinde Mkoga, were excavated over 14 days in September 2002 as part of a larger research project (Msemwa 2002). One of the objectives was to establish a general chronology and culture history for the Iringa region. After making local enquiries, visiting known sites, and conducting walkover surveys, the Mlambalasi site was selected for excavation based on abundant surface scatter including grindstones, iron slag, lithics, and pottery (Msemwa 2002: 10).

A 2 x 1 m test pit (trench 1) was excavated in the centre of room 1 in arbitrary 10 cm levels, with the matrix screened through a 5 mm sieve (Figure 4.3). All materials recovered from this excavation are described in Table 4.1. Fire cracked rocks, pottery, lithics, bone (human and faunal), iron slag, iron metal sheeting, shells, and beads were recovered in the first 30 cm below surface (b.s.). This material was consistent with the Iron Age. Other signs of an Iron Age occupation included tuyere fragments (the blowpipes for forcing air into a furnace), and soot staining on the interior roof of the rock shelter.

Based on modern European trade beads and the dominance of modern pottery styles, Msemwa believed that the first 30 cm of the rock shelter was in a disturbed context subjected to foraging or smelting activities occurring as late as the 20th century. He even noted that potsherds collected from the surface with coarse roulette decorations were similar to those still in use in the area (Msemwa

2002: 13). By contrast, the following levels from 30-60 cm b.s. appeared to be stratigraphically-intact LSA deposits, as suggested by microlithic artifacts and an absence of pottery. The unit ended at 60 cm b.s. due to the interference of large boulders and roof fall.

Fragmentary human remains were recovered on September 22, 2002 from levels 1-3 of trench 1 in the disturbed portion attributed to historic and Iron Age occupations (Table 4.2). They were commingled with faunal bones from wild ungulates, zebra, and antelope (Msemwa 2002: 14). Along with the other artifacts from the site, the bones were transported to the National Museum and House of Culture, Tanzania where they were accessioned but remained unstudied.

The human remains represent 1 adult individual of indeterminate sex (see Chapter 6). The individual elements from this excavation are detailed in Tables 4.2 and 4.4. It was not specified if the remains were found *in situ* and the elements do not indicate a particular body orientation, so the precise context is unknown. However, given the advanced state of fragmentation and the disturbance of the levels in which it was found, it is unlikely that the body was in its original mortuary context.

Following his field research, Msemwa (2002) submitted a report to the Division of Antiquities and conducted no further work on the site. However, the report was not made publically accessible, leading to the rediscovery of the site by Pamela Willoughby in 2005. In 2010, Willoughby's team recovered additional elements of this skeleton, which is now designated Burial-3 (B-3).

Figure 4.3: Location of Trench 1 in 2002 (Msemwa 2002: 11, plate 3)

Depth Level (cm below surface)	**Pottery**		**Lithics***	**Shells**	**Bones**	**Beads**	**Metal**	**Slag**
	Decorated	**Undecorated**						
0-10	11	11	6	7	6	-	-	12
10-20	15	16	Cobbles (5), 38 (45)	8	90	1	1	27
20-30	-	1	21 (73)	3	76	-	-	2
30-50	-	-	Bored stone 1, 58 (10)	6	13	-	-	-
50-60	-	-	15 (53)	2	3	-	-	-

* Numbers in parentheses represent artifacts not collected.

Table 4.1: Inventory list for Mlambalasi Rock Shelter Site (Msemwa 2002: 12, table 1(a))

Level	**Depth (cm below surface)**	**B-3 identifiable bones represented by fragments**
1	0-10	ulna radius or ulna
2	10-20	cranial fragments mandible radius ulna clavicle rib metacarpals proximal manal phalanges intermediate manal phalanx proximal pedal phalanx
3	20-30	occipital

Table 4.2: Human skeletal elements recovered from the 2002 excavation

4.4 2006 Excavations

Joyce Nachilema, District Cultural Officer for Iringa Rural (*Iringa Vijijini),* introduced Willoughby to the site in 2005 after she inquired about *mapango,* or rock shelters, in the vicinity. Preliminary site survey revealed dense surface accumulations of Iron Age pottery and slag, glass beads, preserved bone and shell, LSA white quartz lithics, and suspected MSA crypto-crystalline lithic materials (Willoughby 2006). In 2006, Willoughby returned to the site from August 2-10 with her graduate students, Katie Biittner and Pastory Bushozi, and Tanzanian antiquities officer Peter Abwalo. Willoughby excavated an additional two 1 x 1 m test pits at the site: one towards the back of room 1 (TP 1, Figure 4.4) and one down slope from the main rock shelter (TP 2). Surface collections were also made in three areas: rooms 1 and 2, and the slope in front of the main shelter.

TP 1 (Figure 4.4) was excavated in arbitrary 5 cm levels. Soft, unconsolidated sediment made it difficult to control for depth and some levels were slightly greater. The matrix was then hand sorted in large iron head pans, or *karai*. The test unit possessed a well-defined stratigraphic sequence extending from the historic period through the Iron Age, LSA, and possibly MSA. Similar to the previous excavation, artifacts such as pottery, iron slag, lithics, and bone dominated the first 40 cm of the unit. The excavators also encountered an anthropogenic ash layer and charcoal, likely associated with remnants of an iron-smelting furnace.

Figure 4.4: Location of test pit 1 (TP 1) in 2006 (photo by P. Willoughby)

A charcoal sample taken from 25 cm b.s. was submitted for Accelerated Mass Spectrometry (AMS) radiocarbon dating. The results suggest the sample belongs to a young Iron Age, 460 ± 50 uncalibrated years BP (TO-13416).

Around 40 cm b.s., the archaeology began to shift into a LSA occupation dominated by quartz and quartzite lithic debris, partially fossilized bone and shell, and a reduction in iron and pottery. The depth of this transition was roughly equal to that found by Msemwa in 2002. At this level, the excavators also began to encounter pebble and cobble sized clasts, with an associated reduction in artifacts. At this depth, a number of large boulders and roof fall also restricted the area available for excavation. By 60 cm b.s., only the northeast corner of the unit could be accessed. The matrix in the LSA levels was characterized as fine-grained, well-sorted silty soil that was poorly consolidated. At greater depths, dense accumulations of crumbling bedrock were also encountered (Biittner n.d.).

Fragmentary, commingled human remains were discovered under a large piece of roof fall at 70 cm b.s., with the burial feature extending from 70-90 cm and concentrated between 85-87 cm (Figures 4.5, 4.6). The skeleton was the first in the rock shelter to be identified by our research team, and was subsequently given the designation Burial 1 (B-1). The body was overlain and surrounded by cobbles, boulders, and rock slabs. These may have been intentionally placed, although it could not be established since they were a similar material to the surrounding rock shelter. The remains were disturbed before it could be determined whether or not they were in a primary context. However, five metacarpals were still thought to be in anatomical position suggesting the body was *in situ* (Willoughby 2008, personal communication).

Following discovery, Biittner exposed the burial surface and then collected the bones separately. Due to fragmentation and poor preservation, the burial presented as linearly organized shards of long bone (Figure 4.6). Nevertheless, Biittner and Willoughby were able to identify the material as conclusively human and noted that the cranium was absent. Biittner (n.d.: 13) also observed that the individual was in a flexed or semi-flexed position based on the arrangement of the hands and feet. This was consistent with the recovery of the postcrania from the small area of the test pit still unrestricted by boulders and roof fall, which would have made an extended, supine body position impossible. She also suggested two individuals might be present (n.d.: 13). It is unclear whether this number was based on specific skeletal elements or the density of unrecognizable and fragmentary bone. Table 4.3 lists the individual elements I identified from this excavation.

The remains were found in association with lithics, some shell, faunal bone, and an ostrich eggshell bead. However, no artifacts whatsoever were recovered from 85-90 cm b.s., which coincided with the highest concentration of remains. Subsequent lithic analysis by Willoughby demonstrated that this break marked the transition between two different LSA industries: an older macrolithic LSA and a younger microlithic one (Willoughby 2008, personal communication).

Figure 4.5: TP 1 at Mlambalasi at 60-85 cm below surface just prior to the discovery of B-1 (arrow pointing south)

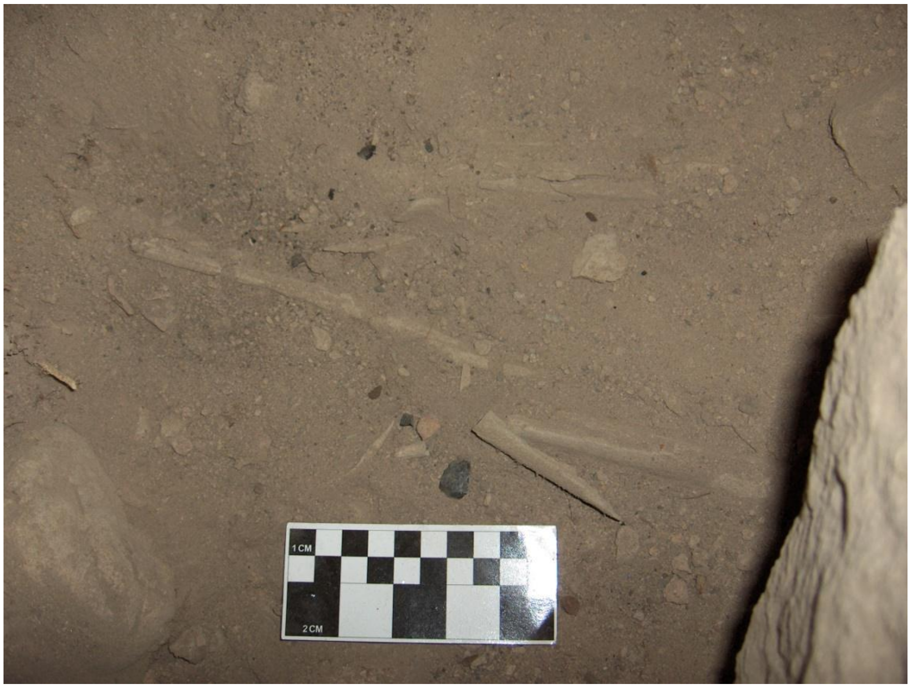

Figure 4.6: *In situ* human remains in TP 1. Note the possible flexed position of the body

AMS radiocarbon dating of land snail shells (*Achatina africana*) from around the remains suggests the burial belongs to the terminal Pleistocene. Samples from 65-70 and 110-120 cm b.s. were dated to 12,940 ± 90 BP (TO-13417) and 11,710 ± 90 BP (TO-13418), respectively. It is atypical that the dates are inverted so that the younger date was found at a lower depth. This could suggest either that the sediment was disturbed during interment (i.e., by "back filling" a grave) or that the snails were agents of bioturbation that entered the sequence independently of humans. The test pit concluded at 110 cm b.s. shortly after the burial feature due to the severe drop in artifact breadth and density. At that depth, a number of large boulders and roof fall also prevented further excavation.

Test pit 2 on the slope outside the rock shelter was excavated in 10 cm arbitrary levels to a depth of 160 cm b.s. The unit yielded archaeological deposits from the historic period, Iron Age, LSA, and MSA. However, no clear stratigraphy could be observed and the artifacts appeared to be out of context due to erosion and slumping on the hillside. Furthermore, the test unit was overgrown with roots and interlaced with rodent and insect burrows. An active termite nest was also discovered at 50 cm b.s. Finally, artifacts towards the bottom of the unit were heavily cemented with a carbonate coating. This suggests moving water also disturbed them. Based on these findings, the interior of the rock shelter was determined to be the best location for future excavations.

Level	Depth (cm below surface)	B-1 identifiable elements represented by fragments
11	70-75	metatarsal talus tibia fibula os coxa
13	85-87	proximal manal phalanges intermediate manal phalanges distal manal phalanges proximal pedal phalanges metacarpals metatarsals lunate scaphoid calcaneus ulna radius femur tibia fibula ilium pubis os coxa, acetabulum sacrum manubrium (juvenile) ribs coccyx vertebrae, unspecified thoracic vertebrae
Unspecified	70-100	probable pubis probable ilium intermediate pedal phalanx metacarpals trapezium humerus ischium vertebrae, unspecified thoracic vertebrae pubis

Table 4.3: Human skeletal elements recovered from the 2006 excavation

The materials from this excavation were exported on loan to the University of Alberta where I analyzed the human remains for my B.A. (Honours) project (Sawchuk 2008). I determined that two individuals were present: a large portion of an adult (B-1) and a manubrium fragment from a juvenile (B-2). The excavators originally suspected that the adult remains might also be juvenile based on the absence of long bone epiphyses (Biittner n.d.: 13). However, closer inspection revealed this was the product of taphonomic breakage and weathering. I also determined that the skeleton was represented almost exclusively from the mid-thorax to the feet. Based on the extensively fragmented material, I suggested that a small percentage of the cranium might be present in the tiny, unidentifiable shards. However, it was more likely that some of the skeleton remained unexcavated.

Prior to leaving Tanzania in 2006, Willoughby was informed of the earlier excavation by Msemwa's former antiquities officer, Eliwasa Maro. Maro was also able to acquire a copy of the excavation report produced for the Division of Antiquities (Msemwa 2002). Although the stratigraphy of TP 1 appeared to be intact, it was unknown whether it overlapped with Trench 1 from 2002. This cast significant doubt on the validity of artifact provenience from the excavation. Additionally, since the adult remains recovered from both field seasons were incomplete, it was unclear whether they represented a single individual and, if so, whether the burial belonged to the Stone Age or Iron Age. The issue of having two independent test excavations at the site necessitated additional research to determine the relationship of trench 1 and TP 1 and the stratigraphic integrity of the artifacts excavated therein.

4.5 2010 Excavations

Prior to returning to Mlambalasi, the Canadian and Tanzanian teams collaborated to share field results and discuss further excavations plans for the site. Msemwa provided additional information on his findings and permitted access to the artifacts housed at the National Museum and House of Culture, Tanzania. Willoughby revisited the site in 2008 while conducting other research to confirm that the rock shelter had not been disturbed.

Willoughby returned to Mlambalasi in 2010 accompanied by her graduate students Katie Biittner, Pastory Bushozi, Frank Masele, Jennifer Miller, and Elizabeth Sawchuk. Three Tanzanian antiquities officers, Emmanuel Katoroki, Eva Masorme, and Anthony Tibaijuika, and a total station technician from the University of Dar es Salaam, Sayid Kilindo, also assisted with excavations. The four objectives in this field season were: (1) to determine the locations and relationship of the two prior test pits; (2) to further investigate the stratigraphic integrity and culture history of the site; (3) to determine the extent of the sequence (and whether an MSA component was present) by excavating to find bedrock; (4) to determine if additional archaeological human remains were present. Excavations were conducted from July 10-August 16, 2010.

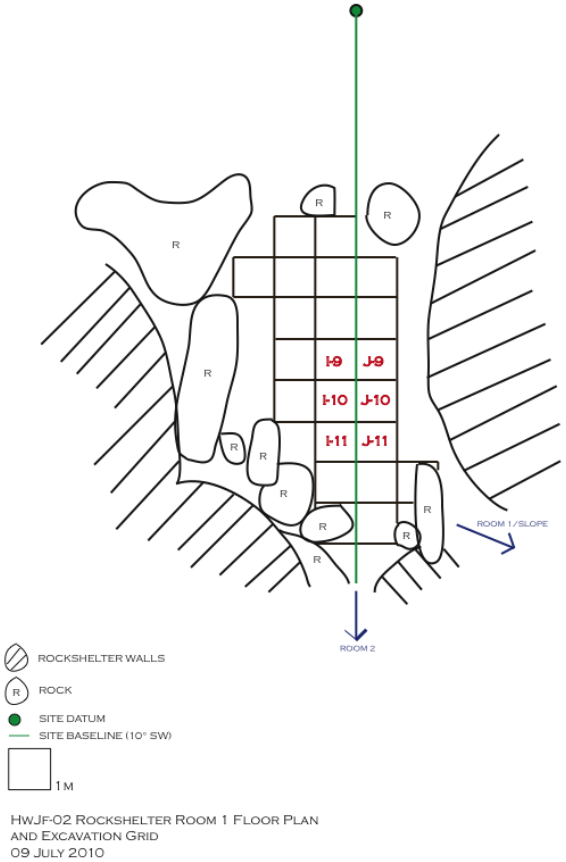

Figure 4.7: Map of room 1 (image by K. Biittner)

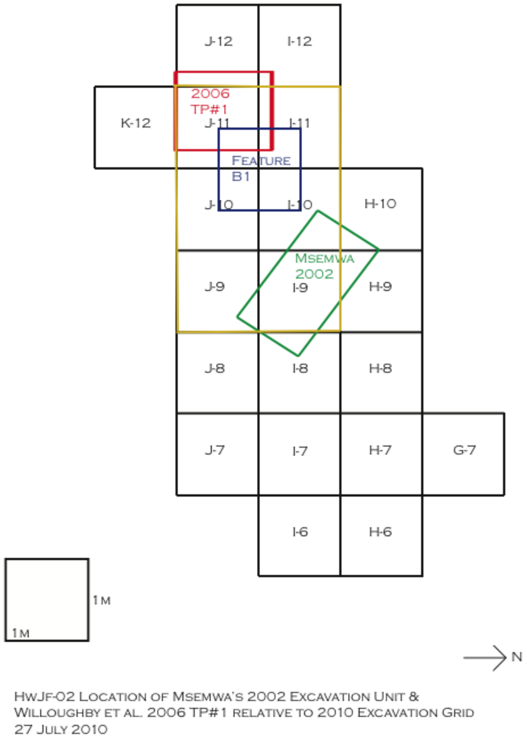

Figure 4.8: Room 1 grid with previous excavations indicated (image by K. Biittner). The location of 2010 trench is outlined in yellow

After a site datum was established and rooms 1 and 2 of the rock shelter were mapped using a total station (Figure 4.7), we established a grid for room 1 with 20 potential excavation units (Figure 4.8). However, due to the wealth and density of artifacts at the site, we were only able to excavate six units forming a 2 x 3 m trench. The trench was placed in a position believed to encompass both trench 1 from 2002 and TP 1 from 2006 and was comprised of units I-09, J-09, I-10, J-10, I-11 and J-11.

J-11 and I-09 were roughly the locations of the former test pits (Figure 4.8). The disturbed contexts were recognizable by soil colour changes, the absence of the Iron Age anthropogenic ash level, and a more unconsolidated and soft matrix. Both units were prone to sink holes resulting from air pockets created while backfilling, as well as increased rodent and insect burrowing activity. Additionally, empty Maji Africa bottles stamped with the date 2002 were discovered in Levels 5 and 6 of I-09 at a maximum depth of 25 cm below datum (b.d.) or 61.4 cm b.s., marking the bottom of Msemwa's excavation unit. Despite strong evidence of previous excavation, artifacts were still found throughout both units. This was likely due to the inclusion of surface artifacts while backfilling and the post-depositional mobility of artifacts.

The areas untouched by previous excavations were found to be relatively stratigraphically intact. As with the test excavations, the first 40 centimeters (to level 4, or the datum line) represented historic and Iron Age deposits with iron and iron slag, plastic and ostrich eggshell beads, pottery, lithics, shell, and bone. The artifacts decreased in density below the Iron Age, which roughly coincided with a dense “pebble horizon.” This feature was first identified in level 4 and was the most concentrated in level 5 (5-10 cm b.d. or 43.4-53.4 cm b.s.). In the western extent of the trench, it began to disappear around 11 cm b.d. or 49.4 cm b.s. It was still present to some extent in levels 7-8 to a maximum depth of 84.4 cm b.s. However, at that depth it was intermingled with a burial feature, and so it may have sloped lower due to the disturbed, unconsolidated matrix. In 2006, the pebble horizon was intermingled with the same burial and extended to 90 cm b.s. In general, this horizon caps the LSA deposits at the site and appears to mark the transition from the Iron Age.

Below the pebble horizon, the LSA component of the site includes microlithic quartzite and chert artifacts, ostrich eggshell beads, shell, bone, and an absence of pottery and iron. Artifact density decreased after level 8 (35-45 cm b.d., or 74.4-84.4 cm b.s.) as we approached the bedrock located at the bottom of Level 10 in I-11 (55-65 cm b.d., or 94.4-104.4 cm b.d.). This was similar to the depth of the 2006 TP 1 at 110 cm b.s. The bedrock was difficult to identify given its crumbling, attritional nature and the vertical mobility of large pieces in the archaeological sequence. After finding bedrock in room 1, we concluded that any MSA deposits were restricted to the slope of the rock shelter complex and were likely in a disturbed context. It is possible that the large piece of roof fall that shelters room 1 fell directly overtop an MSA component underneath the drip line of the shelter. Regardless, the stratigraphically intact sequence is limited to historic, Iron Age, and LSA deposits.

Our final objective was to determine if additional archaeological human remains were present in the rock shelter. Although all six units from the 2010 excavation bore human bone, the skeletal material was concentrated in two locations related to the previous finds (Figure 4.9). Additional elements of the individual recovered in 2002, B-3, were found in the northeast corner of the 2010 trench. Units I-09, J-09 and I-10 all contained some back fill from Trench 1. Consequently, human bone was recovered from the surface and levels 1-4, 7 and 9 representing a range of 0-91.4 cm b.s. Of the fragments recovered in 2010, many were likely missed by the original excavator due to their small size or were concealed by the many large boulders in the unit. Additionally, the remains only represent the upper portion of the individual with the exception of the left intermediate cuneiform and three pedal phalanges. Since it appears that part of this burial remains unexcavated, some of those elements may have also become incorporated into the backfill during the eight-year hiatus. In particular, the foot bones would have been highly mobile due to their small size.

Although the remains are highly fragmentary and incomplete, it is still possible to conclude that they belong to one adult individual of indeterminate sex. Table 4.4 presents the elements of this individual identified in 2002 and 2010. The remains recovered in 2010 were disturbed by the previous excavation and could not provide any information on the burial features or body position. This disturbance is apparent when the specific elements are compared by depth and by field season. In particular, it is interesting to note that cranial material was recovered from the first and penultimate levels of the 2010 excavation.

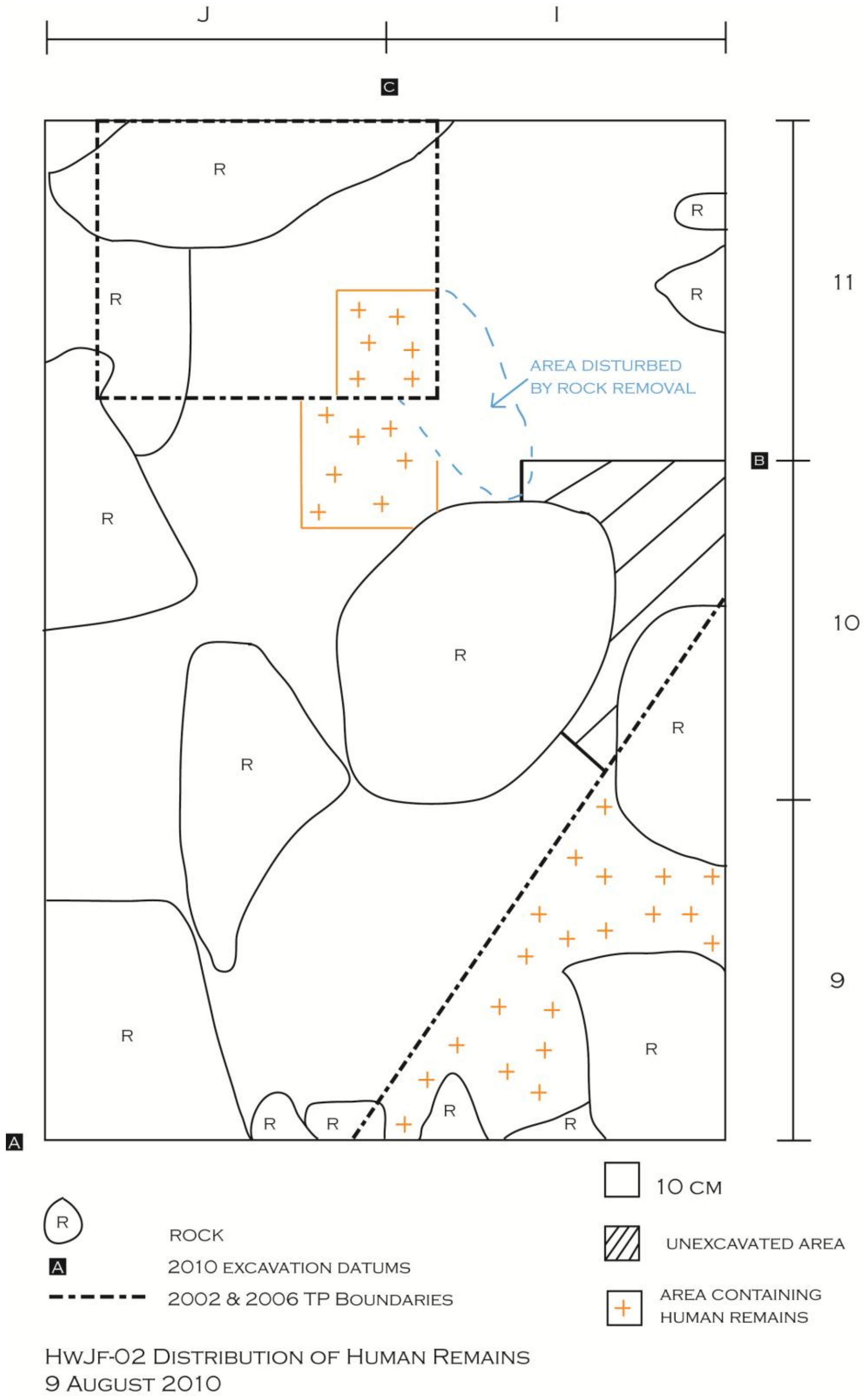

Figure 4.9: Map of the 2010 excavation area with human remains indicated (image by K. Biittner)

Level	Approximate depth (cm below surface)	B-3 identifiable elements from 2002	B-3 identifiable elements from 2010
Surface	0	ulna radius or ulna	cranial fragments frontal
1	10		cranial fragment proximal manal phalanges intermediate manal phalanx distal manal phalanges trapezium lunate vertebra, unspecified intermediate pedal phalanges
2	20	cranial fragments mandible radius ulna clavicle rib metacarpals proximal manal phalanges intermediate manal phalanx proximal pedal phalanx	cranial fragment
3	30	occipital	cranial fragments ribs
4	40	-	cranial fragments metacarpal
5	50	-	-
6	60	-	-
7	70	not excavated	proximal manal phalanx rib
8	80	not excavated	cranial fragment
9	90	not excavated	cranial fragment (fused temporal and occipital)
10	100	not excavated	-

Table 4.4: B-3 skeletal elements recovered in 2002 and 2010

We recovered additional remains from the B-1 individual in the western portion of the trench. Units I-10, J-10, J-11 and most of I-11 contained stratigraphically intact elements of the burial feature including the head, upper arms, and rib cage. J-11 was primarily composed of the TP 1 backfill but still contained remains, likely due to the same processes that affected B-3. A burial feature grid was established overtop the existing excavation grid, encompassing the southeast quadrant of I-11, the southwest quadrant of I-10, the northeast quadrant of J-11 and the northwest quadrant of J-10 (Figures 4.10, 4.11).

Based on the lack of security at the site, the sensitivity of human remains, and the recommendation of our antiquities officer (Tibaijuika), we elected to remove the skeleton over two days. The remains were exposed by gentle brushing with paintbrushes and then excavated with plastic trowels. After each bone or concentration of bone (e.g. fragmented ribs) was provenienced, it was collected *en bloc* in its surrounding sediment in aluminum foil. The excavators covered their hands in plastic to minimize contact with the fragmentary remains. After removing the large elements, the quads were screened using a 1 mm x 1 mm screen and hand sorted in *karai* to ensure collection of small fragments such as tooth roots. On August 10, we recovered the cranium and the left upper limb, which were located closest to the surface from 23.8 cm b.d. (63.2 cm b.s.) to 38.9 cm b.d. (78.3 cm b.d.) (Figure 4.12). On August 11, we recovered the thorax and right upper limb (Figure 4.13).

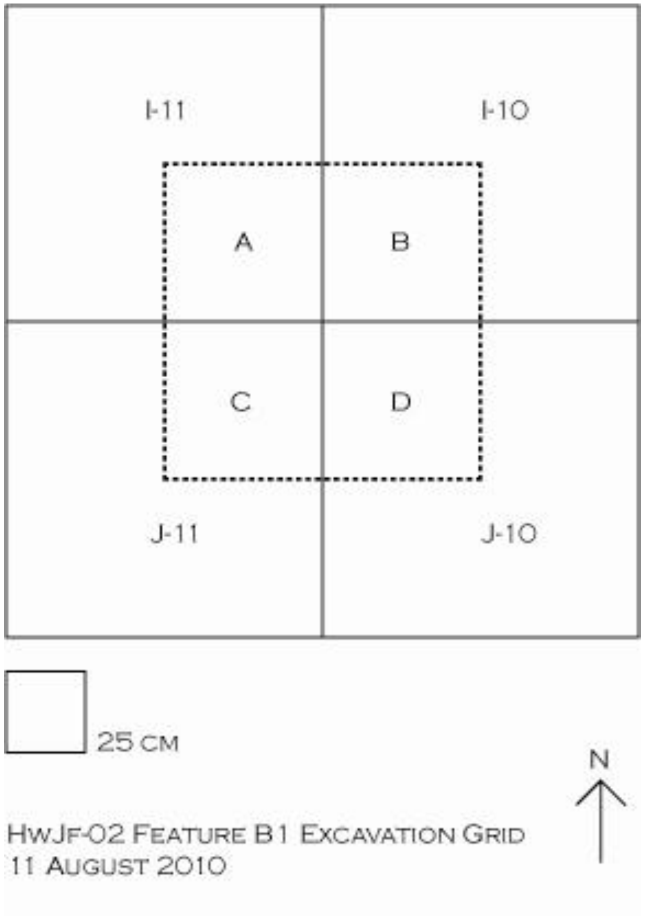

Figure 4.10: B-1 feature grid (image by K. Biittner)

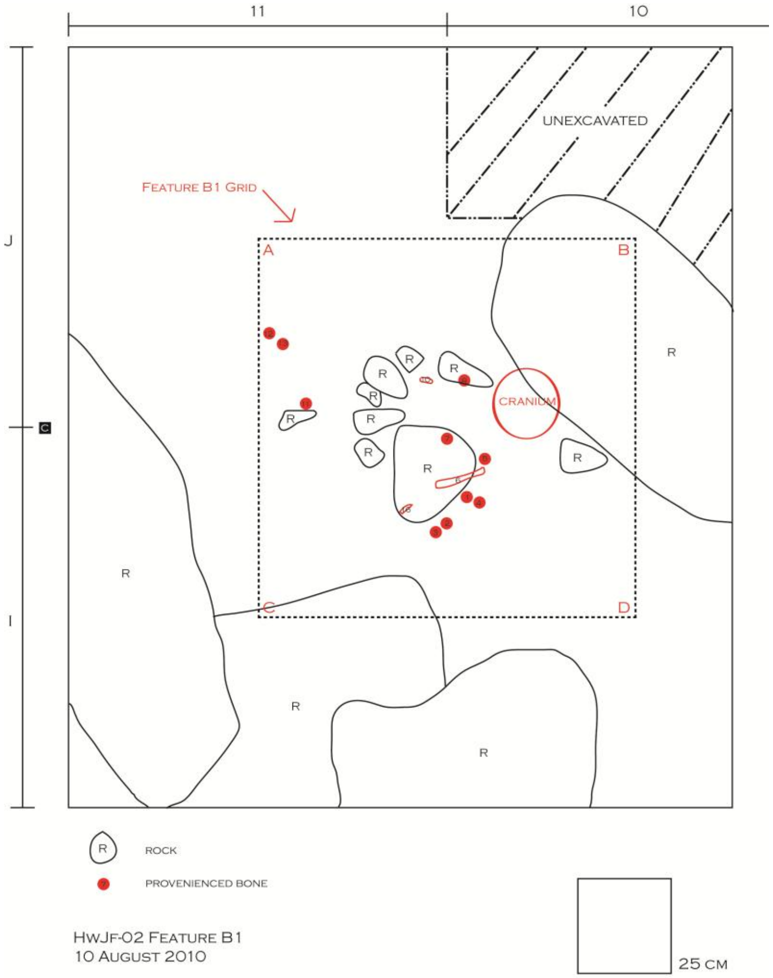

Figure 4:11: B-1 feature (image by K. Biittner). Note the small rocks overlying the skeleton.

Figure 4.12: B-1 cranium and left arm

Figure 4.13: B-1 thorax and right arm

No further human remains were found after level 8 (45 cm b.d., or 84.4 cm b.s.), although we excavated to the end of level 9 (55 cm b.d., 94.4 cm b.s.) to ensure complete recovery. This was necessary given that elements of this individual were found at 90 cm b.s. in 2006.

The skeleton was found *in situ* and partially articulated, although the bones were extremely fragmentary and fragile. The body was located towards the back of the rock shelter directly beneath the overhang of a large bounder. It was facing west and lying in a supine position. The upper limbs were parallel to the thorax and the cranium was resting on its right side (Figures 4.12, 4.13). The skeleton abruptly ended mid-thorax at the level of the lower ribs, where a soil colour and texture change clearly delineated the edge of the 2006 test pit that transected the body at a right angle (Figures 4.14, 4.15). The line also marked the disappearance of the pebble horizon that was removed with the lower body during the 2006 excavation. Based on the position of the body, the elements represented, and evidence of TP 1, we confidently concluded that this feature was the remainder of the B-1 skeleton excavated four years prior. The position of the pebble horizon overtop and throughout the burial suggested it was not intrusive from a later period since the pebbles would have been disturbed by the excavation of a burial pit. This provides some evidence that this burial was contemporaneous with the surrounding LSA occupation. A charcoal sample from next to the right shoulder at 30 cm b.d (69.4 cm b.s.) was AMS radiocarbon dated to 12,765 ± 55 years BP (OxA-24621). This is consistent with the shell dates from the burial in 2006, which place the remains in the terminal Pleistocene LSA.

Figure 4.14: B-1 feature with soil colour change delineating TP 1 boundary (marked with arrow)

Figure 4.15: Detail of TP 1 boundary (lighter soil is the undisturbed matrix)

Overall, the B-1 remains were recovered from a lesser depth than in 2006. The crushed skull was discovered at 23.8 cm b.d. (63.2 cm b.s.). The rest of the burial feature extended to a maximum depth of 45 cm b.d. (84.4 cm b.s). The body had slumped down slope towards the southwest entrance to the rock shelter so that the most caudal elements were found at a greater depth. This explains why the portion of the same individual recovered in 2006 was found concentrated between 85-87 cm b.s., over 20 cm below the cranium.

The B-1 material from the 2006 and 2010 excavations represents the majority of one individual. The skeleton is missing 6 teeth, 12 carpals and tarsals respectively, 1 metacarpal, 4 metatarsals, 5 manal phalanges and 22 pedal phalanges. Several ribs and vertebrae, the patellae, and large portions of the pelvic and pectoral girdles and the face are also absent. In general, the left side of the body is slightly better preserved, particularly the basicranium and left clavicle. However, most of the fragments identified represent less than 25% percent of the whole bone. The elements recovered in 2010 are presented in Tables 4.5 and 4.6.

Table 4.6 compares the elements recovered in 2006 and 2010, illustrating the shift from bones of the lower body to the upper. In 2006, the most cranial element of the recovered skeleton was a fragment of the distal humerus. In 2010, the majority of the remains were from the cranium, thorax, and upper limb, with the exception of a small fragment of a proximal femur and 2 pedal phalanges. The staggered recovery of the upper and lower body supports the interpretation that the remains represent a single individual.

Level	Depth above/ below datum	Approx. cm below surface	B-1 identifiable elements from 2010*	
Surface	Surface – 35 cm a.d.	0-4	-	
1	35-25 cm a.d.	4-14	*intermediate pedal phalanx*	
2	25-15 cm a.d.	14-24	-	
3	15-5 cm a.d.	24-34	cranial fragments	
4	5-5 cm b.d.	34-44	*vertebrae, unspecified* intermediate manal phalanx proximal pedal phalanx	
5	5-15 cm b.d.	44-54	rib thoracic vertebra	
6	15-25 cm b.d.	54-64	cranial fragments	**B-1 cranium: 23.8 – 39.4 cm b.d.** frontal parietal probable parietal occipital probable occipital temporal probable temporal cranial sinus fragments cranial fragments sphenoid maxilla maxillary teeth I^2 left C^1 left C^1 right P^3 left P^4 left M^1 unsided M^1 unsided M^2 left M^3 right
7	25-35 cm b.d.	64-74	frontal bone *cranial fragments* probable maxilla Maxillary teeth I^1 left I^1 right mandible mandibular tooth M_1 right scapula probable scapula clavicle ribs probable ribs humerus probable humerus radius or ulna shaft *proximal manal phalanx* cervical vertebrae thoracic vertebrae vertebrae, unspecified	

8	35-45 cm b.d.	74-84	cranial fragments maxillary teeth P^3 right P^4 right M^2 right tooth roots, unspecified molar roots zygomatic hyoid manubrium sternal body scapula cervical vertebrae thoracic vertebrae vertebrae, unspecified ribs probable ribs *probable ribs* *ribs* humerus probable humerus radius radius or ulna shaft scaphoid *femur*	M^3 left upper molar roots mandibular teeth I_1 left I_2 left C_1 left C_1 right P_3 left P_4 left P_3 right P_4 right M_3 left M_3 right lower molar roots mandible molar root fragments tooth crown fragments atlas axis cervical vertebrae probable vertebra scapula manubrium rib probable rib
9	45-55 cm b.d.	84-94	-	

* Bones from disturbed contexts are italicized

Table 4.5: B-1 skeletal elements recovered in 2010

B-1 elements recovered in 2006	B-1 elements recovered in 2010
manubrium (juvenile)	frontal
humerus	parietal
ulna	temporal
radius	occipital
metacarpals	zygomatic
trapezium	sphenoid
lunate	cranial fragments
scaphoid	cranial sinus fragments
proximal manal phalanges	maxilla
intermediate manal phalanges	maxillary teeth (except right lateral incisor)
distal manal phalanges	mandible
ribs	mandibular teeth (except right incisors, second molars, and left first molar)
thoracic vertebrae	tooth crown and root fragments
vertebrae, unspecified	hyoid
os coxa, unspecified	scapula
os coxa, acetabulum	clavicle
pubis,	manubrium (adult)
probable pubis	sternal body
ilium	atlas
probable ilium	axis
ischium	cervical vertebrae
sacrum	thoracic vertebrae
coccyx	vertebrae, unspecified
femur	ribs
tibia	humerus
fibula	radius
calcaneus	radius or ulna
talus	scaphoid
metatarsals	proximal manal phalanx
proximal pedal phalanges	intermediate manal phalanx
intermediate pedal phalanx	proximal pedal phalanx
	intermediate pedal phalanx
	femur

Table 4.6: Comparison of B-1 elements from 2006 and 2010, in descending order from the cranium

No further remains from the juvenile B-2 individual were found in this excavation. However, another individual was discovered. A fragment of fused right and left maxillae with a grossly carious right lateral incisor was recovered with the rest of the B-1 cranium. It was originally believed this was part of the same individual. However, the right central incisor from B-1 did not fit in the fragment's alveolus. Furthermore, the alveolar process was very thin and it appeared that some of the anterior teeth had been lost antemortem, possibly related to advanced dental disease. Consequently, this fragment could not be from the same individual as the rest of the dentition. Instead, it represents a third adult, termed burial 4 (B-4).

Following the excavation, the human remains from the 2010 field season were exported on loan to the University of Alberta where I removed the material from the *en bloc* sediment packages and performed a full osteological investigation. The details of my laboratory and osteological methods are discussed in Chapter 3, while the osteobiographies for these individuals are presented in Chapters 5 and 6.

4.6 Dating

Samples of *Achatina* shells and charcoal were obtained from the 2006 and 2010 excavations for AMS radiocarbon dating. The Isotrace laboratory at the University of Toronto processed the samples from 2006. Table 4.7 presents the dates from this excavation, and Figure 4.16 demonstrates the relationship of the stratigraphy and the radiocarbon dates in TP 1. The stratigraphy of TP 2 was determined to be out of primary context, but the radiocarbon dates from shell fragments suggest the presence of Iron Age and LSA occupations.

Whether or not these shells represent cultural behaviour is important for the interpretation of these dates. Mumba Höhle rock shelter in northern Tanzania has also been radiocarbon dated using *Achatina* fragments associated with LSA industries and human remains (Mehlman 1979; Brooks and Robertshaw 1990). Although other sites have used snail and marine shells for dating, at Mumba, they were specifically interpreted as the food waste of prehistoric hunter-gatherers. Land snail shell middens and the development of so-called *escargotières* are well established in many regions of North Africa, but their existence is debated south of the Sahara (summarized in Mehlman 1979: 87-89). It is plausible land snails were part of the expansion of hunter-gatherer diets during the Pleistocene ice ages as expressed by the "broad spectrum revolution" theory (Flannery 1969). They are also part of the ethnographically documented diet of modern Tanzanian groups such as the Hadza, who seek out snails during the onset of the rainy season in February and March (Mehlman 1979; Bushozi 2011). In his excavation report, Msemwa hypothesized the shell fragments at Mlambalasi were anthropogenic, and noted that land snails were still eaten among the Makonde ethnic group of Mtwara, Tanzania (2002: 14). Therefore, the dates derived from them should reflect the approximate antiquity of the LSA occupation.

Test pit	Depth (cm below surface)	Description	Age (years BP)	Lab Number
1	25	Charcoal	460 ± 50	TO-13416
1	65-70	*Achatina* shell fragments	12,940 ± 90	TO-13417
1	110-120	*Achatina* shell fragments	11,170 ± 90	TO-13418
2	20-30	*Achatina* shell fragments	1860 ± 60	TO-13419
2	110-120	*Achatina* shell fragments	3050 ± 60	TO-13420
2	150-160	*Achatina* shell fragments	6090 ± 60	TO-13421

Table 4.7: AMS radiocarbon results from the 2006 excavation

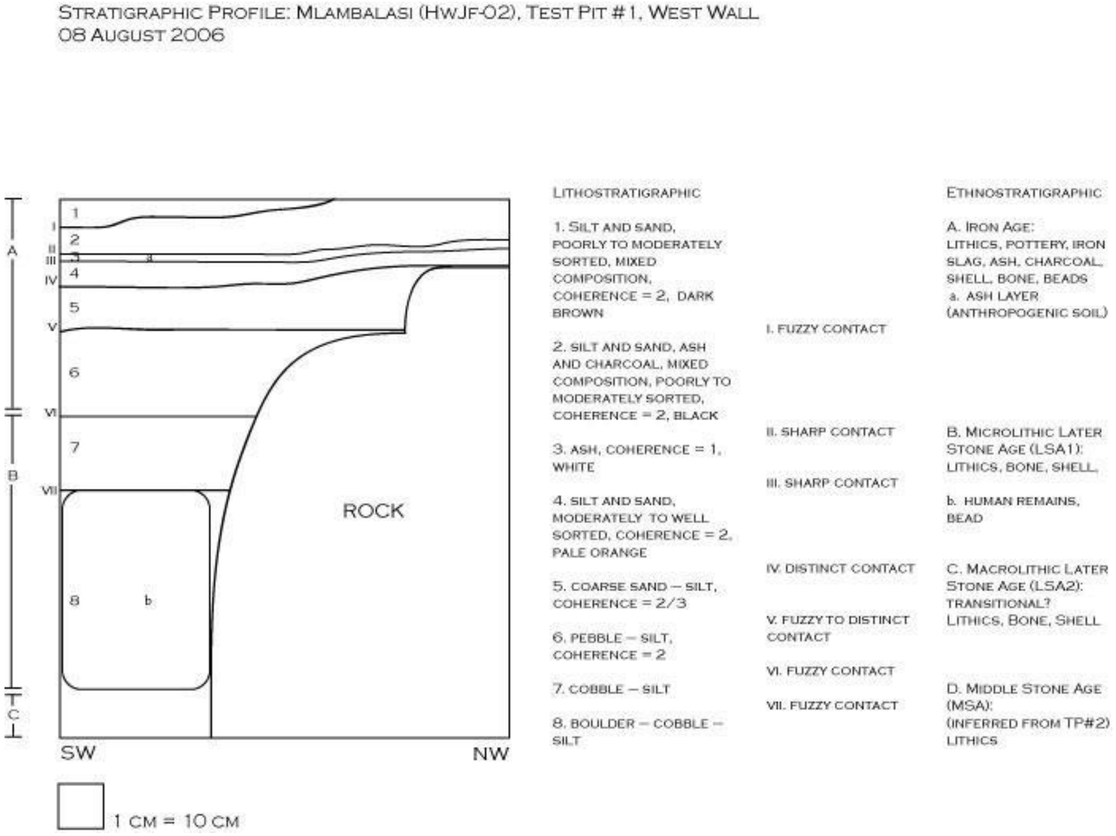

Figure 4.16: Stratigraphic profile of TP 1 from 2006 (image by K. Biittner)

The Oxford Radiocarbon Accelerator Unit (ORAU) processed the samples from 2010. We attempted to acquire direct dates from two provenienced, *in situ* human bone fragments from B-1. The selected fragments were from the left clavicle (ORAU P-28367) and right humerus (ORAU P-28366). Unfortunately, the samples had insufficient collagen for radiocarbon dating. Several charcoal samples were collected from I-11, the unit from the 2010 excavation trench that was the most stratigraphically intact. The charcoal was collected by trowel with its sedimentary matrix and deposited directly into aluminum foil (as described in Ambrose 1998a: 380). Table 4.8 presents the results, and Figure 4.17 is the stratigraphic profile of the north wall of I-11.

Despite what we believed to be intact stratigraphy, most of the radiocarbon dates from this unit are from historic times. One of the samples from within the burial feature, however, dates to the terminal Pleistocene. This charcoal sample was located less than 2 cm from the right shoulder at the same depth as the humerus and scapula. This date is consistent with the associated LSA artifacts, and its position below the transitional pebble horizon. If the remains were intrusive from an earlier time period, the gravel layer would have been disturbed or absent in the area overtop and surrounding the remains, as was the case with TP 1. It also closely agrees with the dates from the shell fragments found around the postcrania, 12,940 and 11,170 BP respectively. The fact that the 2010 charcoal sample falls between these shell dates provides compelling evidence that the burial is from a Pleistocene LSA occupation.

Provenience	Depth (cm below surface)	Description	Age (years BP)	Lab Number
I-11 North wall profile, Unit A	~ 12	Charcoal	342 ± 24	OxA-24622
I-11 North wall profile, Unit B	~ 4	Charcoal	151 ± 24	OxA-24623
I-11 North wall profile, Feature 4	~ 40	Charcoal	398 ± 26	OxA-24642
I-11, Level 2, SW quad	19.9	Charcoal	189 ± 24	OxA-24619
I-11, Level 5, SE quad	48.4	Charcoal	267 ± 25	OxA-24618
I-11, Level 7, NE quad	73.4	Charcoal	182 ± 24	OxA-24617
Feature B-1	69.4	Charcoal	12,765 ± 55	OxA-24620
Feature B-1	75.4	Charcoal	372 ± 26	OxA-24621

Table 4.8: AMS radiocarbon results from the 2010 excavation

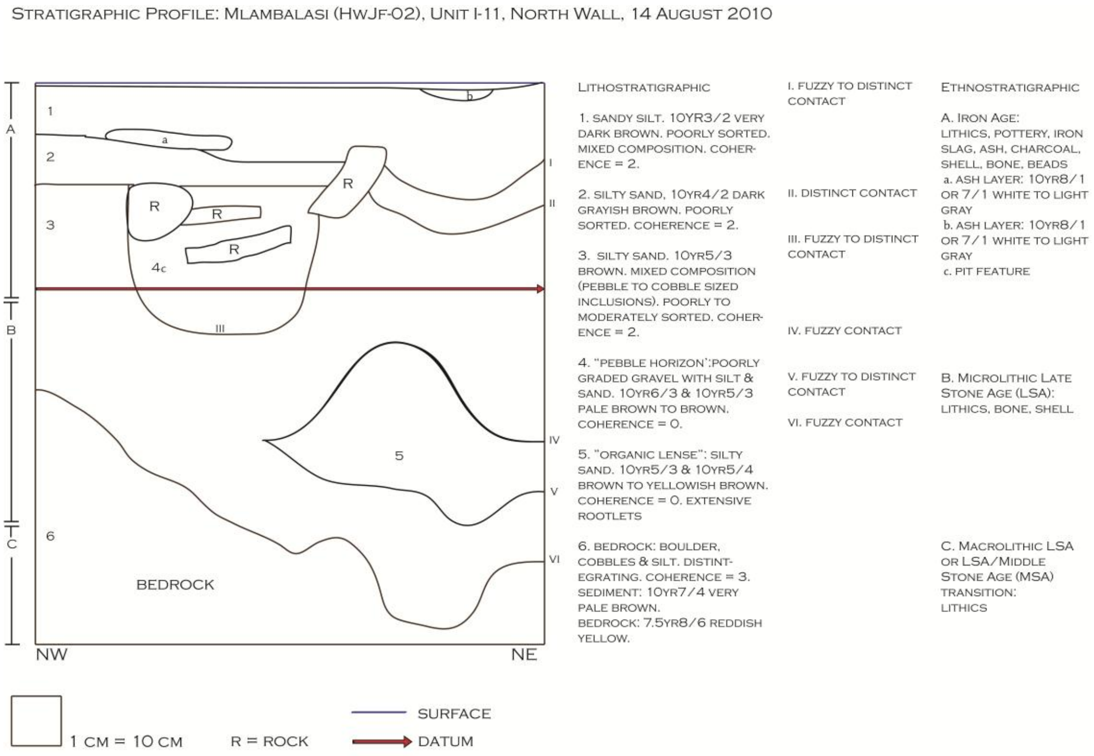

Figure 4.17: Stratigraphic profile of the north wall of I-11 from 2010 (image by K. Biittner)

Some of the younger dates are likely the result of modern carbon contamination. The samples from the north wall and I-11 level 2 were collected from the first 40 cm of the trench, which is the disturbed Iron Age deposit. Therefore, the young dates of 151-398 uncalibrated years BP are not unexpected. However, the dates from levels 5 and 7, and the other sample from the B-1 feature, are inconsistent with what appears to be an older archaeological context. This could be due to the inclusion of modern charcoal and ash. The unconsolidated, silty sediments of the site may have hampered the collection of uncontaminated charcoal. In particular, the sample from level 7 was collected at the northeast extent of the unit in a location where charcoal from earlier levels may have fallen in. Note that charcoal samples from levels 2 and 7 were dated to 189 and 182 years BP respectively and overlap in their margins of error, despite being separated by over 50 cm of deposits. This could suggest commingling of carbon from different time periods during the excavation process.

Additionally, during a brief period away from the site, two local men working with us camped at the rock shelter and built a large fire outside the main entrance, several meters away from our open excavation trench. Given the size and duration of the fire, as well as the high winds on the escarpment, it is probable that some of the ash became incorporated in our charcoal samples. We noted this possibility and did not collect samples from near the exposed surfaces immediately afterward. However, modern ash sitting on the floor of the rock shelter may have been subsequently deposited in the trench. The same men built another fire on the night of August 10, 2010 after we recovered the first half of the

B-1 skeleton. This might explain why the first sample from B-1, which was recovered before the fire, was dated over 12,000 years older than the charcoal recovered the next day. The younger sample was also collected close to the boundary of TP 1, which could have caused contamination with modern carbon from the backfill.

Based on the mixed radiocarbon results from the 2006 and 2010 field seasons, it is apparent that further chronometric dating is needed the site. It is regrettable that the poor preservation of the human remains has so far precluded direct dating. Nevertheless, snail shell fragments and charcoal from the B-1 feature suggest that the skeleton dates to the terminal Pleistocene. The archaeological and dating contexts of B-2, B-3, and B-4 are less certain, and their antiquity cannot be speculated upon at this time.

4.7 Discussion

The Mlambalasi rock shelter is a rich and important archaeological resource for understanding the Iron Age and Later Stone Age in East Africa. However, the site has a complicated history due to three separate excavations by two different principal investigators, as well as its continued use by local peoples. The 2010 field season was designed to identify the relationship between the two separate test excavations, and determine the origin and affinity of the collected artifacts including the human remains. This review describes the excavations to date at Mlambalasi so future researchers are aware of the prior activity and findings at the site. The following is a brief summary of the skeletons collected.

Figure 4.18 illustrates the total remains ascribed to each of the four skeletons. Figure 4.19 represents the total remains recovered from each of the three field seasons, along with the ratio of identifiable to unidentifiable remains.

Willoughby and her team recovered the B-1 individual over two separate field seasons in 2006 and 2010. In 2006, 39.4% of the total skeleton was collected. The remains were exclusively postcranial and included 75.82% of the total appendicular skeleton and 25.23% of the total axial skeleton. The increased limb elements may reflect a flexed or semi-flexed burial position, although it could also be a result of sampling bias. Predictably, the portion recovered in 2010 was dominated by cranial (100% of total) and axial elements (74.77% of total, compared to 24.18% of the total appendicular skeleton). Figure 4.20 compares the skeletal elements recovered in each field season. Although the remains are extremely fragmentary, 74% of the total fragments could be identified to a specific bone. Based on this analysis, the skeleton is almost completely present.

Willoughby and her team excavated B-2 and B-4 in 2006 and 2010, respectively. B-2 is a nearly complete juvenile manubrium while B-4 is a fragment of fused adult maxillae. They were both found commingled with the B-1 remains. It is unclear whether the three individuals were associated in the same mortuary context or if the elements were intrusive from still-unexcavated burials. In historic contexts, it is not uncommon for a single element from a second individual to become associated with an otherwise circumscribed burial (Sandra Garvie-Lok 2008, personal communication). Consequently, the origins of these skeletons are unknown.

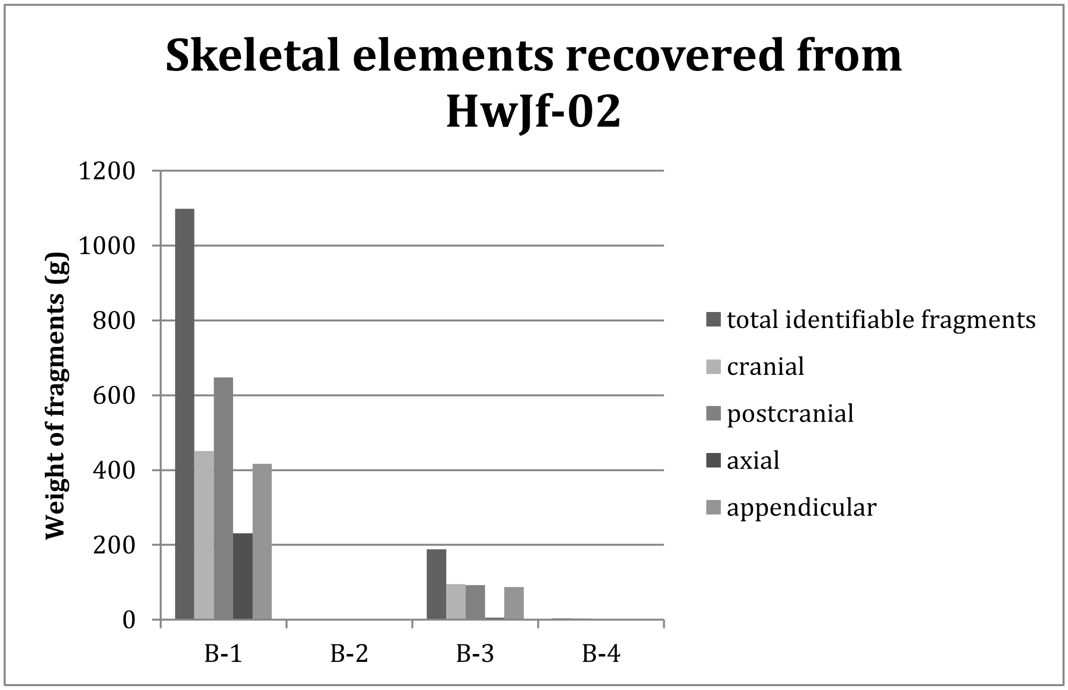

Figure 4.18: Distribution of human remains recovered from Mlambalasi

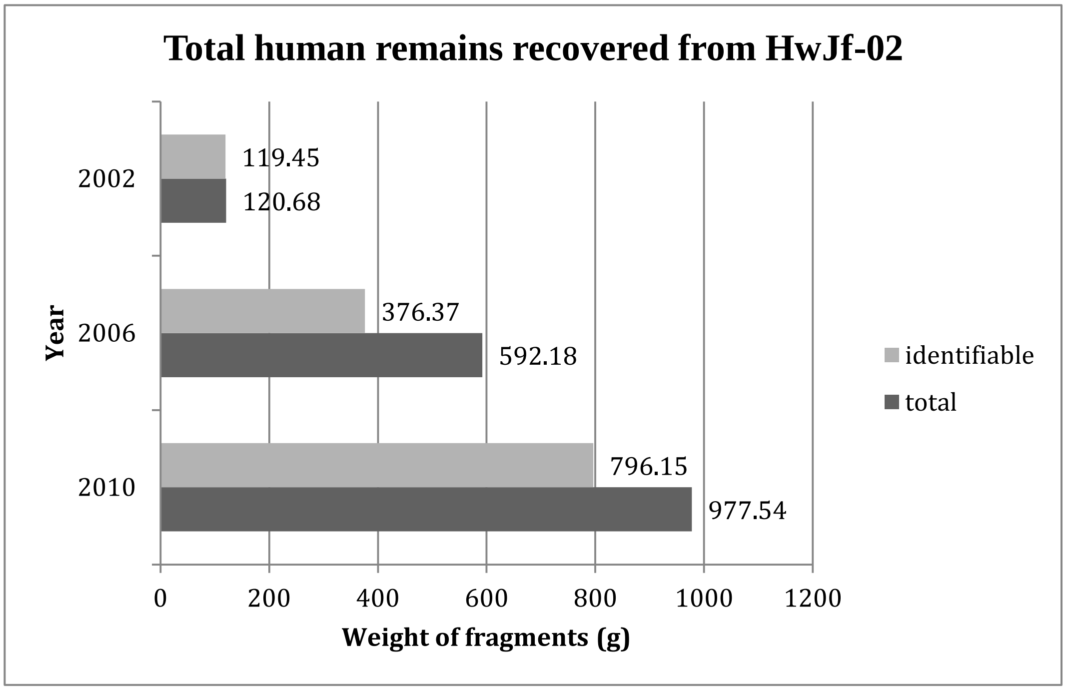

Figure 4.19: Total human remains recovered from Mlambalasi

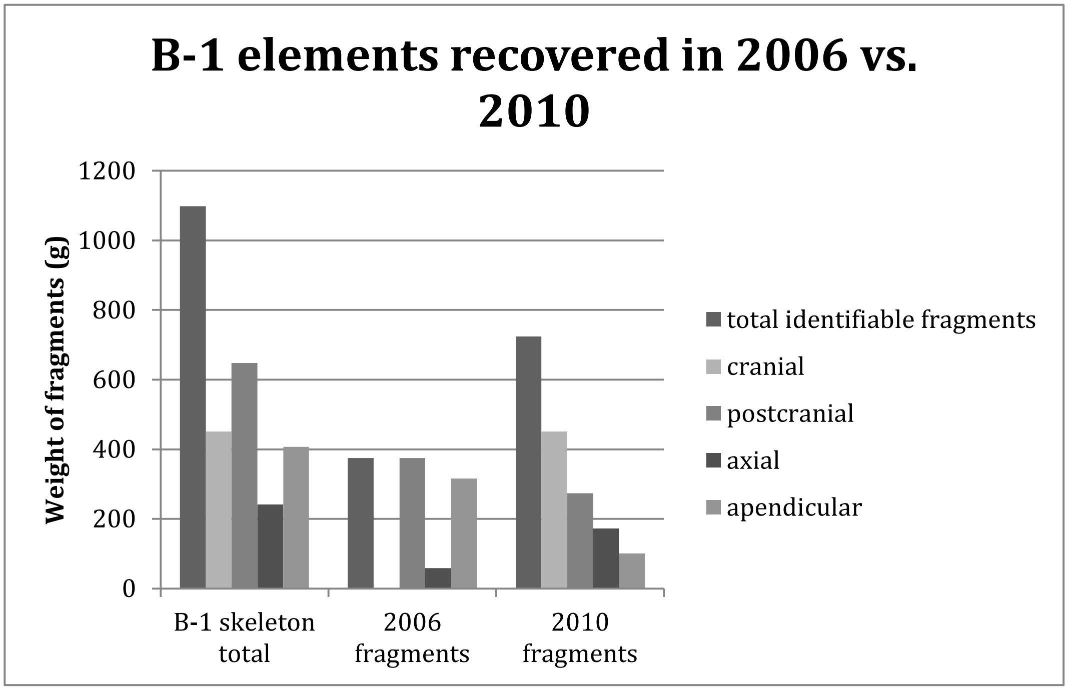

Figure 4.20: Total B-1 skeletal elements recovered

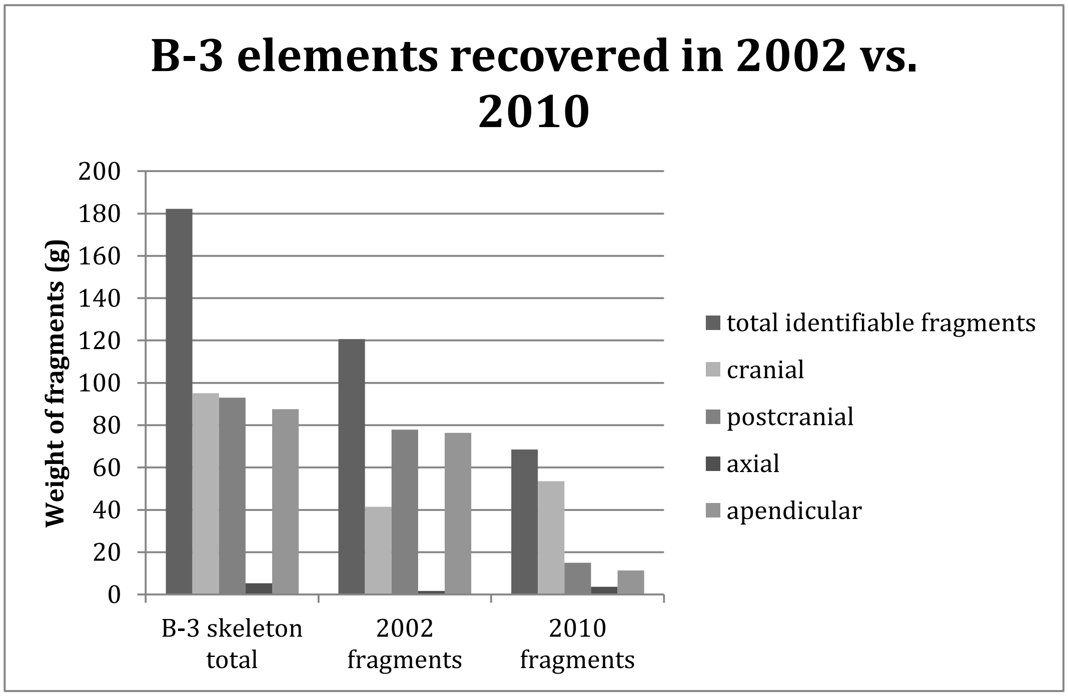

Figure 4.21: Total B-3 skeletal elements recovered

The B-3 individual was partially excavated by Msemwa in 2002 and Willoughby and her team in 2010. Additionally, a significant portion of the skeleton is likely still at the site. It was recovered approximately 50 cm above the B-1 feature and on the other side of a large boulder. Based on the depth and associated artifacts, this skeleton is probably from the Iron Age. Of the 66 identifiable fragments from this skeleton, those from 2002 represent 63.78% of the total weight, including 43.66% of the cranial and 83.87% of the postcranial remains. This includes 30.77% of the recovered axial skeleton and 87.10% of the appendicular skeleton. In 2010, we collected the remaining 36.24%, including the majority of the axial skeleton. A large part of this skeleton is absent or still undiscovered, including the upper arms, most of the thorax, and all of the pelvis and lower limbs. Figure 4.21 presents the distribution of skeletal elements recovered from each field season.

Recovering partial skeletons from this site has been an unfortunate side effect of test excavations, fieldwork constraints, and taphonomy. B-1 was recovered over four years while portions of B-2, B-3, and B-4 likely remain unexcavated. It is interesting to note that B-1 and B-3 follow a similar pattern as half skeletons where certain elements were overrepresented in the original sample. In 2006, the exclusively postcranial bones of B-1 were dominated by appendicular elements. Specifically, bones of the hands and feet (carpals, tarsals, metacarpals, metatarsals, and manal and pedal phalanges) comprised 40% of the appendicular fragment count. The material recovered in 2010 was therefore predominantly cranial and postcranial axial. The same pattern appeared in the staggered recovery of B-3 where predominantly appendicular elements were recovered in 2002. In that excavation, the hands and feet represented 59% of the total appendicular fragment count. The separation of appendicular and axial elements may reflect flexion of the skeletons in the rock shelter, either due to mortuary custom, the physical constraints of digging in the rocky matrix, or a combination thereof. With a small sample size of two, it is impossible to determine the significance, if any, of this coincidence. However, if further remains are recovered from this site, it may be useful to monitor whether this pattern continues.

4.8 Conclusions

The Mlambalasi site is located in Iringa Region of southern Tanzania, which is noted for its abundant rock shelters. This region is also significant since it may have contained highland refugia during the ice ages. It is well known by contemporary Tanzanians as the location of Chief Mkwawa's last stand. Mlambalasi was first test excavated in 2002 by Paul Msemwa, and again in 2006 by Pamela Willoughby. A more substantial area was excavated by IRAP in 2010. These excavations revealed an archaeological sequence spanning the LSA, Iron Age, and historic period. Human remains were recovered from all three field seasons: two adults and a juvenile from the same LSA deposit, and another adult from the Iron Age. However, due to the fragmentary and commingled nature of the skeletons, two of the individuals were recovered over two field seasons. Three of the skeletons are incomplete, suggesting that additional remains may be recovered in future excavations. Although more chronometric dating is needed, initial radiocarbon dates from 2006 and 2010 suggest at least one of the LSA skeletons derives from the terminal Pleistocene, approximately 12,000 years ago.

The Mlambalasi rock shelter has yielded significant archaeological and bioarchaeological resources. Additional field research is scheduled for 2012 and 2014 that will hopefully address lingering questions about the site chronology and the extent of the deposits. The following chapters present and discuss the osteological and taphonomic findings regarding this material, and relate it to current research on the evolution of *Homo sapiens* in East Africa.

Chapter 5: The B-1 Skeleton Osteobiography

The B-1 skeleton was recovered over two field seasons: the lower body in 2006 and the upper body and skull in 2010. The skeleton is extremely fragmentary but mostly complete. It is only missing 6 teeth, 12 carpals and tarsals respectively, 1 metacarpal, 4 metatarsals, 5 manal phalanges, and 22 pedal phalanges. The patellae and several ribs and vertebrae are also absent, as are large portions of the pelvic and pectoral girdles and face. Many of the recovered elements represent less than 25% percent of that bone, and the total weight of the recovered skeleton is only 1.496 kilograms. The degree of fragmentation limited osteological analysis and prevented the application of many typical bioarchaeological methods. By focusing on the most complete fragments and the data available, I was able to compile information on age, sex, stature, body size, dentition, dental pathology, and other pathological changes. Even with poorly preserved material for study, the B-1 individual represents a complex and atypical case that is made all the more interesting by its great antiquity.

5.1 Age at Death

The B-1 skeleton is a middle adult of indeterminate sex, probably 35-50 years old at the time of death (Buikstra and Ubelaker 1994: 9). Although fragmentary, the long bones of the skeleton are adult sized and fully fused, as evidenced by a faint line of fusion on the humeral head. Examples of non-fragmented elements such as the metacarpals and vertebrae are also fully fused. Ten fragments of the cranial vault have suture lines that are partially obliterated, although cranial suture closure cannot be used to estimate age in this case due to extensive damage. A single preserved sternal rib end appears to be in mid phase 1 (ages 16.5-18.) or early phase 2 (ages 20.8-23.1 years) (Isçan et al.1984). However, the method devised by M.Y. Isçan and colleagues (1984) for estimating age from sternal rib ends is based on the fourth rib of white males. This fragment cannot be identified to a specific rib and the diversity in this population is unknown. Furthermore, the sternal end is damaged and partially obscured by concretions, so the age estimation is unreliable. Other skeletal elements favourable for aging such as the pubic symphysis and auricular surface were not preserved.

The individual's dentition provides the most accurate estimation of age. All four third molars are erupted and worn, suggesting a minimum age of 21 years. Wear describes the erosion of tooth enamel, and ultimately crown height, by the action of teeth grinding against one another and by contact with the cheeks, tongue, and food (Hillson 2005: 214). Wear and other dental pathologies are discussed in greater detail later in this chapter. For the purpose of establishing an age at death, the third molar cusps have a combined wear score of 4.73 out of 10 using the Scott system (1979) and 4 out of 8 using the Smith system (1984). This means each cusp quadrant has been worn flat and a small spot of dentine is visible. The rest of the dentition present is also significantly worn, which may indicate an older age range (Ubelaker 1978 figure 62). However, rates of wear depend on diet, tooth morphology, and behaviour, which produce high variation within and between populations (Hillson 1986: 195). Calibrating the rate of wear for a population requires a significant number of skeletons where the age at death is known, which is unlikely when working with medieval and older populations (Hillson 2005: 227). Hunter-gatherers also tend to have higher degrees of wear than agricultural populations. This may lead to an overestimation of age if the applied wear charts were developed for more recent populations. Given that the third molars are erupted and moderately worn, the B-1 skeleton is at least 21 and more likely middle aged.

Other pathological changes, or lack thereof, also confirm this age estimation. The anterior teeth of this skeleton are highly carious, including all four canines and half of the premolars. Caries are progressive, demineralized lesions on teeth caused by the bacteria in plaque, and can eventually lead to loss of the tooth. Studies suggest there is a natural hierarchy of teeth affected, starting with the occlusal fissures of the first molars and progressing to the other molars and premolars. The last sites to be affected are typically the contact points of the second molars, premolars, and incisors, with rare canine involvement (Hillson 1986, 1996, 2005, 2008). Chronic dental caries is a progressive disease that shows a strong relationship to age; as the individual becomes older, a greater proportion of the teeth are affected (Hillson 2005, 2008). The fact that three out of four canines have gross carious lesions, and that all are affected, supports an age assessment of middle to older adult. Additionally, the mandibular left fourth premolar has a periodontal cemental dysplasia, which L.R. Eversole and colleagues found to be more common in individuals over the age of 20 (1972: 202).

Despite indications of middle age in the dentition, there is no arthritis, osteoporosis, or degenerative joint disease in the remainder of the skeleton. These conditions would be more likely if the individual were an older adult. The first coccygeal vertebra is fused to the base of the sacrum, which is more likely pathological than developmental since there is no evidence of sacralization of the first coccygeal vertebrae (although non-sacralized fused coccyges can still occur). When the coccyx and sacrum fuse due to pathology, it typically occurs late in an individual's life. This again supports an older age assessment for B-1 (Bass 2005; White and Folkens 2005). Yet this is a fairly common trait, especially in some populations. L.R. Shore (1930) found the non-pathological acquisition of the 30th, or first coccygeal, vertebra was a strong trait among South African Bantu, present in one fifth of the skeletons in his study. Without the ability to distinguish this trait as developmental or pathological, it is difficult to comment on its relationship to age. Based on the overall evidence available, the B-1 skeleton most likely falls in the 35-50 year range.

5.2 Sex

The sex of the skeleton is indeterminate. As with age estimation, the traditional skeletal indicators on the pelvis and skull were not preserved. I applied osteoscopic and osteometric sex estimation methods to fragments of the cranium and pelvis, the metacarpals, and the ascending rami of the mandible with conflicting and thus inconclusive results. Osteoscopic evaluation, or visual assessment of morphological traits as android or gynecoid, can be up to 100%

effective in sex determination if the remains are complete (Meindl et al. 1985; Işcan 2005). Osteometric techniques rely on variably accurate statistical methods, but are more useful when a skeleton is fragmentary and missing elements. However, both types of methods are population specific. It is therefore recommended that multiple methods be used on any study population to determine norms and variation in that particular group. Ultimately, because this skeleton is an isolated individual with no population for comparison, it is impossible to conclusively determine sex.

Several morphological traits used for sexing are preserved on this skeleton: one greater sciatic notch and the ischiopubic rami of the os coxae, the nuchal crest of the occipital bone, both mastoid processes of the temporals, and the mental eminence and ascending rami of the mandible. The traits were assessed using the dimorphic scoring system outlined in *Standards for Data Collection from Human Skeletal Remains* (Buikstra and Ubelaker 1994) and by R.S. Meindl and colleagues (1985). The scores for each element are presented in Table 5.1.

The pelvic features are generally feminine, although the fragments are isolated and may not reflect overall pelvic proportions. The nuchal crest and mastoid processes on the cranium are more ambiguous, particularly without other individuals from this population for comparison. By contrast, the right and left ascending rami of the mandible appear strongly masculine; they are deep and appear to be set at a steep angle (Meindl et al. 1985; White and Folkens 2005). Although the rami are complete, the mandible was recovered in several fragments that do not perfectly refit. Consequently, the gonial angle and degree of eversion cannot be measured or scored due to the probability of misinterpreting the relationship to the mandibular body. The two ascending rami are also slightly asymmetrical, which makes it difficult to assess them as a pair.

Sex-specific osteometric measurements are usually taken on the pelvis, whole cranium, and long bones. However, I was limited to assessing the mandibular ascending rami and metacarpals in this individual due to the nature of preservation. All measurements were taken with sliding digital calipers to the nearest 100th of a millimeter. Linear discriminant functions were applied to the mandible based on five measurements of the ascending rami: maximum and minimum breadth, condylar height, projective height, and coronoid height (Saini et al. 2011). This method has an overall accuracy of 80.2%, with the coronoid height emerging as the best parameter. All six measurements were taken on the complete left ascending ramus, but only three on the right due to breakage along the inferior border at gonion. These values are presented in Table 5.2, along with the functions and sex estimation results in Table 5.3. All results suggest a male sex estimation, consistent with the osteoscopic assessment of the mandible.

The maximum length, midshaft diameter, and anteroposterior and mediolateral head and base dimensions of the five metacarpals and first proximal phalanx were measured for the sexing method developed by J.L Scheuer and N.M. Elkington (1993). These values are presented in Table 5.4, with the results in Table 5.5. This method boasts a high degree of accuracy, but is criticized for requiring complete metacarpals when the articular ends of these bones are often subject to taphonomic breakage and pathological degeneration (Stojanowski

1999). Accordingly, the method could only be applied to the left first metacarpal and the pooled midshaft diameters. Both functions indicate the B-1 remains are female.

C.M. Stojanowski (1999) improved Scheuer and Elkington’s method by developing a technique to sex fragmentary and pathological metacarpals. Using the same six measurements, he generated seven linear discriminant functions to determine sex. The accuracy of this method falls in the 79-85% range although it has been found to be even higher (Burrows et al. 2003). The results from the left first and both fifth metacarpals are presented in Table 5.5. As with the other sex estimation method using metacarpals, the results were overwhelming female.

The sexing methods applied to this skeleton produced disparate male and female estimates. Of the morphological traits, three were scored female, one male, and two inconclusive. Using metric data, all discriminant functions applied to the mandible produced male estimates, while all functions applied to the metacarpals indicated female sex. Given the commingling of human remains at the site, these elements could represent separate individuals. However, they were found in near-articulation with the rest of B-1 and are consistent in size and preservation, rendering this possibility unlikely. Instead, the discordance in estimates is probably due to using weaker dimorphic traits in lieu of the complete pelvis and cranium. It is also problematic that there are no other skeletons from this population to determine normal human variation for this sample. The other three individuals excavated from the rock shelter either have too little data, as in the case of B-2 and B-4, or are from a significantly different archaeological complex and time period, as with B-3. In the absence of other evidence, the sex of B-1 is uncertain.

All bioarchaeological sex and age estimation methods are population specific and require data from nearly complete adult burials in a sufficient sample size to seriate individual skeletons according to trait. Sexing techniques tend to assume that males are larger than females, and are often developed on comparatively robust modern populations. Using osteoscopic evaluation alone, females are rarely incorrectly sexed. Rather, errors are made when smaller males are classified as female (Meindl et al. 1985). This is a pervasive problem in studies of small-bodied samples and is well documented in populations such as prehistoric and modern Maya (Wright and Vásquez 2003). Among the Khoesan and small-bodied African LSA skeletons, individuals tend to have short extremities compared to their trunks, and shorter upper extremities compared to lower (Kurki et al. 2008). If the metacarpals in the B-1 skeleton follow this trend, they may have erroneously fallen into the female range based on modern comparative data. This may also be the case for other robusticity-ranked traits such as the nuchal crest, mental eminence, and pubic bones; a small, gracile male could be interpreted as female. Without population specific methods and a comparative sample, it is impossible to determine whether this skeleton represents a female or a small male.

Dimorphic trait	**Bone**	**Source**	**Score**	**Interpretation**
Greater sciatic notch	Ilium	Buikstra and Ubelaker 1994	2	Probable female
Inferior pubic ramus	Pubis	Phenice 1969; Meindl et al. 1985	5	Very female
Nuchal crest	Occipital	Buikstra and Ubelaker 1994	3	Ambiguous sex
Mastoid processes	Temporal	Buikstra and Ubelaker 1994	2 or 3	Probable female or ambiguous sex
Mandibular eminence	Mandible	Buikstra and Ubelaker 1994	1	Female
Ascending rami	Mandible	Meindl et al. 1985	1	Male

Table 5.1: B-1 results of osteoscopic sex estimation

Measurement (mm)	**Left ascending ramus**	**Right ascending ramus**
Maximum ramus breadth	43.42	45.20
Minimum ramus breadth	34.64	33.97
Condylar height / maximum ramus height	69.95	-
Projective height	65.96	65.84
Coronoid height	60.79	-

Table 5.2: B-1 metric measurements of the ascending rami (according to Saini et. al 2011)

Skeletal Element Used	**Source**	**Equation**	**Result**	**Interpretation**
Left ascending ramus	Saini et al. 2011	Function 1: Sex = $(0.117)RB_{max} + (-0.113)RB_{min} + (0.095)CNH + (-0.045)PH + (0.167)CRH – 14.814$	0.181	Male
		Function 2: Sex = $(0.155)RB_{max} + (-0.135)RB_{min} + (0.191)CRH – 13.887$	-0.222	Male
		Function 3: Sex = $(0.122)CNH + (-0.062)PH + (0.163)CRH – 13.843$	0.540	Male
		Function 4: Sex = $(0.195)CRH – 11.774$	0.080	Male
		Function 5: Sex = $(0.190)CNH – 11.309$	1.982	Male
		Function 6: Sex = $(0.153)PH – 8.048$	2.044	Male
		Function 7: Sex = $(0.267)RB_{max} – 11.672$	-0.079	Male
		Function 8: Sex = $(0.355)RB_{min} – 10.999$	1.298	Male
Right ascending ramus	Saini et al. 2011	Function 6: Sex = $(0.153)PH – 8.048$	2.026	Male
		Function 7: Sex = $(0.267)RB_{max} – 11.672$	0.396	Male
		Function 8: Sex = $(0.355)RB_{min} – 10.999$	1.060	Male

RB_{max} = Maximum ramus breadth
RB_{min} = Minimum ramus breadth
CNH = Condylar height
PH = Projective height
CRH = Coronoid height

Table 5.3: B-1 ascending rami sex estimates

Metacarpal	Maximum length	ML width base	AP width base	ML width head	AP width head	Maximum midshaft diameter
Left 1st	45.24	12.35	12.90	12.14	11.22	9.28
Right 1st	-	12.94*	-	-	-	9.96
Left 2nd	-	-	-	-	-	8.11
Right 3rd	-	-	-	-	-	7.57
Right 4th	-	-	-	9.70	-	7.89
Left 5th	-	8.42	10.42	9.06	9.71	6.50
Right 5th	52.39	-	-	8.23	12.88	7.45
1st proximal phalanx	45.47	15.07	-	8.63	7.10	8.56

* End is damaged
ML = mediolateral
AP = anteroposterior

Table 5.4: B-1 metacarpal measurements (according to Scheuer and Elkington 1993)

Skeletal Element Used	Source	Equation	Result	Interpretation
Left 1st metacarpal	Scheuer and Elkington 1993	Sex = 4.58 – (0.0092 x a) – (0.0240 x b) - (0.0619 x c) – (0.0118 x d) + (0.0108 x e) – (0.132 x f)	1.822	Female
Metacarpal + 1st proximal phalanx midshaft diameters	Scheuer and Elkington 1993	Sex = 3.82 – (0.177 x A) – (0.102 x B) + (0.0476 x C) + (0.0905 x D) – (0.175 x E) + (0.0858 x F)	1.533	Female
Left 1st metacarpal	Stojankowski 1999	Function 1: Sex = (0.650)APB + (0.367)MLB – 15.62	-2.703	Female

		Function 2: Sex = (0.569)APH + (0.605)MLH – 14.79	-1.061	Female
		Function 3: Sex = (0.451)APB + (0.017)MLB + (0.208)APH + (0.365)MLH – 15.84	-3.047	Female
		Function 4: Sex = (0.106)ML + (0.235)MSD + (0.021)MLB + 0.244)APH + (0.358)MLH – 16.76	-2.441	Female
		Function 5: Sex = (0.127)ML + (0.086)MSD + (0.436)APB + (0.047)APH + (0.265)MLH – 18.12	-2.209	Female
		Function 6: Sex = (0.146)ML + (0.131)MSD + (0.491)APB + (-.0146)MLB + (0.299)MLH – 17.91	-1.929	Female
		Function 7: Sex = (0.155)ML + (0.190)MSD + (0.520)APB + (-0.042)MLB + (0.095)APH – 17.63	-1.600	Female
Left 5th metacarpal	Stojankowski 1999	Function 1: Sex = (0.596)APB + (0.862)MLB – 18.39	-4.922	Female
		Function 2: Sex = (0.701)APH + (0.597)MLH – 15.35	-3.134	Female
		Function 3: Sex = (0.220)APB + (0.703)MLB + (0.388)APH + (0.220)MLH – 19.31	-5.339	Female
Right 5th metacarpal	Stojankowski 1999	Function 2: Sex = (0.701)APH + (0.597)MLH – 15.35	-1.408	Female

a = length; *b* = base M/L; *c* = base A/P; *d* = head M/L; *e* = head A/P; *f* = midshaft

A = metacarpal 1; *B* = proximal phalanx 1; *C* = metacarpal 2; *D* = metacarpal 3; *E* = metacarpal 4; *F* = metacarpal 5

APB = anteroposterior base width
MLB = mediolateral base width
APH = anteroposterior head width
MLH = mediolateral head width
ML = maximum length
MSD = midshaft diameter

Table 5.5: B-1 metacarpal sex estimates

5.3 Stature and Body Mass

Estimation of stature and body mass is difficult for this individual due to the fragmentary nature of the skeletal remains. Traditionally, stature estimates are made by measuring intact long bones and then applying regression formulas derived from known body proportions (Trotter and Gleser 1952, 1958). However, complete, undamaged, and non-pathological long bones are rare in archaeological and forensic situations. New methods have therefore been designed to estimate stature from parts of the humerus, femur, tibia, and fibula using the same concept of proportionality (Steele and McKern 1969; Steele 1970; Wright and Vásquez 2003; Simmons et al. 2003). Unfortunately, the Mlambalasi sample is still too fragmentary to encompass the necessary osteological landmarks. Alternative methods address more commonly preserved elements such as the clavicles, vertebrae, metatarsals, and metacarpals (see Meadows and Jantz 1992). Methods using bones of the hands and feet have been particularly useful given that dense metacarpals and metatarsals are often well preserved, as is the case with the B-1 skeleton.

Even when enough material is available, all methods are still population specific and may not encompass the extremes of human variation. This has been firmly established as the case with small-bodied LSA populations from southern Africa (Kurki et al. 2008, 2010). Consequently, all stature estimations must be evaluated critically. By analyzing LSA archaeological skeletons from South Africa, H. Kurki and colleagues (2010) determined that the best methods for estimating stature in small-bodied populations are the anatomical stature method

(Fully 1956; Raxter et al. 2006) and the femur and tibia method (Olivier 1976). Unfortunately, the bones used in these methods were not preserved in this skeleton. Instead, the stature of the B-1 individual was estimated using the maximum diameter of the femoral head and the complete left first and right fifth metacarpals (Table 5.6).

The femoral head is the only component of the long bones available for stature estimation. For this, and for all further race-specific regression equations, the results for the "black" and "white" formulae were averaged for each sex (as per Sealy and Pfeiffer 2006; Kurki et al. 2010). Modern day Khoesan are neither black nor white, and it stands to reason that prehistoric African groups may have been similarly ambiguous. Using the Simmons et al. (1990) method, the averages for males and females are 155.28 cm and 151.29 cm respectively. The vertical head diameter was also used to generate maximum femur length values of 39.81 cm for a male and 38.48 cm for a female. Applying the traditional regression formulas developed by Trotter and Gleser (1952: 483) then generates average estimates of 155.26 cm for a male and 150.82 cm for a female.

Out of a possible six femur fragment measurements, vertical diameter of the femoral head (VHD) showed the highest and most consistent correlation with maximum femur length and stature, along with the upper breadth of the femur (VHA) and the posterior height of the fibular condyle (LCH) (Simmons et al. 1990). However, the estimates would be more reliable if multiple aspects of the bone could be used. Furthermore, part of the original outer bone surface of the femoral head is missing, so the maximum diameter and all subsequent stature and body mass values may be underestimations.

L. Meadows and R.L. Jantz (1992) devised a method to estimate stature from the maximum lengths of preserved metacarpals. When compared to methods employing long bone fragments (Steele 1970; Simmons et al. 1990), the authors found a stronger relationship between metacarpal length and total stature, as well as lower standard errors of estimate. They recommend using metacarpals two through five to estimate stature in the absence of intact long bones (Meadows and Jantz 1992: 154). As with sex estimates using metacarpals, this method is flawed because it requires the complete bones when many archaeological samples show damage around the articular ends. Regardless, based on the values in Table 5.6, stature can be estimated using the intact left first and right fifth metacarpals.

The average stature estimates for the left first metacarpal are 166.08 cm for a male and 163.16 cm for a female. Using the right fifth metacarpal, the results are 166.33 cm for a male and 162.25 cm for a female. These values are higher than that those calculated using the femoral head. However, given that the metacarpals are better preserved than the fragmentary femur, the results could be more accurate.

Body mass is another area of bioarchaeological estimation where population idiosyncrasies and body size factor heavily into the validity of the method. H. Kurki and colleagues (2010) also evaluated the best methods for mass estimation in small-bodied African populations, and favoured the femoral head method devised by H.M. McHenry (1992). This produces a mass estimate of

44.58 kg regardless of sex. Using a similar method created by C.B. Ruff and colleagues (1991), the same measurement estimates body mass to be 43.67 kg for a male and 50.79 kg for a female. Once again, both these methods might underestimate actual body mass due to the incomplete preservation of the femoral head used.

Table 5.6 presents the equations and results for stature and body mass estimations for B-1. The range of stature estimates for a male is 154.35 ± 3.94 – 168.23 ± 5.67 cm with an average of 160.74 cm. For a female, the range is 149.99 ± 3.41 – 165.25 ± 5.57 cm with an average of 156.88 cm. The range for mass estimates is 43.67 – 44.58 kg for a male and 44.58 – 50.79 kg for a female, with averages of 44.13 and 47.69 kg respectively. The averages for modern Khoesan as defined by A.S. Truswell and J.D.L. Hansen (1976) are 161 cm and 48 kg for males and 150 cm and 40 kg for females. The estimates for the B-1 individual are close to the male Khoesan averages, while a female would be slightly taller and heavier. These results are interesting given our knowledge of LSA populations described in Chapter 2. However, the similarity between the B-1 skeleton and small-bodied southern African populations may be merely coincidental. Larger patterns of human morphology are only identifiable at the population level whereas many ancient specimens are found in isolation, rendering them difficult to interpret. Additional research at the Mlambalasi site and on other East African LSA remains is needed to better investigate the presence of small-body size in this region and time period.

Estimation	Skeletal Element Used	Source	Equation	Result (cm)	Average (cm)	Final Range (cm)
Stature	Max femoral head diameter (37.73 mm)	Simmons et al. 1990	Black male: Stature = (1.51)(VHD) + 97.82 ± 6.92	154.79 ± 6.92	155.28	Male: 154.35 ± 3.94 – 156.16 ± 3.27 Female: 149.99 ± 3.41 – 152.42 ± 5.59
			White male: Stature = (1.11)(VHD) + 113.89 ± 6.77	155.77 ± 6.77		
			Black female: Stature = (1.59)(VHD) + 92.43 ± 5.59	152.42 ± 5.59	151.29	
			White female: Stature = (1.35)(VHD) + 99.22 ± 7.16	150.16 ± 7.16		
		Trotter and Gleser 1952 (using femoral length estimated from Simmons et al. 1990)	Black male: Stature = 2.11(FL_m) + 70.35 ± 3.94	154.35 ± 3.94	155.26	
			White male: Stature = 2.38(FL_m) + 61.41 ± 3.27	156.16 ± 3.27		
			Black female: Stature = 2.28(FL_m) + 62.26 ± 3.41	149.99 ± 3.41	150.82	
			White female: Stature = 2.47(FL_m) + 56.60 ± 3.72	151.65 ± 3.72		
	Left 1st metacarpal length (45.24 mm)	Meadows and Jantz 1992	Black male: Stature = (1.674)(b_1) + 88.81 ± 5.57	164.54 ± 5.57	166.08	Male: 164.54 ± 5.57 – 167.62 ± 5.57 Female: 161.06 ± 5.57 – 165.25 ± 5.57
			White male: Stature = (1.674)(b_1) + 91.89 ± 5.57	167.62 ± 5.57		
			Black female: Stature = (1.674)(b_1) + 85.33 ± 5.57	161.06 ± 5.57	163.16	
			White female: Stature = (1.674)(b_1) + 89.52 ± 5.57	165.25 ± 5.57		
	Right 5th metacarpal length (52.39	Meadows and Jantz 1992	Black male: Stature = (1.433)(b_1) + 89.35 ± 5.67	164.42 ± 5.67	166.33	Male: 164.42 ± 5.67 – 168.23 ± 5.67

	mm)		White male: Stature = $(1.433)(b_1) + 93.16 \pm 5.67$	168.23 ± 5.67		
			Black female: Stature = $(1.433)(b_1) + 84.41 \pm 5.67$	159.48 ± 5.67	162.25	Female: 159.48 ± 5.67 – 165.02 ± 5.67
			White female: Stature = $(1.433)(b_1) + 89.95 \pm 5.67$	165.02 ± 5.67		
Body mass	Max femoral head diameter (37.73 mm)	McHenry 1992; Kurki et al. 2010	Body mass = 2.239(FH) – 39.9	44.58 kg		Male: 43.67 – 44.58 kg Female: 44.58 – 50.79 kg
		Ruff et al. 1991; Kurki et al. 2010	Male: Body mass = (2.741 x FH – 54.9) (0.9)	43.67 kg		
			Female: Body mass = (2.426 x FH – 35.1)(0.9)	50.79 kg		

VHD = vertical head diameter (femur)
FL_m = maximum femur length
b_l = bone length
FH = femoral head diameter

Table 5.6: B-1 Stature and mass estimates

5.4 Dentition and Dental Pathology

The dentition is the most complete part of the entire B-1 skeleton. This is a common occurrence at archaeological sites since enamel is the best preserved of all the hard tissues (Hillson 1986: 119). Twenty-six identifiable crowns, 2 unidentifiable molar fragments, and 25 other crown and root fragments were recovered in association with the skull and have been ascribed to this skeleton. Two other teeth, attributed to the B-4 individual and possibly another, unidentified skeleton, were also found in association with the skull (see Chapter 6). All teeth from the B-1 skeleton were found isolated, and many are missing their roots and sections of the crown. They were matched based on size, colouration, interproximal wear facets, and the pattern of attrition. The maxillary teeth are all present except the right lateral incisor. The right central and lateral incisors, left first molar, and both second molars are missing from the mandibular arcade. The canines and premolars are all present. Figure 5.1 shows the identifiable teeth from B-1 in anatomical position.

It is unknown whether the missing teeth were lost ante- or postmortem because the alveolar processes of the mandible and maxillae are eroded. Teeth are commonly lost antemortem due to calculus, wear, fracture, and dental caries (Hillson 2001: 271). The teeth that were recovered show signs of wear, fracturing and chipping, and caries, so some may have been lost due to these factors. They may have also been destroyed postmortem or missed during the excavation.

Figure 5.1: B-1 dentition in anatomical position

Tooth fragments are one of the most commonly overlooked elements at archaeological sites due to their small size and tendency to be displaced by taphonomic agents (Saul and Saul 2002). Consequently, it is impossible to determine when the teeth were lost.

The teeth were recorded and scored using traditional and revised mensuration methods. They were also inspected for non-metric traits although none were observable, perhaps due to the interference of wear, caries, and fragmentation. Classical odontometry focuses on two aspects of tooth size: maximum mesiodistal diameter, or the length of the tooth, and maximum buccolingual diameter, or the breadth. Measurements are taken at the occlusal surface using sliding calipers to 0.1 mm, more precise than the 1 mm margin recommended for bone (Hillson 2005: 261). These measurements are then used to calculate crown module (the average diameter of the tooth), the crown index (the relative breadth of the tooth), and the robustness index (the area of the occlusal surface) (summarized in Hillson 1986: 232-235). Crown height and root length are also measured where possible. This standardized data expresses the overall size and shape of the teeth for comparison with other samples (Mayhall 2000).

This maximum diameter method has several major drawbacks: a tooth may have multiple maximum diameters or be rotated slightly, altering the position of the contact facets used as landmarks. It can also be hard to use calipers when the teeth are still in the jaw. Most significantly, however, the measurements are altered by attrition. Attrition refers to the formation of well-defined wear facets where teeth meet in mastication (Hillson 1986: 183). Approximal attrition occurs between adjacent tooth crowns, and the wear facets can grow to encompass up to 10% of the unworn diameter. This has a significant impact on measurements taken to 0.1 mm (Fitzgerald and Hillson 2008: 365). Due to this limitation, most studies using dental measurements exclude heavily worn teeth. However, attrition is ubiquitous in hunter-gatherer, proto-agricultural, and agricultural populations, to the extent where its characterization as abnormal and pathological has been challenged (Fitzgerald and Hillson 2008). When studying fossils, is it not practical to diminish already-scarce samples on the basis of something as common as tooth wear.

In response to these criticisms, C.M. Fitzgerald and S. Hillson (2008) developed an alternate method that focuses on the cervix, or neck of the tooth, as opposed to the occlusal surface. They found that tooth dimensions at the cemento-enamel junction are not affected by wear until most of the crown is gone, and that the cervical measurements are more consistent than the maximum measurements. However, they recommend that both cervical and maximum diameters be taken for new studies. Although more accurate for worn teeth, cervical measurements are still affected by gingival calculus, extensive attrition and subsequent root splitting, missing roots, cervical abrasion, chipping, cervical caries, interproximal grooves, and other idiosyncratic use-related attrition and malocclusion (Fitzgerald and Hillson 2008: 381). Furthermore, the authors excluded teeth that were worn above stage 5 of the Smith system (1984), or where two dentine areas have coalesced, which describes most of the B-1 dentition. Therefore, although I included both cervical and maximum diameter measurements in this study, this individual would normally be considered unsuitable for both methods. I have included them anyway with the caveat that the teeth are extremely worn and broken and that this data must be used with caution. Given the small sample size at the site, as well as the rarity of other terminal-Pleistocene skeletal material, it is still important to make this information available. The measurements are included with the other osteometric data in Appendix B.

A number of pathological and taphonomic changes are visible on the B-1 dentition. The teeth are heavily affected by wear, or the inevitable reduction of crowns through the action of chewing. Wear is divided into two types: attrition, caused by tooth contact during chewing that results in wear facets, and abrasion, caused by contact with other elements of the mouth and diet that produces diffuse, random scratches (Hillson 1986: 183). Wear facets are found on the chewing surface between the maxillary and mandibular teeth, as well as between adjacent teeth in the upper and lower arcades. D.J. Ortner and W.G.J. Putschar (1985: 454) further distinguish attrition into physiological and pathological categories. The former is related to natural mastication and the latter to the abnormal position of teeth or idiosyncratic use. As a tooth is worn, cells called odontoblasts lay down secondary dentine to protect the pulp cavity from becoming exposed and necrotic. Simultaneously, the tooth and its socket migrate upward and sideways to stay in occlusion, increasing the distance from the cemento-enamel junction to the alveolar crest. This process is known as continuous eruption, and is accomplished through remodeling of bone and other supporting tissues in the jaw (Hillson 1986, 1996, 2000, 2005; Danenberg et al. 1991). The rate of continuous eruption is usually slow, but P.J. Danenberg and colleagues (1991) found it increased with the severity of wear and is more pronounced in males.

The rate of tooth wear in an individual depends on several factors: the morphology of the crown, the area of the occlusal surface, the internal tooth structure, the thickness and microstructure of the enamel, the presence of enamel hypoplasias, and cultural use of teeth as tools (Hillson 1986: 183). Due to the complex interaction of these factors, it is impossible to calculate a constant rate of wear within and between populations. Generally speaking, tooth wear is a function of age and can be used to identify older individuals in a population. It is a universal human condition that begins as soon as a tooth erupts and continues throughout life. S. Hillson (2005: 14) asserts that "teeth are designed to be worn and may indeed be unable to function properly before they do so."

Dental wear is scored based on the pattern of dentine exposed on the occlusal surface of the crown. In the case of the molars, the various quadrants are scored separately to capture data on asymmetrical patterns of wear. Two systems are used widely by bioarchaeologists to quantify wear: the Scott method (1979) and the Smith method (1984). Both involve visual inspection of the occlusal surface in order to assign a numeric value corresponding with the stage of wear. Following the protocol outlined in *Standards for Data Collection from Human Skeletal Remains* (Buikstra and Ubelaker 1994), I assigned the anterior teeth Smith scores and the molars Scott scores. The extent of wear is presented in Table 5.7 with accompanying descriptions in Table 5.8.

Tooth Number	Tooth description	Smith System: 0-8	Scott system: 0-10				
1	Right M^3		4	4	5	5	Total: 18
2	Right M^2		7	7	-	-	Total: 14
3	Right M^{1*}		9	9	-	-	Total: 18
4	Right PM^4	6					
5	Right PM^3	6					
6	Right C^1	5					
8	Right I^1	6					
9	Left I^1	5					
10	Left I^2	6					
11	Left C^1	5					
12	Left PM^3	6					
13	Left PM^4	6					
14	Left M^{1*}		9	9	-	-	Total: 18
15	Left M^2		6	6	9	9	Total: 30
16	Left M^3		4	4	5	5	Total: 18
17	Left M_3		4	4	5	5	Total: 18
20	Left PM_4	6					
21	Left PM_3	7					
22	Left C_1	6					
23	Left I_2	5					
24	Left I_1	6					
27	Right C_1	6					
28	Right PM_3	6					
29	Right PM_4	5					
30	Right M_1		9	9	-	-	Total: 18
32	Right M_3		4	4	4	4	Total: 16

* Uncertain left of right side

Table 5.7 Degree of wear on B-1 dentition

Tooth wear score	**Description of incisor and canine wear (Smith 1984)**	**Description of premolar wear (Smith 1984)**	**Description of molar wear (Scott 1979)**
1	Unworn to polished or small facets (no dentin exposure)	Unworn to polished or small facets (no dentin exposure)	No information available (tooth not occluding, unerupted, antemortem or postmortem loss, etc.)
2	Point or hairline of dentine exposure	Moderate cusp removal (blunting)	Wear facets invisible or very small
3	Dentin line of distinct thickness	Full cusp removal and/or moderate dentin patches	Wear facets large, but large cusps still present and surface features (Crenulations, noncarious pits) very evident. It is possible to have pinprick size dentine exposures or dots which should be ignored. This is a quadrant with much enamel
4	Moderate dentine exposure no longer resembling a line	At least one large dentin exposure on one cusp	Any cusp in the quadrant area is rounded rather than being clearly defined as in 2. The cusp is becoming obliterated but is not yet worn flat
5	Large dentine area with enamel rim complete	Two large dentin areas (may be slight coalescence)	Quadrant is flat, with dentine exposure one-fourth of quadrant or less
6	Large dentin area with enamel rim lost on one side or very thin enamel only	Dentinal areas coalesced, enamel rim still complete	Dentine exposure greater: more than one-fourth of quadrant area is involved, but there is still much enamel present. If the quadrant is visualized as having three sides, the dentine patch is still surrounded on all three sides by a ring of enamel
7	Enamel rim los on two sides or small remnants of enamel remain	Full dentin exposure, loss of rim on at least one side	Enamel is found on only two sides of the quadrant
8	Complete loss of crown, no enamel remaining; crown surface takes on shape of roots	Severe loss of crown height; crown surface takes on shape of roots	Enamel on only one side (usually outer rim) but the enamel is thick to medium on this edge
9	-	-	Enamel on only one side as in 8, but the enamel is very thin – just a strip. Part of the edge may be worn through at one of more places
10	-	-	No enamel on any part of quadrant – dentine exposure complete. Wear is extended below the cervicalenamel junction into the root

Table 5.8 Descriptions of wear scores (reproduced from Buikstra and Ubelaker 1994: 52-53)

The B-1 individual exhibits a moderate to high degree of wear. Using the Smith system (1984), the incisors have an average wear stage of 5.6, the canines 5.5, and the premolars 6. For the incisors and canines, this describes a state where a large dentine area is exposed but the enamel rim is still complete. Stage 6 for premolars describes two large, coalesced areas of dentine with the enamel rim also still complete (Smith 1984: 45). Using the Scott system, the molars display an average wear value of 6, which indicates dentine exposure on more than one quarter of the quadrant area with a significant portion of enamel remaining (Scott 1979: 214). Some of the teeth, such as the first and second molars, are considerably more worn. However, the degree of wear on the anterior teeth and molars appears to be superficially comparable. A pronounced facet on the lower right first molar was scored as a cervical carious lesion, but may actually be a groove caused by repetitive action. There are no other indications of idiosyncratic behaviour affecting the wear pattern. The degree of wear on these teeth supports a middle adult age at death, as previously discussed.

Chronic dental caries is also prevalent on this skeleton. J.J. Pindborg (1970: 256) defines caries as “a process of progressive destruction of tooth structure initiated by microbial activity on the tooth surface.” Dental enamel dissolves at pH of approximately 4-5.5, which is caused by the action of bacteria on fermented carbohydrates from the diet. Cement is less resistant to caries and demineralizes at a higher pH (Hillson 2008: 113). Carious lesions range in expression from opaque spots to large cavities (Hillson 1986, 1996, 2000, 2005). As with wear, once a lesion is initiated, odontoblasts lay down secondary dentine to protect the pulp cavity. Carious lesions often develop slowly, sometimes over many years, and the tooth many go through multiple phases of demineralization and secondary dentine formation. However, once the carious lesion penetrates the pulp chamber, the result is usually an inflammatory reaction called pulpitis. If the infection proceeds down the root to the apex and restricts bloods supply, this can lead to the death of the tooth. Pulpitis and periapical inflammation often cause acute pain, for which the simplest remedy is tooth extraction. In fact, plaque-related dental disease has been responsible for the majority of tooth loss in human populations for thousands of years (Hillson 1996, 2000).

Caries development involves both hereditary and dietary components, but lesions usually result from bacteria acting on cariogenic diets with high sugar contents (Hillson 2008). Certain conditions such as enamel hypoplasias and other defects can also predispose an individual to caries attack. Lesions are usually divided into root and coronal caries, with the latter category further subdivided into occlusal caries, contact point or approximal caries, and other smooth caries (Hillson 2001). A gross carious lesion is one where the destruction is so advanced that it is no longer possible to determine the specific site where it initiated (Moore and Corbett 1971). Gross gross carious lesions are those only associated with a tooth root, after the entire crown has been consumed (Hillson 2005: 294).

Dental caries can manifest as either acute or chronic cases. Acute cases are associated with the young, while chronic caries are found in older individuals and specifically target the interproximal space between teeth (Ortner and Putschar 1985: 438). In both cases, the lesions progress through hierarchy of sites in the mouth. They first appear in the occlusal fissures of the first and second molars, and then move into the approximal surfaces of the molars, the occlusal surfaces of the premolars, the approximal surfaces and lingual pit of the upper incisors, and finally, the approximal surfaces of the premolars and upper canines (Hillson 2005: 297). The presence of caries on the canines usually indicates advanced progression of the disease, and therefore an older age. Likewise, root caries are usually linked to gingivitis and the exposure of the tooth roots that increases with age (Hillson 2000: 261). Studies suggest this is a life-long disease in which occlusal and approximal lesions are common in youth, and are increasingly replaced by dentine caries, pulp exposure, tooth loss, and root surface caries in middle and old age (Hillson 2000: 263).

Carious lesions are typically recorded by scoring the number and type of caries on each tooth observable (Moore and Corbett 1971; Buikstra and Ubelaker 1994). Caries are identified by visual inspection, and only in cases where the lesion penetrates the surface enamel in order to minimize misdiagnosis. Scoring distinguishes between occlusal, interproximal, smooth surface, cervical, root, and large caries, as well as non-carious pulp exposure (Buikstra and Ubelaker 1994: 55). Wear, abscesses, calculus, and enamel deficiencies are also recorded as they affect the structure of the tooth and encourage the development of carious lesions. However, this system fails to capture information about preserved non-carious sites. To increase clarity of data, S. Hillson (2001) proposed a system that makes comparisons separately for each tooth type, age group, sex, lesion type, and potential lesion site on the tooth using 23 criteria. Tables 5.9 and 5.10 present the dental pathologies on the B-1 skeleton according to the standard method (see attachment 15 in Buikstra and Ubelaker 1994). Tables 5.11A & B present the caries data using the Hillson method.

The B-1 skeleton has 12 interproximal, cervical, and large caries on the incisors, canines, premolars, and one first molar (Figures 5.2-5.6). Figures 5.3-5.6 illustrate some examples of these lesions macro- and microscopically. Seven of the twelve caries are large or gross, but are roughly located in the interproximal spaces between the teeth. The number of caries, the particular teeth involved, and the position of the gross caries between adjacent teeth suggest that this individual suffered from chronic dental caries. This condition may have caused the loss of some or all of the missing six teeth. The involvement of the anterior teeth, in conjunction with the degree of wear, suggests this individual may have been an older adult. However, due to the small sample size of one, the rate and prevalence of caries development is not known. If advanced caries and wear were the norm in this population, the individual may only be a young adult or middle aged.

Carious lesions are considered atypical in hunter-gatherers. The disease is more commonly associated with agricultural populations in which cultivated sources of carbohydrates represent a large portion of the diet (Ortner and Putschar 1985; Hillson 1996, 2005, 2008). Comparatively, the frequency of caries in hunter-gatherers tends to be low: approximately 2-3 lesions per mouth. (Ortner and Putschar 1985: 439). The incidence is even lower prior to the Holocene: “Middle and late Pleistocene cases worldwide can be counted on the fingers of two hands” (Hillson 2008: 128).

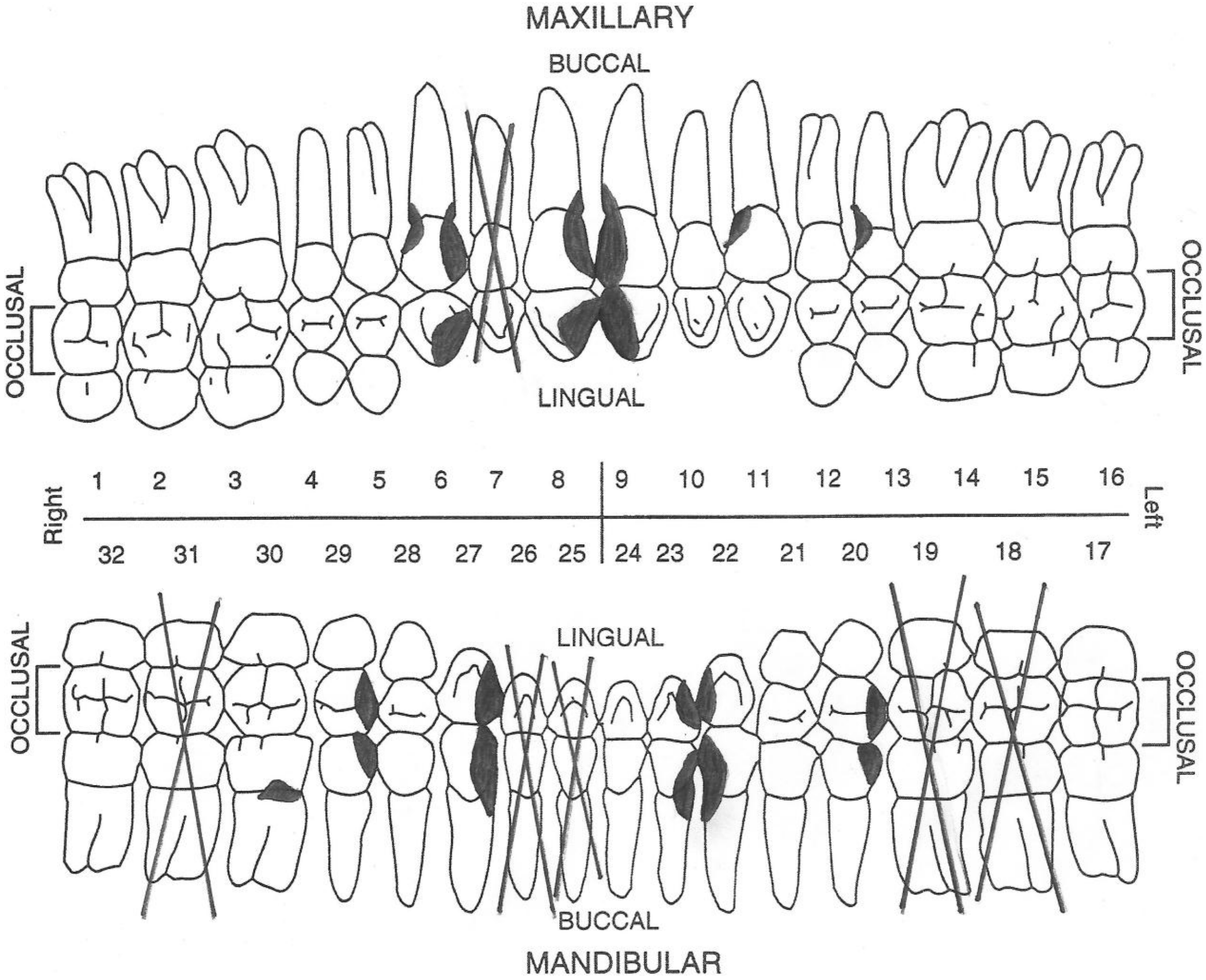

Figure 5.2: B-1 distribution of carious lesions (adapted from Buikstra and Ubelaker 1994, attachment 14a)

Tooth number	Tooth description	Caries		Enamel Defects				
1	Right M^3	0		3	6	7		
2	Right M^2	0		6	7			
3	Right M^{1*}	0		0				
4	Right PM^4	0		6	7	6		
5	Right PM^3	0		7	7	7		
6	Right C^1	2	4	1	1	1	2	
8	Right I^1	6		1				
9	Left I^1	6		7	7	6		
10	Left I^2	0		6				
11	Left C^1	4		1	6	7	1	4
12	Left PM^3	0		6	6	7	7	
13	Left PM^4	6		7	7	6	6	6
14	Left M^{1*}	0		0				
15	Left M^2	0		7	7	7		
16	Left M^3	0		7	7	6	6	
17	Left M_3	0		7	7	7	7	
20	Left PM_4	6		6	6	6	6	6
21	Left PM_3	0		6	7			
22	Left C_1	6		3	4			
23	Left I_2	6		7	6	6		
24	Left I_1	0		1	1			
27	Right C_1	6		1	1	1	7	2
28	Right PM_3	0		6	7	6		
29	Right PM_4	2		1	7	7	7	
30	Right M_1	4^{**}		6	6	6	6	6
32	Right M_3	0		7	7	6		
Total number		12		79				

* Uncertain left of right side

** May also be a groove related to cultural use

Table 5.9: B-1 dental pathology (adapted from attachment 15, Buikstra and Ubelaker 1994)

Number	Caries	Enamel Defects
0	No lesion present	Absence
1	Occlusal surface	Linear horizontal grooves
2	Interproximal surfaces	Linear vertical grooves
3	Smooth surfaces	Linear horizontal pits
4	Cervical caries	Nonlinear arrays of pits
5	Root caries	Single pits
6	Large caries	Discrete boundary opacity
7	Noncarious pulp exposure	Diffuse boundary opacity

Table 5.10: Scores for caries and enamel defects (Buikstra and Ubelaker 1994: 55-57)

Tooth Number[1]	**18**	**17**	**16**	**15**	**14**	**13**	**12**	**11**	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	
	0	0	0	0	0	7		7	8	0	0	0	0	0	0	0	01. Tooth presence, absence, carious
	2															2	2. Occlusal surface caries (fissure, groove, fossa sites)
	0							0		0					0	0	3. Pit caries
	4	10	10	6	6	5		6	5	6	5	10	6	10	6	4	4. Occlusal attrition score
	4							5	6	0						4	5. Occlusal attrition facet dentine caries
	1	1		2	2	3		7	7	2	2	1	1		1	1	6. Attrition facet enamel rim chipping/caries
	2			1	1					0	1		0		1	1	7. Mesial attrition score
	0			0	0	7		7	8	0	3		5		2	0	8. Mesial contact area caries
					0	7		7	8	0	5		5		0	0	9. Mesial root surface caries
																	10. Mesial root exposure, CEJ-AC (mm)
				1	1	0		0	0	0	1		0			0	11. Distal attrition score
				0	2	0		0	0	0	2		0			0	12. Distal contact point caries
					0	5		0	0	0	1		0			0	13. Distal root surface caries
																	14. Distal root exposure, CEJ-AC (mm)
	0				0	0		0	8	0	0		1		2	0	15. Buccal smooth surface enamel caries
	1				0	0		1	8	0	0		1		0	0	16. Buccal root surface caries
																	17. Bucal root surface exposure, CEJ-AC (mm)
	0				1	0		0	8	0	0		1		2	1	18. Lingual smooth surface enamel caries
	1				0	0		0	8	0	0		0			1	19. Lingual root surface caries
																	20. Lingual root exposure, CEJ-AC (mm)
																	21. DDE in the occlusal region
	0			0	0					0	0		0			0	22. DDE in the contact region
	2				0	1		1		0	1		0			0	23. DDE lower down crown side or in cervical area

Table 5.11A: B-1 dental caries (adapted from Hillson 2001)

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[1] Teeth numbered according to FDI World Dental Notation system

Tooth Number	**48**	**47**	**46**	**45**	**44**	**43**	**42**	**41**	**31**	**32**	**33**	**34**	**35**	**36**	**37**	**38**	
	0		0	0	0	7			0	7	7	0	7			0	1. Tooth presence, absence, carious
	2															2	2. Occlusal surface caries (fissure, groove, fossa sites)
	0								0	0						0	3. Pit caries
	3		8	5	6	6			6	5	6	7	6			3	4. Occlusal attrition score
	4					6										4	5. Occlusal attrition facet dentine caries
	1		1	1	2	7			2	2	1	1	1			1	6. Attrition facet enamel rim chipping/caries
	1		0	0	0				0	0			1			1	7. Mesial attrition score
	0		1	1	0				0	0	7		1			1	8. Mesial contact area caries
			1	1	1				0	0	7	0	1			0	9. Mesial root surface caries
																	10. Mesial root exposure, CEJ-AC (mm)
	0				0	0					0	1				0	11. Distal attrition score
	0			3	0	2					3	2	7			0	12. Distal contact point caries
	0			5	0	1					5	1	7				13. Distal root surface caries
																	14. Distal root exposure, CEJ-AC (mm)
	2		3	1	1	1			0	2	0	0	0			0	15. Buccal smooth surface enamel caries
	0		5	1	1	0			0	1	0	0	1			0	16. Buccal root surface caries
																	17. Bucal root surface exposure, CEJ-AC (mm)
	2			0	0	1			0	0	0	1	0			2	18. Lingual smooth surface enamel caries
	0			0	0	0			0	0	0	1	0			0	19. Lingual root surface caries
																	20. Lingual root exposure, CEJ-AC (mm)
	0															0	21. DDE in the occlusal region
	0			0	0											0	22. DDE in the contact region
	0			1	0	1			1	0	2	0	0			0	23. DDE lower down crown side or in cervical area

Table 5.11B: B-1 dental caries continued (adapted from Hillson 2001)

Figure 5.3: B-1 maxillary right central incisor with a large carious lesion (at none and 2.5 times magnification)

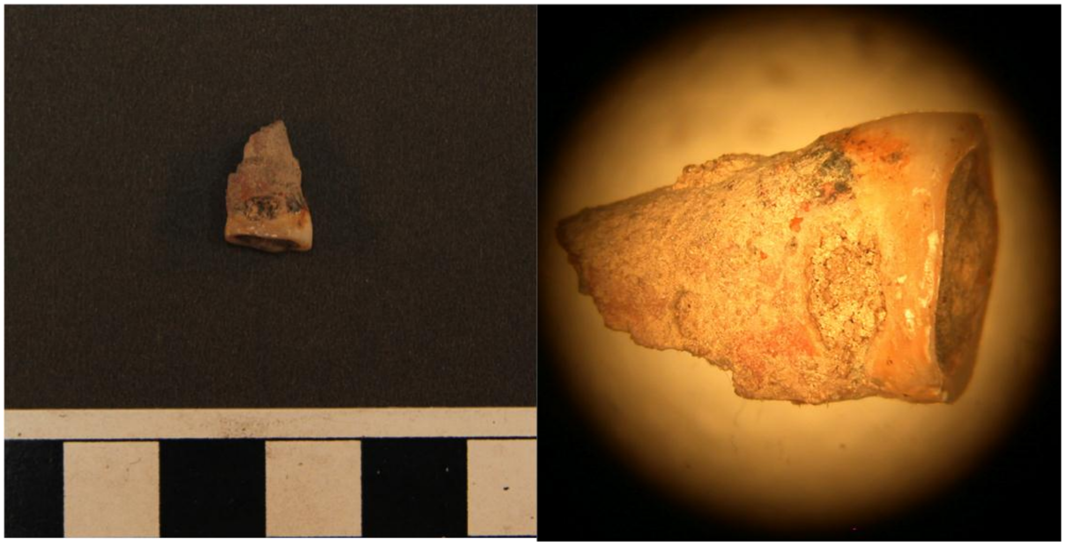

Figure 5.4: B-1 maxillary left fourth premolar with a cervical carious lesion (at none and 2.5 times magnification)

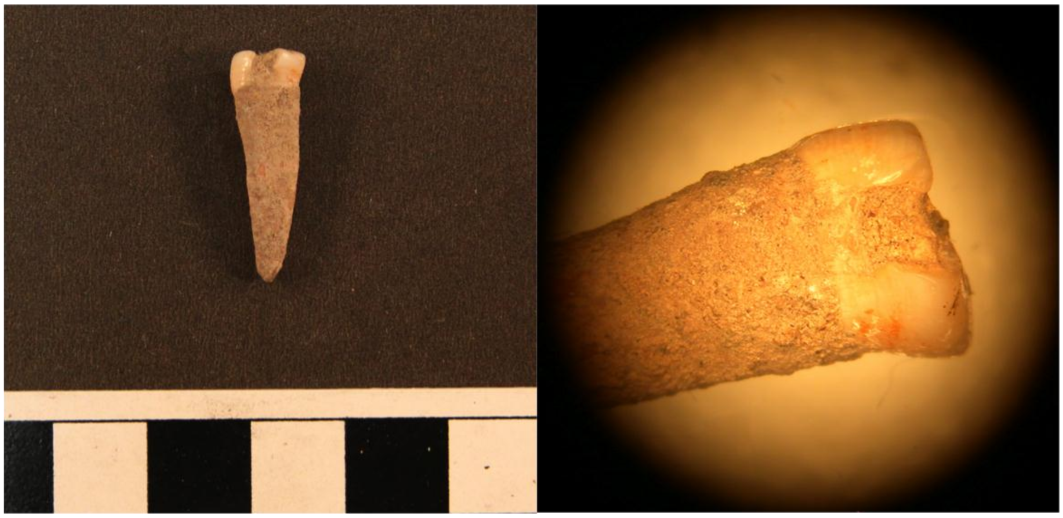

Figure 5.5: B-1 mandibular right fourth premolar with an interproximal carious lesion (at none and 2.5 times magnification)

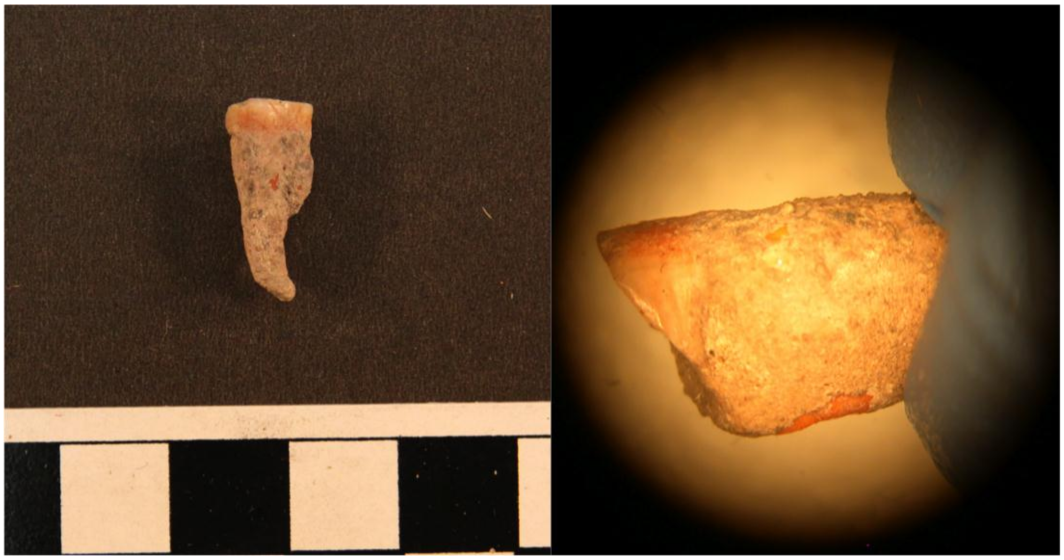

Figure 5.6: Fragment of B-1 mandibular right first molar with a possible cervical carious lesion or cultural wear pattern (at none at 2.5 times magnification)

Although taphonomic forces have further eroded many of the carious lesions in the B-1 dentition, the underlying pathological condition is unequivocal (Mary Jackes, personal communication 2011). The concentration of carious lesions on the anterior teeth is unusual. One possible explanation is the presence of sticky foods in the diet (e.g., certain fruits and seeds) that might collect in the interproximal spaces (Sandra Garvie-Lok, personal communication 2012). It may also be due to an unknown pattern of cultural use. Whether the prevalence of caries in this individual represents broader dietary or behavioural patterns in this population, or an anomalous case, is unknown. However, indications of advanced plaque-related dental disease on the B-4 skeleton implies it may be the former (see Chapter 6). Given that the two skeletons were found in the same LSA context, this population may represent an intriguing and largely unique case of dental disease in Pleistocene hunter-gatherers.

These carious lesions are also likely connected to the high degree of attrition. Whereas agricultural societies are known for caries, hunter-gatherers are associated with tooth wear (Hillson 1996, 2008). It was formerly believed that there is a negative relationship between attrition and caries; wearing down of vulnerable occlusal fissures could remove the sites first attacked by the lesions (Ortner and Putschar 1985). This may be the case for younger individuals, but the rate of wear is usually insufficient to stop a carious lesion once it has begun development (Hillson 2001: 263). In middle to older adults, there may be a correlation between tooth wear, caries, and eventual tooth loss. Instead of having a protective effect against caries, wear predisposes an individual to chipping and fracturing that can cause the accumulation of plaque, and even expose the pulp chamber to bacterial attack. This was demonstrated among Australian hunter-gatherers, where plaque was found concentrated in enamel fractures and the gaps between worn teeth (Hillson 1996: 301-302). Additionally, secondary dentine and cement demineralize at a lower pH than enamel. This causes carious lesions to develop on worn occlusal and exposed root surfaces. Due to these factors, it is not uncommon to find caries in archaeological specimens with heavily worn teeth, particularly in the dentine of exposed attrition facets (Hillson 2001). With respect to this, there may be more caries present in the B-1 dentition that were not recorded due to the concretions adhering to the occlusal surface. The positive relationship between wear and caries may also explain the prevalence of the latter in B-1, despite low frequencies in other hunter-gatherer populations.

Other pathological changes on the dentition may have also contributed to the progression of wear and carious lesions. Tooth wear and caries on this individual were scored visually. For other pathologies, I inspected each tooth under 2.5 times magnification using a traditional biocular microscope. Twenty-four of the twenty-six recovered teeth bear enamel hypoplasias, including linear horizontal and vertical grooves and pits, nonlinear pits, and discrete and diffuse boundary opacities. The well-defined horizontal grooves and furrows present on six of the anterior teeth are likely Linear Enamel Hypoplasia (LEH). LEH is a hypoplastic disorder that causes a deficiency in the enamel thickness that was initiated during matrix secretion (Hillson 1996: 165). Since the deciduous and permanent teeth begin forming *in utero* and continue throughout childhood, the etiology of enamel hypoplasias is exceedingly complex. Proposed causes include: chromosomal anomalies, congenital defects, inborn errors of metabolism, neonatal disturbances, infectious disease, neurological disturbances, endocrinopathies, nutritional deficiencies, etc. (Hillson 1986: 131). In the case of hunter-gatherer populations, it is usually broadly attributed to dietary or immunological stress. Enamel hypoplasias can manifest as furrows, pits, and planes, and predispose the teeth to a number of other effects such as caries development and fracture.

The dentition also exhibits diffuse and discrete boundary opacities that constitute hypocalcifications, or the deficient mineralization of the enamel at the maturation stage (Hillson 1986, 1996). The etiology of opacities is also poorly understood. They are often associated with hypoplasias, suggesting a disruption to both matrix secretion and maturation (Hillson 1986). Under the microscope, the opacities appear brown, orange, and white/cream in colour. Taphonomic processes and bone diagenesis can also cause discolourations in buried skeletal remains, which makes this condition hard to recognize. They can also be confused with discolourations in which pigment is deposited as a result of various metabolic disorders (Hillson 1996).

There is a growth on the fourth left mandibular premolar termed a periapical cemental dysplasia (Figure 5.7). This condition is variably referred to as a cementoma, cementoblastoma, periapical cementoblastoma, periapical osteofibrosis, periapical fibroma, and periapical fibrous dysplasia (Eversole et al. 1972: 208).

Figure 5.7: B-1 mandibular left fourth premolar with a large carious lesion and periapical cemental dysplasia

The pathology is most often called a cementoma, although the term is disfavoured because the lesion may contain dentine and enamel as opposed to strictly cement (Eversole et al. 1972). It presents as an odontogenic, irregular, periapical lesion adhered to the apex and lateral aspect of the root. The mass appears solid and measures 6.00 mm wide and 3.97 mm long, and extends 3.14 mm laterally from the root surface. The associated tooth has a gross carious lesion extending from the occlusal surface to below the cemento-enamel junction, but it is unclear if the pathologies are interconnected.

L.R. Eversole and colleagues (1972: 208) theorized such dysplasias could arise from rickets, syphilis, trauma, mild infection, and endocrine imbalance, although none showed a definitive link. Based on their case review, they also noted that the condition primarily affects the anterior mandibular teeth of females and shows a predilection for “negroid races.” It is also primarily found in adults; six out of seven clinical cases described as cementomas occurred in patients over 20 years (Eversole et al. 1972: 202). If related to the cement deposition of continuous root development, the presence of this dysplasia could be another indicator of an older age range. The condition would have likely been asymptomatic in life, although the associated mandibular bone cannot be inspected for complications.

Although the B-1 skeleton’s dentition is very fragmentary, it is still the most complete and informative element of this individual. Based on the 26 preserved tooth crowns and associated crown and root fragments, this individual was a middle to older adult with moderate tooth wear and chronic dental caries.

He or she also had various enamel deficiencies and a periapical cemental dysplasia on one of their lower premolars. Although the Mlambalasi site has a small skeletal sample of four, and only one has preserved dentition, the data from this individual may provide a useful comparison for other rare skeletal material from the terminal Pleistocene in sub-Saharan Africa.

5.5 Other Pathological Changes

Due to the high degree of fragmentation and poorly preserved bone surfaces, there is little evidence for other pathological changes on the B-1 skeleton. The petrous pyramid of the right temporal exhibits a blastic lesion 4.23 mm high and 8.63 mm long, extending posterosuperiorly from just above the internal auditory meatus (Figure 5.8). The osseous growth is firmly attached to the superior petrous pyramid and could not be the result of taphonomic disturbance. It likely represents an exostosis or an osteoma, neoplastic bony tumours of the petrous temporal bone (Wright et al. 1996; Imhor et al. 2004; Viswanatha 2008, 2011; Baik et al. 2011). Such benign tumours are relatively common in the external auditory canal (EAC), but significantly rarer around the internal auditory canal (IAC). Exostoses are usually found in the ear canal as multiple and bilateral, smooth bordered, broad-based bony growths that protrude medially. By contrast, osteomas are usually solitary, pendunculated lesions. They can appear in the ear canal, mastoid area, squamous portion, zygomatic process, promontory, glenoid fossa, middle ear, Eustachian tube, petrous apex, internal auditory canal, and styloid process (Viswanatha 2008, 2011). Osteomas are also characterized by the presence of bone marrow (Baik et al. 2011: 259). Due to its isolation, spindly appearance, and location on the petrous pyramid, this lesion is more likely an osteoma. However, A. Wright and colleagues (1996: 504) caution that only histological analysis can confidently differentiate exostoses and osteomas.

Both types of lesions are slow growing and typically asymptomatic. They are most often found incidentally in patients during routine examinations or when being assessed for an unrelated complaint (Viswanatha 2011: 75). The etiology of these tumors is still unknown. Current theories include trauma with subsequent ossifying periosteitis and chronic inflammation, surgery, radiotherapy, pituitary hormone imbalance, infection, congenital mechanisms, and contact between sites of different embryologic origin (Viswanatha 2008, 2011; Baik et al. 2011). It is also possible that there are multiple causes for the condition depending on the timing and location.

Osteomas rarely develop before puberty, and are more commonly found in females (Wright et al. 1996: 503). Depending on their location, they can compress the eighth cranial nerve causing progressive hearing loss, vestibular weakness, vertigo, tinnitus, facial nerve palsy, and imbalance (Viswanatha 2008: 383). The modern recommended treatment is neurosurgery to excise the growth. It is unclear whether the B-1 individual would have suffered from this condition. The growth appears small, and there is not enough evidence available to speculate on symptoms.

It is possible, although less likely, that this growth could originate from another tumour of the external ear, middle ear, or inner ear. Such cancers are extremely rare, but tend to target the apex of the petrous bone due to its high degree of vascularization (Imhor et al. 2004). Secondary tumours related to squamous cell carcinoma of the head and neck, mammary gland, and lung, as well as kidney and prostate carcinoma and certain melanomas, can produce lesions in this area (Imhor et al. 2004: 79). Although the postcranial remains do not exhibit evidence of these cancers, fragmentation and weathering may obscure any pathological indicators. The blastic lesion on the petrous pyramid represents an abnormal, pathological condition that was likely associated with a benign or malignant tumour.

On the same side of the skull, the right portion of the sphenoid appears deformed (Figure 5.9). When compared to the normal left side, the right pterygoid process is absent, with what appears to be reactive, frothy bone on the anterior surface. In clinical cases, interruption of the pterygoid processes is documented as the result of infection, cancer, or facial trauma. The pterygoid processes are located on the inferior aspect of the sphenoid bone in the midskull and serve to anchor the facial skeleton to the cranial base. Each pterygoid process is comprised of medial and lateral pterygoid plates that fuse anterosuperiorly and create a v-shaped pterygoid fossa. This structure provides an attachment for the medial and lateral pterygoid muscles that are involved in mastication, and the tensor veli palatini muscle that tenses the soft palate and prevents choking during swallowing. This area of the skull is vulnerable to infection because it forms the posterior border of the pterygopalatine fossa, a funnel-shaped compartment that houses the maxillary artery and nerve as well as the pterygopalatine ganglion.

Figure 5.8: B-1 right petrous pyramid of the temporal with pathological growth, compared to normal left petrous pyramid (in anatomical position)

Figure 5.9: Normal sphenoid (University of Alberta reference collection) compared to B-1 normal left pterygoid process and absent right pterygoid process

These structures provide parasympathetic innervation and blood supply to the deep facial structures (Osborn 1979). This fossa provides interconnections between the nasal and oral cavities, infratemporal and middle cranial fossa, and orbit. It is therefore a natural pathway for the spread of many disease processes (Osborn 1979: 394).

A variety of pathologies affect the sphenoid. Necrotizing granulomas, fungal infections, fibrous dysplasia, and osteomyelitis are known to involve the pterygopalatine fossa and cause focal bone destruction (Osborn 1979; Whitehead et al. 1998). Other nontumourous lesions may also cause pressure erosion of the sphenoid sinus and can extend to the base of the pterygoid process if sufficiently large (Osborn 1979). Any inflammation at this site can lead to resorption of bone and the separation of the pterygoid process. Benign and malignant cancerous tumours target the pterygoid plates for the same reason as infection; these structures are intimately involved in vascular supply and innervation. Due to the complex arrangement and delicate bones of the facial skeleton, cancerous tumours anywhere in the vicinity can cause marked destruction of bone and disruption of the pterygoid process.

In modern cases, damage to the sphenoid is commonly seen in patients with severe facial trauma. The human facial skeleton is a framework of four vertical and four transverse buttresses (Figure 5.10). These areas of increased bone thickness support the face by providing a stable reference to the skull base or cranium. They are also designed to absorb impact and fail along predictable lines of weakness to protect the underlying brain. As a result, maxillofacial fractures are rarely associated with cerebral injury (Fromm 1960: 346).

Le Fort fractures are defined by separation of all or part of the maxilla from the skull base, which requires disruption of the posterior vertical maxillary buttress at the junction of the pterygoid plates (Hopper et al. 2006: 791). Therefore, the key diagnostic feature of a Le Fort fracture is at least one damaged pterygoid process. There are three types: I, or transmaxillary, II, or pyramidal, and III that entails total craniofacial disassociation (Figure 5.11) (Fromm 1960; Osborn 1979; Hopper et al. 2006; Alcalá-Galiano et al. 2008; Carvalho et al. 2010; Kim and Huoh 2010). Le Fort III fractures interrupt the pterygoid plates where they meet the sphenoid body. This superficially describes the pathology in the B-1 skeleton. However, Le Fort fractures rarely occur in isolation, but rather as combinations of the three types and other complex maxillofacial fractures (Fromm 1960; Alcalá-Galiano et al. 2008; Kim and Huoh 2010).

Automobile accidents, falls, and other types of blunt trauma commonly cause this type of trauma in modern clinical cases. However, two independent studies determined that interpersonal violence is the leading cause of Le Fort fractures and other maxillofacial trauma (Carvalho et al. 2010; Hwang and You 2010). Assaults usually target the jaw, nose, and zygoma, which can interrupt the pterygomaxillary buttress causing the fracture patterns discussed. The majority of the patients in these studies required surgical intervention.

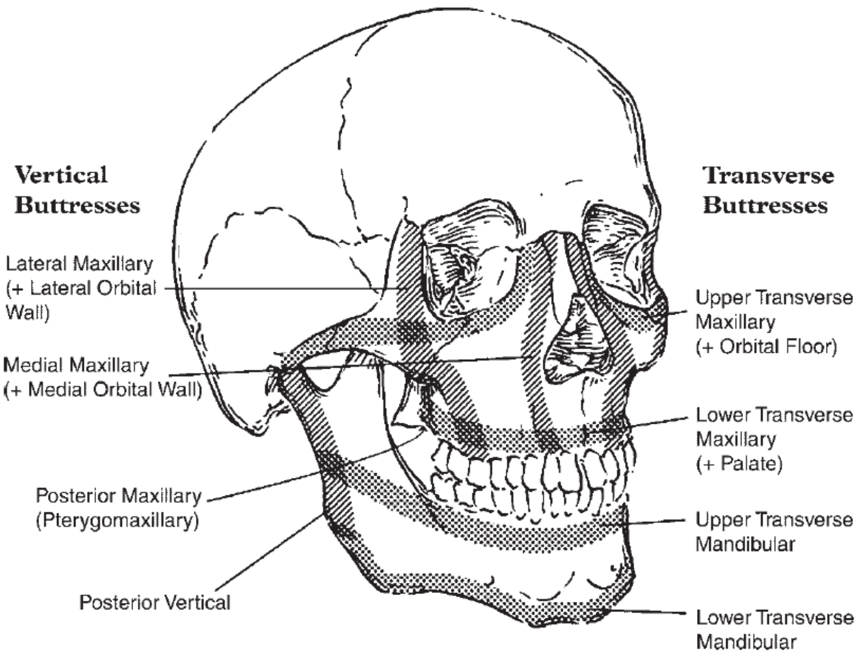

Figure 5.10: The vertical and transverse buttresses of the adult face (Hopper et al. 2006: 784, figure 1). Republished with permission

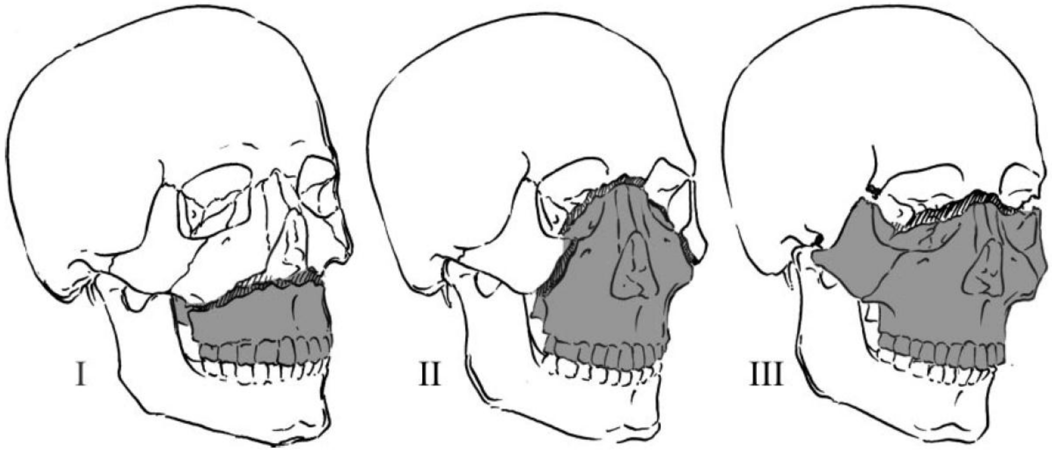

Figure 5.11: Structures affected by the different types of Le Fort fractures (Hopper et al. 2006: 792, figure 15). Republished with permission

If left without treatment, maxillofacial fractures can lead to minor complications such as cosmetic deformity, airway obstruction, dental malocclusion, and tooth avulsion, displacement, loosening or fracture. Serious complications include blunt cerebrovascular injury and brain hemorrhage (Kim and Huoh 2010: 595).

Attributing this sphenoid abnormality to infection, cancer, or facial trauma would require careful inspection of the rest of the skull and postcranial skeleton. Unfortunately, this is impossible given the degree of fragmentation and taphonomic destruction. As with the potential osteoma, the etiology of the sphenoid pathology is inconclusive due to poor preservation.

Perhaps related to the other abnormalities on the right side of the skull, the ascending rami of the mandible are slightly asymmetrical (Figure 5.12). The right ramus is quite deep with a height of 64.51 mm vs. 62.66 mm for the left. The left condyle is also more oblong with a noticeable bias towards the medial aspect. When placed in anatomical position, the standing heights of the rami appear to be roughly equivalent. However, the depth of the mandibular notch is more pronounced in the right ramus and has a different shape. Figure 5.6 illustrates the slight asymmetry between the rami when compared side by side.

The cause of this slight disparity is unclear. If the damage to the sphenoid were caused by a facial fracture, mandibular asymmetry may be a side effect of the trauma. Lower face fractures involving the mandible account for approximately 25% of all maxillofacial fractures (Kim and Huoh 2010: 581). In some cases, the trauma caused fracture and displacement of the condyle neck (Fromm 1960; Jacobsen and Lund 1972; Davis 2002; Kim and Huoh 2010).

However, the mandibular fossa on the left temporal appears normal with no indications of trauma, and the right fossa was not preserved. Furthermore, asymmetrical condyles and mandibular notches cannot be traced to a specific etiology.

Other possibilities include non-pathological and taphonomic explanations. Minor asymmetries in individuals are considered a normal part of human variation. The inferior articular facets of one cervical vertebra in the B-1 skeleton are slightly different sizes. Additionally, the body of the first thoracic vertebra leans slightly to one side. The rami could represent the same phenomenon. If not the result of normal asymmetry, this condition may also be taphonomic. Elements from separate individuals could have become associated in the burial environment, as in the cases of B-2 and B-4 (see Chapter 6). Alternatively, the difference could result from taphonomic distortion and crushing. Based on the recovery of the rami in anatomical position with the B-1 skull and the similarity in size, degree of preservation, and colouration, they likely belong to the same individual. Whether the asymmetry can be considered pathological, normal, or taphonomic is unclear.

The only other potential pathological change on the B-1 skeleton is a manal phalanx that bears signs of a nonunion fracture (Figure 5.13). Following a fracture, a blood clot forms around the injury and is soon permeated by granulation, or fibrous connective, tissue. This granulation tissue helps form a fibrous callus that unites the fragment ends and eventually becomes the primary bony callus.

Figure 5.12: B-1 paired mandibular ascending rami, with a slight asymmetry. The left ramus (right) is deeper set with a mediolaterally elongated condyle, while the right ramus (left) has a deeper mandibular notch

Figure 5.13: Potentially pathological phalanx fragment compared to a healthy phalanx (University of Alberta reference collection)

In the final stages of healing, the fibrous bone is replaced by lamellar bone, the callus is broken down, and the new bone is remodeled (Ortner and Putschar 1985: 62-63). Nonunion fractures occur when the healing process is delayed or incomplete, often when the bone is improperly immobilized. If the callus does not adequately mineralize and the fractured ends continue to move, a pseudoarthrosis develops and the union remains flexible. With continued movement, it may become a nearthrosis, or a true joint. Both types of nonunion fractures usually result in severely diminished function of that bone (Ortner and Putschar 1985).

The isolated fragment from the B-1 skeleton appears to have smooth bone on its proximal aspect where it should have been attached to the shaft of the phalanx, as though the bone has been remodeled. The medial and lateral aspects of the distal end also appear deformed. The remainder of bone could not be identified in the other fragments and was possibly not recovered. There are two other isolated distal phalanx fragments in the Mlambalasi collection. By comparison, these fragments have rough, jagged ends suggesting they were broken postmortem. The potentially pathological phalanx could have been subjected to the same processes, however, and then further modified to appear remodeled. This bone is also darker stained than the rest of the B-1 skeleton. It was found in the disturbed backfill of the 2006 test pit, and thus may not belong to the burial with which it was associated (see Chapter 6). Regardless, the atypical morphology of this distal end may indicate another possible traumatic injury to this individual.

These differential diagnoses for the possible pathological changes are presented with the caveat that the B-1 skeleton is poorly preserved and the majority of bone elements and surfaces are unobservable. The presence of abnormalities on the right petrous pyramid and the right sides of the sphenoid and mandible may point towards a larger-scale issue such as a facial fracture or cancerous tumor. However, the coincidence may also be an artifact of taphonomy and the burial environment. The potential osteoma on the petrous pyramid is unequivocally pathological given the addition of new bone. The absence of the pterygoid process and the deformation of the mandibular condyle, however, could have been caused by post-depositional crushing and warping. The individual was buried on his or her back with the skull resting on its right side. Damage to the various structures on the right could have occurred from the overlying weight of the rest of the skull and debris. This may also be the case with the phalanx that now resembles a nonunion fracture. It is only possible to speculate on pathologies that could have produced this damage without providing concrete diagnoses. However, these conditions differ from the pseudopathologies in which the damage is certainly taphonomic (see Chapter 7).

5.6 Conclusions

The B-1 individual is most likely a middle adult aged 35-50 years who is either female or a gracile male. Age was determined primarily on the degree of dental wear and pathology. Sex was assessed from dimorphic fragments of the cranium and pelvis as well as osteometric analysis of the mandible and metacarpals. However, the results were conflicting, rendering sex indeterminate. Averaged stature and body mass estimates using the metacarpals and the femoral head predict this individual would have been about 161 cm and 44 kg if male, and 157 cm and 48 kg if female. This is significantly smaller than contemporary Canadian averages of 175.3 cm and 86.6 kg for males and 162.3 cm and 68.4 kg for females (Shields et al. 2010). The estimated B-1 body size is closer to the historical averages for southern African Khoesan, i.e., 161 cm and 48 kg for males and 150 cm and 40 kg for females (Truswell and Hansen 1976). This may suggest an affinity with LSA populations from southern Africa. Unfortunately, the size of the skeleton reduces the efficacy of many traditional osteological methods that were developed using larger, more robust populations. Without others from this group for comparison, it is difficult to be certain about the age, sex, and body size of this isolated individual.

The dentition is the most complete element of the B-1 skeleton, which is common in archaeological sites given the good preservation of dental tissue. Twenty-six crowns were recovered, representing five out of the eight incisors, all four canines and eight premolars, and nine out of the twelve molars. All the teeth were found isolated and many are chipped, fragmented, and missing roots. Traditional maximum diameter and cervical diameter measurements (Fitzgerald and Hillson 2008) were taken of the suitable teeth, as well as crown and root height. The teeth were also scored for various pathologies and defects including wear, caries, and enamel hypoplasias. Tooth wear was scored using the Smith (1984) and Scott (1979) systems for the anterior teeth and molars respectively, and caries were scored using both the Moore and Corbett (1971) and Hillson (2001) methods. Both wear and chronic dental caries are advanced in this individual, contributing to an estimation of middle age. The teeth are also affected by LEH, pit defects, and enamel opacities, which may have predisposed the individual towards caries attack. Finally, a periapical cemental dysplasia is associated with the lower left fourth premolar.

Aside from the dentition, the skeleton possesses other interesting potential pathologies. A bony growth of the right petrous pyramid probably represents an osteoma or exostosis, but could also be the remnant of a tumourous condition. The right pterygoid process of the sphenoid is missing, which could be due to infection of the pterygopalatine fossa, a benign or malignant tumour, or trauma to the face. In particular, all three types of Le Fort fractures separate the pterygoid process from the body of the sphenoid. Such trauma is well documented in modern clinical literature and is a plausible explanation for this damage in an individual practicing a hunter-gatherer lifestyle. Facial trauma could have also caused asymmetry between the ascending rami, in which the condyle shape and mandibular notch depth are noticeably different. This could also be naturally occurring or the result of taphonomic alteration. Finally, the distal end of a manal phalanx is remodeled where it should have joined with the phalanx shaft, suggesting it is part of a nonunion fracture. However, the remainder of the bone was not recovered to verify such a condition.

With the exception of the nonunion fracture and possible complications from facial trauma, these pathologies were likely asymptomatic in life.

Furthermore, aside from the bony growth on the petrous pyramid, these potential pathologies are indicated by bone loss that may actually result from taphonomic processes. In addition to being highly fragmented, the bone surfaces of the fragments are weathered which makes it difficult to observe biological changes. The differential diagnoses provided for each of these observations are only possibilities and cannot be confirmed given the present state of the skeleton. Regardless, what can be observed provides intriguing clues about the health of this individual.

As is common in archaeological research, the damage to this skeleton reduces the information that can be gleaned from it. Furthermore, taphonomic processes may have distorted the observations and measurements that were completed. Nevertheless, the osteobiographical information available provides insight into this individual’s age, sex, size, and health. Given the dearth of comparative skeletons from sub-Saharan Africa during the Late Pleistocene, this information is still an important source of comparison for existing and future research. Ultimately, this case allows us to contemplate a people and a time period about which we know relatively little.

Chapter 6: The B-2, B-3, and B-4 Skeleton Osteobiographies

The minimum number of individuals at this site is four. The B-2 and B-4 individuals present in the B-1 burial were only discovered during subsequent skeletal analysis. The B-3 skeleton was discovered during the 2010 excavation, and then additional elements were found at the National Museum and House of Culture, Tanzania. Compared to B-1, the remaining skeletons from the Mlambalasi site are far less complete. Two of the individuals, B-2 and B-4, are represented by a single skeletal element. The B-3 skeleton is comprised of 66 identifiable pieces, but they only represent the cranial vault and upper body. There are also several fragments that were recovered from the backfill of test pit 1 that may belong to any of the four skeletons in this sample, or to still unexcavated remains. Additional skeletal elements of one or more of these individuals will likely be recovered during upcoming excavations in the rock shelter. Based on the present level of recovery, however, little can be said about these people. As with the B-1 skeleton, common osteometric methods could not be applied given the absence of complete skulls, pelves, and long bones. This chapter presents the available osteobiographical information on these incomplete sets of remains.

6.1 B-2 Osteobiography

B-2 consists of a partial juvenile manubrium, which represents approximately 75% of the complete bone (Figure 6.1). It was excavated with the lower body of the B-1 individual in 2006, although no further juvenile remains were discovered in that excavation or in 2010. It is clear that this element does not belong to the adult. The bone surface is characteristically porous indicating it is juvenile. It is also too small to be adult, even though the size of B-1 makes other elements, such as the ribs and fibulae, appear child-sized when they are fully matured. Finally, two manubrium fragments, a left and right clavicular notch, were recovered with B-1 in 2010 that overlap with the juvenile fragment and confirm it belongs to a separate individual. Otherwise, the colouration, preservation, and surface weathering of the B-2 bone compares to the B-1 and B-4 individuals with which it was found. This may indicate that the skeletons were interred at the same time, and their context constitutes a triple burial. It could also be broadly indicative of environmental conditions in the rock shelter.

Unfortunately, the manubrium has little utility in osteological research. The fragment is not indicative of the sex of the individual, nor does it show any markers of health or identifying features. It is also of limited use in age estimation. In humans, the manubrium is attached to the sternal body via the manubriosternal joint, a secondary cartilaginous joint consisting of a fibrocartilaginous disc between plates of hyaline cartilage. The disc never ossifies, allowing the joint to remain open and flexible into late adulthood (Scheuer and Black 2004: 235). As the manubrium does not typically fuse to the sternum, closure at this point cannot be used as an indicator of age. The only true epiphyses on this bone, the suprasternal flakes located on the anterior and superior margins, are not visible on the specimen due to poor preservation. Even if they were, the sternum is not recommended for age estimation due to the considerable variation in the timing and appearance of the centres of fusion (Scheuer and Black 2004).

When compared to the University of Alberta reference collection, the fragment is roughly consistent with an older child, around 8-10 years. However, the sample size is too small to account for the potential effects of variation in the Mlambalasi population. Consequently, it can only be said that this element belongs to a juvenile individual, the remainder of whom was either not preserved or is yet unrecovered.

6.2 B-4 Osteobiography

B-4 consists of the fused alveolar processes of right and left adult maxillae, representing less than a quarter of the complete bones (Figure 6.2). The fragment encompasses the maxillary alveolar processes from the eroded alveolar margin to the anterior nasal spine, and from the right lateral incisor to approximately the left canine. The right lateral incisor is present in the alveolus, although a gross gross carious lesion eliminated the total crown surface, leaving only the root. The alveolus for the right central incisor is also present, which suggests the tooth was lost postmortem. The left anterior alveoli are partially present, but the thinness of the surrounding bone suggests that the teeth were lost antemortem and the bone had remodeled. This is corroborated by other indicators of dental disease in this fragment, namely the large lesion above the right incisors.

This fragment was originally assumed to be part of the B-1 skeleton, since it was found *in situ* with that cranium. Furthermore, the same portion of the alveolar process and the right lateral incisor are missing from the B-1 skeleton, so this fragment appeared to fit with the recovered material.

Figure 6.1: B-2 fragment of a juvenile manubrium

Figure 6.2: B-4 fragment of fused adult maxillae with associated lesion

However, the right central incisor recovered from B-1 did not fit into the corresponding alveolus. Additionally, although there is a gross carious lesion on that incisor, the presence of secondary dentine suggests it did not penetrate the pulp cavity or cause pulpitis. Furthermore, the root tip is intact and bears no indication of infection. This is inconsistent with the major lesion in close proximity. Between the B-1 dentition and this fragment, the latter is more likely to be intrusive. The B-1 teeth were found *in situ* with the rest of the skull, whereas the maxillae were recovered from the cranium *en bloc* package in the laboratory.

Isolated maxillae fragments cannot be used in sex estimation, but some researchers have attempted to estimate age based on maxillary suture obliteration (Mann et al. 1987, 1991). Unfortunately, the only suture preserved on this fragment is the anterior intermaxillary suture, which ceases to grow during early childhood between the ages of 1 and 2 (Latham 1971). From that point on, the suture remodels with growth of the alveolar process but remains visible, unlike those on the roof of the mouth that gradually disappear (Scheuer and Black 2004).

The single preserved tooth in this fragment is therefore the best indicator of age. The tooth is a permanent maxillary lateral incisor, which emerges around 7.3 years in males and 7.0 years in females (Haavikko 1970; Scheuer and Black 2004). However, the extensive caries development in this tooth indicates it has been erupted for some time. Furthermore, in the normal progression of dental caries, the approximal surfaces and lingual pits of the upper incisors are the penultimate place where disease attacks (Hillson 2005: 297). It is likely that this fragment is from an adult who suffered from caries for some time. Finally, the alveolar bone of the maxillae is very smooth and thin, a feature of increasing age (Mann et al. 1987). Based on the single element recovered, this individual was an adult of undetermined sex.

Although information on age and sex is sparse, the fragment exhibits an interesting pathological condition that would have affected the individual's life. There is an inflammatory lesion above the right central incisor, measuring 8.57 mm horizontally and 12.55 mm vertically on the lingual aspect of the bone, with a 5.65 mm by 4.65 mm sinus on the labial surface. The lingual cavity is eroded and may have been expanded postmortem, but the edges of the sinus are smooth and unbroken. The root of the remaining tooth, the grossly carious right lateral incisor, is visible on the lingual aspect. The proximity of the alveolus for the right central incisor suggests that multiple teeth were affected.

Such lesions are usually classified as periapical abscesses in the archaeological literature, although this blanket term is imprecise since the condition arises from different etiologies (Dias et al. 2007). Abscesses are caused by infections, which in this case was probably pulpitis following carious lesion or trauma (Ortner and Putschar 1985; Hillson 1986, 1996, 2000, 2001, 2005, 2008; Dias et al. 2007). The infection restricts blood supply as it progresses toward the apex, effectively killing the tooth and allowing bacteria and their toxins to enter the jaw through the apical foramen. The resulting periapical inflammation can be either acute (rapid developing) or chronic (slow developing), and many cases alternate between the two stages (Hillson 2005, 2008). In acute cases, pus rapidly accumulates causing swelling and pain until it is drained via a channel to the surface. The channel usually appears on the buccal bone surface (Hillson 2001). Chronic cases exhibit more bone loss due to remodeling around the lesion, but are often painless and the tooth is not necessarily exfoliated. Chronic cases also produce sinuses on the buccal or lingual surfaces of the mandible or maxillae, inside the nose, or into the soft tissues of the cheek or chin (Hillson 2005).

All abscesses are defined by the presence of pus, which is impossible to observe in dry bone. Consequently, many of the periapical abscesses described in the archaeological literature are more likely granulomata or cysts (Hillson 2005; Dias et al. 2007). These benign lesions also usually develop around tooth apices due to inflammation, but are not caused by the accumulation of pus. Instead, tumour-like masses of granulation tissue form around the opening of the offending tooth to curtail the infection. At the granuloma stage, the condition will resolve if the source of the infection is eliminated, i.e., the tooth is lost or extracted. If the irritation continues, epithelial cells line the lesion to produce a periodontal cyst that persists even after the tooth is gone.

G.J. Dias and colleagues (2007) differentiate between these conditions based on size: periapical granulomas measure less than 3mm at their maximum intra-bony diameter, while periodontal cysts are anything larger. Large cysts cause the surrounding bone to remodel in order to incorporate the mass, which can cause thinning or “eggshell cracking” of the overlying bone and mimic a pus sinus in fragile archaeological specimens (Hillson 2005). However, abscesses can usually still be distinguished from other periodontal masses based on the cavity; granulomata and cysts have smooth walls, whereas those caused by pus are rough.

It is not possible to conclusively diagnose this condition based on the preservation of the B-4 remains. The size of the lesion suggests this is a case of periodontal cyst as opposed to a milder granuloma. However, the roughened walls and presence of a sinus indicate a true periapical abscess, although the bone surface is weathered and difficult to observe. Both diagnoses may be accurate, since abscesses often form from pre-existing granulomas and cysts (Hillson 2001). Periodontal cysts are well known in archaeological populations. Today, they are also found in approximately 0.8% of people, and 5.2% of grossly carious teeth (Hillson 2001; Dias et al. 2007: 620). They typically occur in the maxillae of individuals between 20-60 years old and are often virtually symptomless. However, complications such as meningitis and hematogenous osteomyelitis may result from the spread of the infection (Dias et al. 2007; Ortner and Putschar 1985: 439). It is quite plausible that this individual suffered from both chronic and acute effects of a periodontal cyst and associated periapical abscess, and that infection in that area and other locations in the mouth caused antemortem loss of teeth.

As with B-2, the osteobiographical information derived from B-4 is limited by the lack of skeletal remains. Based on the recovery of a single element, this individual represents an adult of indeterminate sex that suffered from dental disease as indicated by a gross gross carious lesion and a periodontal infection. It is not apparent whether these conditions were symptomatic, or if they contributed to the death of the individual. Further recovery of skeletal elements associated with this individual would enrich its osteobiographical potential.

6.3 B-3 Osteobiography

Compared to the previous two skeletons, considerably more of the B-3 skeleton was recovered. Seventy fragments from this individual were excavated during the 2002 and 2010 field seasons, with 66 fragments identifiable to a specific bone. However, the recovered elements still only represent the cranium, partial thorax, and upper limbs of this individual. Within those structures, large elements are missing including the facial skeleton and the upper arm bones. Consequently, it presents the same challenges to osteobiographical reconstruction.

Based on the available evidence, this individual was an adult of indeterminate age at the time of death. The proximal and distal radii are fully fused, which occurs during adolescence between 11.5-20 years in both males and females (Scheuer and Black 2004: 283). The left mandibular corpus is preserved from the mental spine to the second molar, with what appears to be a diastema between the premolars (Figure 6.3). There are adult-size empty alveoli for the incisors, the canine, and the third premolar, and broken-off tooth roots for the fourth premolar and first molar. Although the corpus and ascending ramus do not refit, it looks as though there are spaces for erupted second and third molars on either side of the break. This would place the age of this skeleton above 21 years. No complete teeth are present to gauge dental wear and caries development, and there are no other signs of advanced age on the skeletal elements. Therefore, refining the age range beyond adult is impossible.

This individual's cranium is highly fragmented and the pelvis was not recovered, eliminating many potential sex estimation methods. However, the left ascending ramus can be used for osteometric sexing (Tables 6.1, 6.2). Both osteoscopic and osteometric evaluation strongly suggest this individual is female. However, such assessments are fairly weak when based on an isolated skeletal element. Furthermore, the utility of the mandible in sex estimation has been questioned because the bone remodels under environmental pressure (Meindl et al. 1985). Therefore, the feminine appearance of this bone may be due to a dental or pathological condition, as opposed to sexual dimorphism.

Compared to the other skeletons in the rock shelter, this individual appears notably more robust (Figure 6.4). Robusticity bears on sex estimation since males are usually considered larger and more muscular than females. However, the small sample size of this population, along the potential chronological disparity of the skeletons, limits such conclusions. It is generally believed that Iron Age skeletons are larger than LSA skeletons because the Iron Age in many parts of sub-Saharan Africa is associated with the Bantu migration and the spread of stereotypical “black Africans.” Bantu-speaking groups dispersed from modern-day Cameroon to occupy most of the subcontinent beginning around 4,000 years ago (Phillipson 1976; Huffman 1982; Vansina 1984, 1995; Ehret 2001; Schoenbrun 2001). In contrast to the incumbent LSA populations, these migrants were farmers or cattle pastoralists, as well as ironworkers.

Figure 6.3: B-3 left mandibular corpus and ascending ramus

Figure 6.4: B-3 right trapezium (left) and B-1 left trapezium (right), showing size difference

Measurement (mm)	**Left ascending ramus**
Maximum ramus breadth (RB_{max})	-
Minimum ramus breadth (RB_{min})	28.24
Condylar height / maximum ramus height (CNH)	57.15
Projective height (PH)	45.28
Coronoid height (CRH)	-

Table 6.1: B-3 metric measurements of the ascending ramus (according to Saini et al. 2011)

Skeletal Element Used	**Equation**	**Result**	**Interpretation**
Left ascending ramus	Function 5: Sex = (0.190)CNH – 11.309	-0.451	Female
	Function 6: Sex = (0.153)PH – 8.048	-1.120	Female
	Function 8: Sex = (0.355)RB_{min} – 10.999	-0.974	Female

RB_{min} = Minimum ramus breadth
CNH = Condylar height
PH = Projective height

Table 6.2: B-3 ascending ramus sex estimates (Saini et al. 2011)

Although the theory of the Bantu migration is largely based on linguistic and archaeological evidence, this transition is also defined by changes in the associated skeletons. The archaeological shift from the LSA to Iron Age in many parts of eastern and southern Africa is accompanied by the replacement of gracile, “bushman” skeletal remains with larger, “negroid” ones (Huffman 1982: 138). However, many aspects of the Bantu migration theory are still heavily contested, partly due to the dearth of archaeological skeletal remains from the LSA and Early Iron Age (Bräuer 1976). Regardless, in studies comparing LSA and Iron Age skeletal samples, the latter groups is almost always larger and more robust (Bräuer 1976; Harrington and Pfeiffer 2008). This also appears to be the pattern at the Mlambalasi site, and may account for the increased size and robusticity of the B-3 remains in relation to the rest of the skeletons. There are very few sites possessing both LSA and Iron Age remains, which renders the Mlambalasi site attractive for further research on this topic.

Assessment of the recovered skeletal remains suggests this individual was an adult female of indeterminate age. There are no indications of pathological change aside from pseudopathologies caused by taphonomic damage, as discussed in the next chapter. The bones are also weathered and fragmented, although less so than the other remains, which is another indication of lesser antiquity. Since the lower half of this skeleton is completely absent aside from a few foot bones, further excavation of the rock shelter may yield the remaining portion of the burial.

6.4 Bones of Uncertain Affiliation

Given the complicated, commingled context of the B-1, B-2 and B-4 remains, the affiliations of some elements remain uncertain. In particular, bones recovered from unit J-11, which encompassed test pit 1 in 2006 and was then backfilled, are difficult to attribute to a specific skeleton due to a lack of context. These include: 2 cranial fragments, a partial molar, a vertebral spinous process, one proximal and one intermediate manal phalanx, and a proximal pedal phalanx (Table 6.3). The bones are all very small and were found in isolation. This could have enhanced their mobility in the fine, shifting sediments of the test pit. These remains may represent more of the poorly known B-2, B-3, and B-4 individuals, or could belong to additional persons interred in the rock shelter. Another bone from the J-11 unit, an intermediate pedal phalanx (2010.56) can be confidently assigned to B-1. Outside of the test pit area, it was possible to attribute fragments to specific skeletons based on context and clear visual affinity.

The cranial fragments (2010.34, Figure 6.5) and intermediate manal phalanx (2010.63, Figure 6.6) likely belong to the B-3 individual, despite being found with B-1. Both are a darker colour and more robust than the other B-1 elements, but are consistent with those affiliated with B-3. These bones were both found in or near the former test pit 1. Since cranial fragments and phalanges from B-3 were recovered two meters away on the ground surface in 2010, those deposits could have been accidentally incorporated during backfilling. However, the bones could also come from B-1, since they were found in the same place as the 2006 remains.

Bone Description	Catalogue Number	Provenience	Comments	Figure	Probable affiliation
Cranial fragments (2)	2010.34	J-11 Feature 2 Level 7	- cranial tables are not delaminated like the B-1 fragments - darker colouration & thicker than B-1 vault - similar thickness to B-3 cranial fragments	6.5	B-3
Intermediate manal phalanx	2010.63	J-11 Level 4 NE	- darker colouration than B-1 bones - consistent in size, shape, and colour with B-3 intermediate manal phalanges (2002.24)	6.6	B-3
Vertebral spinous process	2010.49	J-11 Feature 2 Level 4	- darker colouration than B-1 bones - consistent in size and shape with B-3 spinous process (2010.65), but no comparable elements from B-1 aside from cervical vertebrae	6.7	B-1 or B-3
Proximal manal phalanx, possible non-union fracture	2010.66	J-11 Feature 2 Level 7	- darker colouration, consistent with B-3 - similar colouration to intermediate manal phalanx (2010.63) of similar unknown affiliation - consistent in size with both B-3 and B-1 proximal manal phalanges, impossible to determine to which it belongs	6.8	B-1 or B-3
Proximal pedal phalanx, M1/3	2010.64	J-11 Level 4 NE	- very small shaft of a proximal pedal phalanx - light coloured, consistent with the rest of B-1 - Both B-3 and B-2 proximal pedal phalanges are larger – could be smallest digit of B-1 or another small individual	6.9	B-1?
Partial molar crown and root (refit)	2010.9.86	B-1 provenience 9: 105 N, 118 E and 23.8 cm b.d.	- likely a first or second mandibular molar - wear on crown is less than on the B-1 third molars, therefore inconsistent with the rest of the B-1 dentition	6.10	?

Table 6.3: Bones of uncertain affiliation

Figure 6.5: B-1 (left) and B-3 (right) cranial fragments, with unknown fragments centre

Figure 6.6: B-1 (left 5) and B-3 (right 3) intermediate manal phalanges, with unknown fragment in the centre

Figure 6.7: Unknown vertebral spinous process (left) and B-3 spinous process (right)

Figure 6.8: B-1 (left 2) and B-3 (right) proximal manal phalanges, with unknown fragment in the centre

Figure 6.9: B-1 (left 3) and B-3 (right) proximal pedal phalanges, with unknown fragment in the centre

Figure 6.10: B-1 third molars (in anatomical position) with unknown molar in the centre

If so, the darker colouration may result from subsequent sediment mixing and other post-excavation taphonomic processes. Small bones, particularly the intermediate manal phalanx, could have been missed during the 2006 excavation and recovered four years later from the backfill. A third possibility is that the fragments come from an individual other than B-1 and B-3, and the test pit caused artifacts and their matrix to shift into the disturbed cavity. The bones are adult sized and therefore not from the juvenile, but they could be from B-4 or another individual that has yet to be discovered. Considering only the known individuals from this sample, the cranial fragments and finger bone most closely resemble B-3 and are likely intrusive elements from backfilling.

A spinous process, most likely from a lumbar vertebra (2010.49, Figure 6.7), and a broken proximal manal phalanx (2010.66, Figure 6.8) could equally derive from B-1 or B-3. The spinous process is approximately the same size and shape as one from B-3, although the colouration is slightly lighter. However, there are no comparable bones from the B-1 sample, which along with the small size of the fragment, limits possible comparisons. The distal end of the proximal manal phalanx (discussed in the previous chapter due to its possible fracture) is similarly neutral. It is consistent in size and shape with others from the B-1 sample, but there are no unbroken comparables from B-3. The bone is also noticeably stained, which makes it difficult to attribute to either individual. No further conclusions can be drawn from these specimens.

A proximal pedal phalanx shaft likely belongs to B-1, but cannot be confidently attributed due to its small fragmentary size (2010.64, Figure 6.9). It is smaller than both the B-1 and B-3 proximal pedal phalanges, but that may be because the smaller digits were not recovered. The ends are absent so it is difficult to determine if this element is juvenile. If so, it may also represent another part of the B-2 skeleton. However, given that the B-1 individual is small and lightly built, it could just as easily represent an adult fourth or fifth toe.

Two refit fragments of a permanent molar were found with the B-1 cranium but are inconsistent with the rest of the teeth (2010.9.86, Figure 6.10). The B-1 skeleton is missing a mandibular first molar and both second molars. The tooth in question appears to be one of these based on mesial and distal wear facets, the wear gradient, and root morphology. However, the degree of wear on the crown is less than on the B-1 third molars. Since all the B-1 maxillary molars are present, it is not possible that this tooth could belong to the same dentition without demonstrating more wear.

There are no indications of pathology other than a white diffuse boundary opacity present on the mesial aspect. The first molars emerge between 5 and 5.3 years and the second molars between 9.9 and 11.4 years (Haavikko 1970), so the tooth could still belong to either the nearby B-2 or the B-4 skeletons. Given the broken and isolated nature of the tooth, it is difficult to determine its affiliation aside from that it does not belong to the B-1 individual.

The context of the Mlambalasi remains is complicated due to the overlapping 2006 test pit and the B-1 feature, and the recovery of the skeletons over three field seasons. In all the cases stated here, the affiliation of the bone is unclear. I have provided my rationale for attributing these unknown remains to various individuals, but other researchers may wish to reassess them in the future. Further excavations of the rock shelter, particularly the unexcavated units in the vicinity of the B-1 burial, may also help establish their true provenance.

6.5 Conclusions

In addition to the B-1 individual, two other adults and a juvenile were recovered from the site. Within the B-1 context, there were two incongruous bones: the B-2 manubrium and the B-4 maxillae. Both were recovered with B-1 in the field, and later separated in a laboratory setting. The manubrium did not match the rest of the skeleton due to its juvenile size and appearance. It also overlapped with other manubrium fragments recovered in 2010. The B-4 maxillae did not overlap, but the fragment was inconsistent with the recovered dentition. It is more plausible that a single maxillae fragment intruded into an unrelated burial, as opposed to twenty-six isolated teeth. Consequently, this fragment represents a separate adult. The last skeleton, B-3, was recovered from a considerably lesser depth and on the other side of a large boulder, making it unlikely to have naturally commingled with B-1, B-2, and B-4. There are also several overlapping elements between B-1 and B-3, including the cranium, a clavicle, and the ulnae. Based on this evidence, the MNI of the site is four.

Compared to B-1, little osteobiographical information is available from these skeletons due to a paucity of recovered remains. Based on size alone, the B-2 individual is likely an older child of indeterminate sex. B-4 is an adult, also of indeterminate sex, that suffered from dental pathology including a gross gross carious lesion and potentially related infection. Despite the significantly greater number of bones attributed to B-3, the elements are still highly fragmentary and do not derive from structures that are useful for assessing sex and age. The most striking feature of this potentially female adult is a larger size and greater robusticity when compared to the other skeletons in the rock shelter. The larger skeleton comes from an Iron Age context, reproducing the pattern of increasing size from the LSA to Iron Age found at other sub-Saharan African sites. This shift may be associated with the expansion of Bantu-speaking peoples. There are also six fragments, most of them from a former test pit, which are of questionable affiliation and may belong to any of these skeletons or additional individuals. Based on the excavations to date, it is clear that at least four individuals are present in this rock shelter.

Chapter 7: Taphonomy and Diagenesis

The Mlambalasi skeletons were modified by a series of factors after their deposition, including burrowing animals and insects, moving water, gravity, sediment compaction, trampling, and human behaviour. Fragmentation and other postmortem changes remove information from bones, but they also add traces that can be misinterpreted as signs of disease or mortuary treatment. Consequently, it is important to identify these processes at archaeological sites. This chapter provides an overview of taphonomy and its particular relevance to caves and rock shelters. The gross preservation of the Mlambalasi remains is then discussed in terms of completeness, articulation, fragmentation, and weathering. Finally, pseudopathologies such as cranial vault delamination, non-pathological lesions, and dental staining and pitting are reviewed. Based on their condition, these individuals were likely buried after death and subsequently affected by biological, geological, and chemical processes. Identifying and understanding these processes mitigates their bias, permitting a more genuine interpretation of the skeletal sample.

7.1 Overview of Taphonomy

J.A. Efremov (1940: 85) first defined taphonomy as: “the study of the transition (in all its details) of animal remains from the biosphere into the lithosphere.” Although the discipline originated in paleontology, archaeologists were “pre-adapted” to thinking taphonomically by working with the incomplete archaeological record (Lyman 2010: 4). Taphonomic studies have since expanded to encompass artifacts and other aspects of archaeological sites.

The aim of taphonomic research on human and faunal remains is to identify post-depositional alterations in order to remove biases in understanding past human behaviours. Organisms exist in life in the biocoenose, become associated in death in the thanatocoenose, and are finally incorporated into archaeological sites in the taphocoenose (Micozzi 1991). Taphonomic studies seek to draw connections between these assemblages in order to understand the behaviour of the organisms in the life and how they relate to one another in death.

This is achieved by identifying taphonomic agents and the traces, or the marks or residues of past behaviours, that they leave on archaeological materials. Taphonomic agents originate from diverse biological, physical, chemical, and geological sources. They can effect change at multiple levels, sometimes affecting an entire region (Fernádez-López 2006). Information is both added and removed from bone, creating a complex network of traces from contemporary organisms, past environments, and physico-chemical processes over time (Fernández-López 2006; Perez 2006; Lyman 2010; Fernández-Jalvo et al. 2011).

Taphonomy is premised on two theoretical principles: uniformitarianism and equifinality. First of all, it is assumed that bone and other artifacts respond to various stresses uniformly over time. Consequently, biases identified from modern day experimentation and other archaeological sites can be applied to new data through the use of analogy (Gifford-Gonzalez 1991). Secondly, although certain traces can be ascribed to a particular agent, the state of a bone is usually the result of many factors acting together or successively (Fernández-Jalvo et al. 2011). Longer-term processes such as chemical and physical diagenesis may also overprint earlier modifications like microbial attack (Smith et al. 2006). It is consequently difficult to identify the precise trajectory the material took from deposition to recovery. Equifinality is a concept borrowed from system theory that refers to “reaching the same final state from different initial states in an open system, one capable of exchanging materials with its environment” (Ludwig von Bertalanffy in Lyman 2004: 15). In archaeology, equifinality is used to characterize instances where a particular pattern cannot be definitively attributed to one taphonomic process or processes (Gifford-Gonzalez 1991; Behrensmeyer et al. 2000; Enloe 2004; Lyman 2004). It is necessary to acknowledge the effects of “noise” in the archaeological record, particularly when dealing with complex scenarios like mortuary ritual (Harrold 1980).

Taphonomy is divided into two phases: biostratinomy, the biological processes that occur between death and burial, and diagenesis, the geological and chemical processes that operate between final burial and discovery (Lyman 2010). Biostratinomy involves a host of intrinsic and extrinsic factors that affect the deposition of bone. Intrinsic factors such as body size, element, side, sex, and especially density impact the survivability of a bone (Lyman and Fox 1997; Enloe 2004; Lieverse et al. 2006). Extrinsic factors then amplify those effects by determining the burial environment. Faunal bones that have been defleshed, dismembered, and/or cooked prior to disposal follow a very different pattern of decomposition than human skeletons that are buried whole. At this point, the bones may also be affected by weathering. Weathering is “the process by which the original microscopic organic and inorganic components of a bone are separated from each other and destroyed by physical and chemical agents operating on a bone in situ, either on the surface or within the soil zone” (Behrensmeyer 1978: 153). The biostratinomy stage includes early decomposition and skeletonization of the remains, including autolysis and putrefaction, which results in the net loss of organic material.

Whereas biological change prevails in biostratinomy, physical and chemical processes dominate diagenesis. In life, bone is about 75-80% inorganic and 20-25% organic, and assumes the form of hydroxyapatite crystals bundled in collagen fibers. This combination of organic tensile and inorganic rigid strength is what allows a bone to function, and leads to its comparatively good preservation in archaeological sites. However, as collagen is degraded by microbial attack or leached into the soil, the inorganic remnants of the bone become more brittle and friable, exacerbating fragmentation due to trampling and soil compaction (Chaplin 1971; White and Hannus 1983; Holmes et al. 2005). Dual processes of dissolution and recrystallization then start to break down the inorganic hydroxyapatite component. This breakdown of bone is initiated and sustained by interaction with water, although soil chemistry and other environmental attributes play an integral role (Gordon and Buikstra 1981; White and Hannus 1983; Hedges and Millard 1995; Douglas Price et al. 1992; Karkanas et al. 2000; Nielsen-Marsh and Hedges 2000; Nielsen-Marsh et al. 2006; Hedges 2002).

Taphonomists record the general environmental characteristics of archaeological sites to the minute chemical attributes of fragments in an effort to recreate the sequence of events from an organism's death to discovery. If the pattern of biases is well understood, it is possible to separate them from the underlying evidence of past human behaviour. Some environments are more taphonomically active than others. This is why bone may survive for decades in some contexts and millions of years in others. Fossilization is an emergent property in bone as opposed to an aggregate trait. It may occur over varying time scales and due to different intrinsic and extrinsic properties (Fernádez-López 2006: 115). Due to the complex interaction of biological, chemical, and physical factors involved, it is usually impossible to pinpoint the exact causes of taphonomic alteration. Consequently, it is important to acknowledge equifinality at the core of all taphonomic studies.

5.2 Cave and Rock Shelter Environments

Taphonomy is particularly germane to studies of caves and rock shelters due to their culturally and geologically specialized niche. They represent identifiable markers on the landscape that repeatedly attract archaeological assemblage-producing humans and animals, sometimes over the course of millennia. Secondarily, they act as natural containers for accumulated deposits through rapid sedimentation, protection from surface erosion and weathering, self-sealing roof falls and other collapses, and more stable interior microclimates (Colcutt 1979; Straus 1979; Farrand 1985; Barker et al. 2005; Lundelius 2006).

This combination of attraction and preservation, in conjunction with the fragility and archaeological invisibility of many open-air sites, renders caves and rock shelters the major source of data on the Stone Age in Eurasia and Africa. In fact, the link between caves and the Stone Age is entrenched in popular culture through the term “cave man,” which is variably applied to all species and populations prior to agriculturalist modern humans.

There are a few problems with the conceptual link between palaeoanthropological research and caves and rock shelters. Most significantly, they are considered by some to be the only stratified, reliable records of the Stone Age to the extent where open air sites have been interpreted as the contents of hypothetical destroyed rock shelters (Glover 1979: 302). However, the notion that “caves are valuable as *relatively stable containers* of stratified deposits” (Glover 1979: 304, emphasis original) has been challenged by studies of sinkholes and other phenomena operating in such environments. A suite of post-depositional taphonomic agents affect these deposits, including human activity and trampling, cryoturbation and percolating water, gullying and sinkholes, and burrowing animals (Straus 1979: 334). The search for living floors, a staple in archaeological excavations, may not be possible at some sites due to the layering of cultural deposits in palimpsests.

Some researchers have called for an individualized approach to studying caves and rock shelters. Each site should be interpreted without drawing conclusions from other cave and rock shelter sites, even those in close proximity (Farrand 1985; Barker et al. 2005). Regional sequences and culture histories are based on these deposits in many parts of Europe and Africa, but research is rarely standardized regarding geological methods and analysis (Colcutt 1979; Glover 1979). Some older sites have been re-examined for the effects of erosion, slumping, and warping on occupation deposits, but those from the terminal Pleistocene and Holocene have received little attention (Glover 1979: 314). Caves and rock shelters continue to yield some of the longest and most complete archaeological records and preserve organic materials such as bone (Lundelius 2006). Consequently, there is a need for additional taphonomic research on these sites, in order to separate post-depositional biases from the archaeological interpretation.

It is necessary to understand rock shelters and the particular taphonomic processes affecting them in order to assess the Mlambalasi remains. The bones have been altered by a variety of post-depositional agents, influencing the osteobiographical data and larger site interpretation. No taphonomic research has been conducted at Mlambalasi aside from on a sample of faunal remains (Collins 2009). However, sediment samples and human and faunal remains are available for future study. Research on the chemical and histological diagenetic parameters of the human bone may be particularly useful for investigating antiquity, mortuary practices, and site formation. Studying the taphonomic context of this skeletal sample will not only improve the clarity of existing data, but also permit comparison with other rock shelter and cave sites from this region and time period.

7.3 Preservation of the Mlambalasi Remains

The Mlambalasi remains were assessed for articulation in the burial environment, completeness, fragmentation, and stage of weathering. The B-1 and B-4 individuals demonstrate approximately the same level of taphonomic destruction, likely because they were found buried together. The B-2 individual was also part of this burial, but exhibits a slightly different pattern of destruction, perhaps because it is juvenile. The B-3 individual from an Iron Age context is generally better preserved, which is consistent with later deposition. The skeletons were assessed separately for each aspect of post-depositional alteration. The data are presented in Tables 7.1, 7.2, and 7.3.

Articulation refers to the location and orientation of adjacent bone elements with respect to their anatomical relationship in the living body. As such, the articulation of a skeleton can only be assessed *in situ* after it is exposed but before removal from the burial environment. A skeleton is considered articulated when elements are in a position that would have been achievable if the body were still fleshed (Lieverse et al. 2006). Following the protocol defined by A.R. Lieverse and colleagues (2006), the entire element had to meet this criterion in order to be scored articulated. Missing or otherwise unobservable elements were not scored. No provenience information is available for the remains excavated in 2002 and 2006, and the B-2 and B-4 individuals cannot be scored based on a single element. Therefore, only the portion of the B-1 individual excavated in 2010 was assessed.

Element	Articulation	Completeness (average)[2*]	Approximate Number of Identifiable Fragments[*]	Combined weight of identifiable fragments (g)
Cranium	Yes	2.83	285	383.35
Mandible	No	2.5	6	42.99
Teeth	No	1.79	69	24.25
Atlas	Yes	2.5	2	4.5
Axis	Yes	2.5	2	3.36
Cervical vertebrae	Yes	2.35	16	46.18
Hyoid	-	2	1	0.36
Left scapula	No	3	4	8.22
Right scapula	No	3	4	21.56
Unsided scapula	No	3	9	8.25
Left clavicle	Yes	2	1	5.84
Right clavicle	Yes	3	10	4.37
Sternum	No	3	3	3.58
Thoracic vertebrae	No	2.89	11	10.6
Unidentified vertebrae	No	3	6	2.95
Ribs	No	2.97	146	80.62
Left humerus	Yes	3	12	37.31
Right humerus	Yes	2.67	12	36.13
Unsided humerus	No	3	4	3.82
Left radius	-	-	-	1.37

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[2] 1 = 75-100% complete, 2 = 25-75% complete, 3 = 0-25% complete, see Buikstra and Ubelaker 1994
[*] These variables were not scored where the bone fragments were refit using adhesive

Right radius	-	-	-	13.12
Unsided radius	No	3	4	15.68
Left ulna	-	-	-	8.13
Right ulna	-	-	-	19.41
Carpals	-	1.25	4	2.72
Metacarpals	-	1.25	9	20.31
Manal phalanges	-	1.58	27	21.19
Os coxae	-	2.91	16	24.1
Sacrum/coccyx	-	2.86	26	24.71
Left femur	-	-	-	34.99
Right femur	-	-	-	28.46
Unsided femur	-	-	-	16.22
Left tibia	-	-	-	28.07
Right tibia	-	-	-	37.23
Unsided tibia	-	-	-	29.28
Left fibula	-	-	-	2.88
Right fibula	-	-	-	4.13
Tarsals	-	2	3	4.72
Metatarsals	-	1.33	6	9.26
Pedal phalanges	-	1.08	6	3.95

Table 7.1: Articulation, average completeness, number of fragments, and weight of the identifiable B-1 elements

Element	Completeness (average)	Approximate Number of Identifiable Fragments	Combined weight of identifiable fragments (g)
Cranium	3	22	71.98
Mandible	2	2	23.1
Left Clavicle	2	1	4.48
Unidentified vertebrae	3	1	0.36
Ribs	3	4	4.97
Left radius	3	2	16.8
Right radius	3	3	11.59
Left ulna	3	2	8.37
Right ulna	3	3	10.43
Unsided ulna	3	1	3.22
Carpals	1	2	2.65
Metacarpals	2.6	5	6.09
Manal Phalanges	1.81	11	9.85
Tarsals	1	1	1.92
Pedal Phalanges	2	3	1.55

Table 7.2: Completeness, number of fragments, and weight of the identifiable B-3 elements

Skeleton	Element	Completeness	Weight of fragment (g)
B-2	Manubrium, juvenile	1	1.87
B-4	Maxillae, fused alveolar process	2	3.51

Table 7.3: Completeness and weight of the elements constituting B-2 and B-4

The cranial half of the B-1 skeleton (to the level of the mid-thorax) was recovered with the following elements in articulation: the cranium, atlas, axis, cervical vertebrae, left and right clavicle, and left and right humerus. The ribs and scapulae were highly fragmented, which could have caused displacement of small fragments out of articulation. The same processes likely affected naturally small elements such as the teeth. The majority of *in situ* skeletal elements were in articulation or near-articulation. This suggests the burial was not extensively disturbed following deposition.

Completeness was scored using the method in *Standards for Data Collection from Human Skeletal Remains* in which a “1” denotes 75-100% of the bone is complete, “2” is 25-75%, and “3” is 0-25% (Buikstra and Ubelaker 1994: 7). This system is not ideal. A.R. Lieverse et al. (2006) recommend estimating the percentage of each fragment with respect to the whole bone to the nearest five points, but the high degree of fragmentation rendered this impossible. For example, 146 rib fragments weighing a combined total of 80.62 grams were recovered from the B-1 skeleton. When working with fragments that average half a gram, distinguishing between 5% and 10% completeness is impractical. More precise completeness scores would also require some knowledge of the size of the complete bone. This was difficult to estimate given the small sample size and body proportions of the B-1 individual. Although less precise, the larger categories were more realistic for this collection.

The overwhelming majority of the B-1 elements were scored close to or less than 25% complete. Large, complex elements such as the cranium, ribs, pelvis and sacrum were the least complete. Small, dense bones such as the carpals, tarsals, metacarpals, metatarsals, and manal and pedal phalanges fared better. The teeth were also fairly well preserved, as is common at archaeological sites. The mandible, vertebrae, and clavicles were intermediate in their completeness. The long bones were generally less complete. However, the lower limbs were not assessed due to prior reconstructive work that involved refitting pieces with adhesive.

Although suspected to be much younger, the B-3 skeleton follows a similar pattern. The cranium, ribs, and long bones are the least complete, while the carpals, tarsals and manal phalanges are the most complete. The mandible, clavicle, metacarpals, and pedal phalanges fall in-between. Again, this is likely due to the density of the small elements.

The B-2 and B-4 examples present a unique problem in that they must be scored for completeness in the absence of any other elements from those individuals. Regardless, they both appear to be generally well preserved. When compared to a modern manubrium of an 8-10 year old, the B-2 fragment is more than 75% complete. The maxillary alveolar process of the B-4 adult is at least 25% complete when compared to modern adults. Greater completeness may explain why these isolated elements survived when the rest of the individuals did not. More likely, however, they belong to yet-unexcavated skeletons where the overall preservation and completeness is unknown.

Fragmentation is difficult to quantify in these skeletons. A.R. Lieverse and colleagues (2006) documented fragmentation as the number of fragments comprising each identifiable element, recorded during skeletal recovery to minimize the effects of post-excavation breakage. This was not possible for this collection since the elements were removed *en bloc*. Instead, both the number of fragments and their weight were recorded to approximate the same clarity of data (see Tables 7.2, 7.3). Lieverse et al. also calculated a fragmentation ratio by dividing the completeness percentage discussed earlier by the number of fragments. This is also inapplicable here due to the imprecision of the completeness rankings. It is apparent that the four skeletons from this rock shelter are extremely fragmentary, but quantifying this requires a more detailed taphonomic study.

What can be said about fragmentation involves the type of breakage exhibited. P. Villa and E. Mahieu (1990) studied patterns of human long bone fragmentation from three archaeological sites in southern France using fracture angle, outline, and edge, as well as shaft circumference, fragmentation, and length. All four skeletons at Mlambalasi exhibit right angle fractures, with predominantly curved and transverse outlines and jagged edges. This suggests the bones were not green or fresh at the time of destruction. However, most of the fracture edges are covered by carbonate concretions, making characterization difficult. Shaft circumference is more variable, with both complete and partial circumferences measured. The long bone shafts have been mostly reduced to elongate splinters, which is sometimes associated with weathering (Behrensmeyer 1978). The B-1 skeleton in particular follows the pattern of bones broken *in situ*. Fragments of the same bone were found adjacent to one another, if not in articulation, with incomplete fractures prolonged by fissure lines. This suggests the breakage occurred due to slow compaction acting on progressively weakened bones (Villa and Mahieu 1990: 29).

Finally, the amount of surface weathering was scored. A.K. Behrensmeyer's (1978) seminal method for recording weathering separates bone into stages 0-5 based on macroscopic appearance. Scores reflect the most advanced stage covering a patch more than 1 cm^2, with limb shafts and flat surfaces preferred (Behrensmeyer 1978: 152). Stage 0 refers to still-greasy bone with no cracking or flaking. Stage 5 is where the bone is falling apart *in situ*, may have lost its original shape, and is associated with large splinters (Behrensmeyer 1978). Although this method provides a useful rubric for describing weathering, it should be noted that it is based on surface weathering of various fauna. Therefore, application to human material in buried contexts must be done with caution.

The majority of the B-1 skeleton falls into stage 4. Most of the bone surfaces are coarsely fibrous and rough, and large and small splinters fell off when the elements were moved. For the most part, weathering penetrated the inner cavities and the cracks have splintered or rounded edges (Behrensmeyer 1978: 151). Some fragments are better or worse preserved based on their size, density, and element. The B-2 and B-4 bones exhibit a comparable amount of surface destruction and breakage. However, B-2 is also juvenile, and immature bones degrade differently than adult bone (Behrensmeyer 1978; Gordon and Buikstra 1981).

The B-3 skeleton differs significantly in its degree of weathering. The remains are best described by stage 2, where concentric thin layers of outmost bone show some flaking and cracking, particularly long thin flakes (Behrensmeyer 1978: 151). This reduced weathering may be due to different burial treatment, but it is more likely the result of lesser antiquity. Considering the skeleton was found in an Iron Age context 50 cm above the other individuals, it is likely the remains were not exposed to taphonomic forces for as long.

Following this overview of the destruction of the skeletal sample, it is now appropriate to discuss specific taphonomic traces and their potential agents. This is accomplished through description of the pseudopathologies, the majority of which are present on B-1. Additional traces may have been rendered unobservable by subsequent alteration, or complicating factors such as high fragmentation. Nevertheless, the evidence present permits speculation on the post-depositional factors at play.

7.4 Pseudopathologies

Pseudopathologies are taphonomic alterations that simulate certain pathological conditions, leading to errors in bioarchaeological interpretation (Perez 2006: 34). Since “there is almost no limit to the pseudopathology that freakish circumstances can produce,” taphonomy is highly relevant to palaeopathological research (Wells 1967: 14). The Mlambalasi skeletons, particularly the more complete B-1 and B-3 individuals, exhibit a host of pseudopathologies. These include fragmentation with cranial vault delamination, pseudopathological “lesions” on the cranium, ribs, and vertebrae, and pitting and staining of the teeth. These anomalies are discussed using the same differential diagnosis approach used for pathologies, with taphonomic agents substituted for known pathogens.

Some of the of cranial and postcranial fragmentation could be interpreted as the result of perimortem breaks from injury or interpersonal violence. Specifically, the separation of the internal and external tables of the cranial lamina in B-1 could be interpreted as cranial bone displacement, in which the cranial bones separate along suture lines rather than a fracture (Crist et al. 1997: 322). This type of trauma is common among child abuse victims due to the fragile nature of the unfused cranium and developing diplöe. However, cranial diplöe are a naturally weak point due to the presence of trabecular air cells containing hematopoietic red bone marrow in life. This structure is enclosed between the inner table, which is relatively thin and brittle, and the outer table, which is denser to protect the cranium from biomechanical forces (Crist et al. 1997). When the bone marrow decomposes after death, mechanical stress exerted on the cranium can cause the tables to delaminate, or separate into interior and exterior portions at the junction of the diplöe.

In their study of immature modern crania, T.A.J. Crist and colleagues (1997) found that solar exposure and fluctuations in ambient temperature and humidity could cause postmortem warping of the cranial bones including delamination. A juvenile cranium from the Tenth Street First African Baptist Church Cemetery (1810-1822) in Philadelphia exhibits a gap in the diplöic space caused by the outer tables of both parietals extending away from the internal tables. Additionally, the cranial bones separated along the suture lines due to mechanical stress. This damage was interpreted as a warping reaction to sunlight and heat (Crist et al. 1997). This is also a suitable explanation for the cranial fragmentation and delamination of the B-1 remains. However, the cranial fragments of B-3 are not delaminated although the skull was also broken apart. The difference may be due to the localized effects of heat. There is evidence of Iron Age smelting activity inside the rock shelter, including a hearth found 45 cm directly overtop the B-1 feature. Consequently, the B-1 remains may have been disproportionately exposed to temperature fluctuations. Advanced fragmentation may also be a function of a longer duration in the burial environment.

A series of holes are present on the cranium, ribs, and vertebrae of the B-1 skeleton and the cranium of the B-3 skeleton. In B-1, these appear as furrows that partially penetrate the surface and expose underlying trabecular bone (Figures 7.1-7.3). In the B-3 cranium, they are disjointed, irregular pits or holes originating on the interior surface that penetrate mostly or completely through the vault (Figure 7.4). Lytic lesions arise from a variety of causes, but the etiologies most appropriate for these locations are osteomyelitis and metastatic tumours. Osteomyelitis causes lytic lesions as a result of pyogenic bacterial infection of the bone following trauma, soft tissue infection, or remote sepsis (Ortner and Putschar 1985: 105-106). However, vertebral and cranial primary osteomyelitis are exceedingly rare. Metastatic tumours are common in carcinomas and the spine, ribs, and skull are all commonly affected. Metastasization of the skeleton most commonly occurs with prostate, breast, thyroid, and lung cancers, but there is no further evidence of such conditions (Ortner and Putschar 1985). The combination of lesion locations, as well as the presence of the holes on two skeletons from different time periods, renders a taphonomic explanation more plausible. Furthermore, similar holes transect a number giant land snail shells from the same deposits, suggesting burrowing activity by organisms at the site.

Osteophagous insects are the most likely cause of the pseudo-lesions. Four insect groups are known to damage bone: mayflies (Ephemeroptera, Polymitarcyidae), termites (Isoptera and numerous other families), moths (Lepidoptera, Tineidae), and beetles (Coleoptera, Dermestidae) (Britt et al. 2008: 65). B.B. Britt and colleagues (2008) documented grooves, pits, borings, and furrows on the spongy bone of a *Camptosaurus* skeleton that they attributed to dermestid beetles. The damage on the B-1 and B-3 skeletons is more likely due to termite activity. Termites are well known taphonomic agents at archaeological sites in sub-Saharan Africa, both for their effect on bone preservation and for changes to the textural, chemical, mineralogical, and stratigraphic properties of soil (Hay 1987; McBrearty 1990; Mercader et al. 2003). Termites consume fresh and weathered bone, leaving furrows and irregular patches of pockmarks and pits. They infest a carcass after other agents have consumed most of the muscles and tissue, with workers carrying out the tunneling (Britt et al. 2008: 65).

Figure 7.1: Possible termite furrowing on ribs from the B-1 skeleton

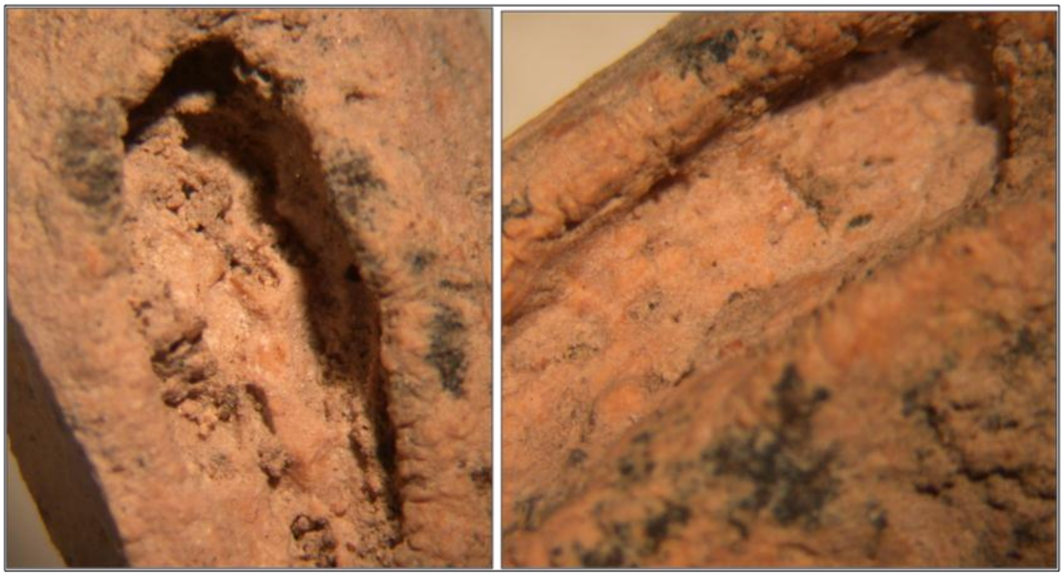

Figure 7.2: Possible termite furrowing on ribs from the B-1 skeleton at 2.5 times magnification

Figure 7.3: Possible termite furrowing on the interior of an occipital fragment from B-1

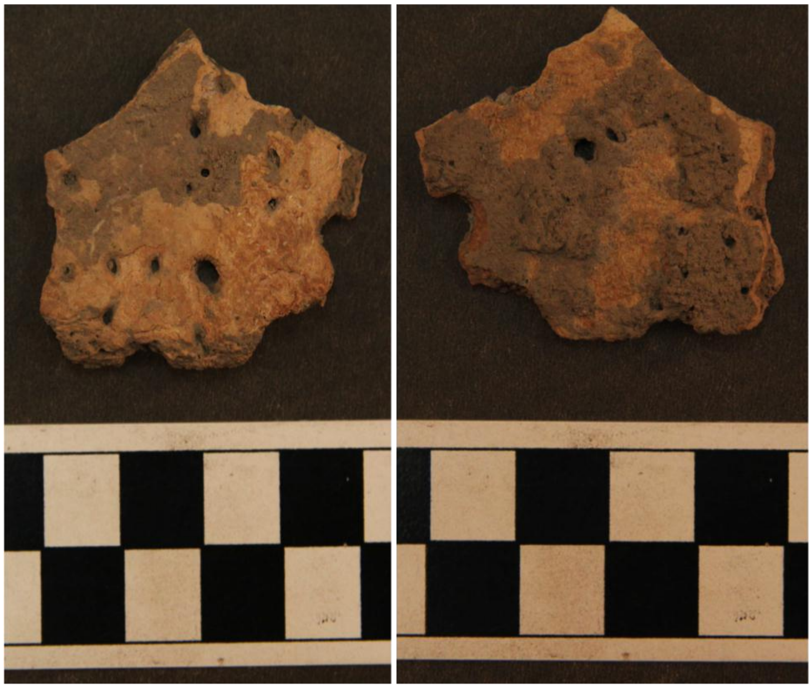

Figure 7.4: Possible termite pitting on the interior (left) and exterior (right) of a cranial fragment from B-3

It is impossible to distinguish termite traces from those of other insects without additional research. However, termite furrows on an archaeological skeleton from Peru appear strikingly similar to the damage on the Mlambalasi remains (Huchet et al. 2011: 95, figure 3). Furthermore, a termite nest was present in test pit 2 located just outside the rock shelter, establishing such activity in the vicinity. Other evidence for termite activity at the site includes fragments of compact or vesicular construction material, excavated foraging passages, and vertically dispersed artifacts (McBrearty 1990: 132). Based on this information, the pseudopathological lesions on the skeletons were most likely caused by osteophagous insects, and they were probably termites.

The other pseudopathologies in this collection are located on the B-1 dentition. When viewed under the microscope, many of the crowns exhibit small, black flecks on the surface. These could be dental calculus, which would have been present on at least some of the teeth given the degree of plaque-related dental disease. Calculus may have been dislodged in the rocky burial environment, or removed from the teeth during cleaning if adhered to the concretions. However, inspection prior to cleaning did not reveal any obvious signs of it.

The staining likely results from chemical or other taphonomic interactions in the burial environment. Bones in cave and rock shelter environments can become naturally coated with manganese oxides, which are transported by water percolating through cave sediments and deposited onto bone surfaces (López-González et al. 2006). However, this kind of staining is more common in calcareous environments, whereas the Mlambalasi rock shelter is granite. It also tends to be more widespread than isolated flecks. Other materials known to produce black traces on bone include: carbonaceous material such as soot, humate, tar, coal-derived organic material, and surface vegetarian-derived material; fungi; bacteria; and bat and rat guano (López-González et al. 2006; Stoetzel et al. 2011). Considering the limited extent of the discolouration, it may have even begun post-excavation in the laboratory setting. Regardless, the isolated black stains are inconsistent with dental calculus or any other known pathology and are probably taphonomic.

Several of the molars and premolars, particularly the left mandibular and maxillary third molars, are heavily pitted with associated white and cream discolourations. The lesions superficially resemble fluorosis, in which hypoplastic pitting and opaque white patches in the enamel develop from drinking high fluoride content water over an extended period of time (Ortner and Putschar 1985; Hillson 1986, 1996, 2001). Fluoride ions become incorporated into apatite crystals creating abnormalities in the dental enamel, particularly in the secondary dentition that forms during childhood. In severe cases, the postcranial bones are mechanically weakened causing pathological fracturing (Ortner and Putschar 1985: 289). Fluorosis can also have positive effects on an individual's health, such as protection against dental caries. Adding low levels of fluoride to drinking water is a common practice in North America for this reason.

Fluorosis is extremely difficult to diagnosis in archaeological skeletal material because other diagenetic processes can cause chipping and discolourations. Furthermore, it cannot be chemically determined because bones and teeth continue to absorb fluoride after burial (Hillson 1996, 2001). Consequently, known incidences of fluorosis in antiquity are rare. In order to establish a case, dental anthropologists recommend evaluating the present-day geology and fluoride content of the drinking water around the archaeological site (Hillson 2001: 267). Tanzania is well known for naturally fluoridated water and is the focus of many present-day studies on fluorosis (Kilham and Hecky 1973; Nanyaro et al. 1984; Yoder et al. 1998; Vuhahula et al. 2009). However, most of the studies concentrate on the Great Rift Valley instead of the Southern Highlands. Additionally, fluorosis in this area is impacted by modern dietary practices such as the consumption of *magadi*, a trona or salt often used as a food tenderizer and to speed up cooking time (Yoder et al. 1998; Vuhahula et al. 2009). It is therefore difficult to use these studies to determine whether the B-1 individual exhibits fluorosis.

It is more likely that the pits and white mottling on the dentition are the result of taphonomic damage. When viewed under the microscope, many of the tooth crowns exhibit rough, uneven pitting that likely occurred in the rocky burial environment. These pits and chips differ from the smooth, glossy deformations and opacities I scored as enamel hypoplasias and the smoothed small chips that likely occurred antemortem. Additionally, several of the tooth crowns including the left upper third premolar and the two upper first molars were fractured postmortem. The breaks follow structural patterns of weakness: along the buccolingual axis in the premolar, and into quadrants for the molars (Hillson 2001: 267). All of the molar and upper premolar crowns are also separated from their roots. Given the rocky, dry nature of the burial environment, it is reasonable to see a range of taphonomic chips and fractures on the dentition.

Pathologies and pseudopathologies are both difficult to determine in archaeological bone. Even when all other etiologies are eliminated in palaeopathology, the researcher still lacks the decisive clinical data to make the diagnosis (Perez 2006: 31). The same is true of taphonomy, where much of the bone is likewise destroyed or modified so traces, like lesions, cannot be confidently diagnosed. However, these pseudopathological explanations are the most parsimonious for the features observed. With a greater understanding of the condition of the remains and specific taphonomic changes, it is now appropriate to discuss the overall pattern of taphonomy at the site.

7.5 Discussion

Excavation and subsequent analysis of the Mlambalasi skeletal sample revealed a host of current and former taphonomic agents at work. The 2010 trench was pocketed with krotovina, or animal burrows, from various bioturbation agents. These created miniature sinkholes that displaced artifacts and caused minor collapses during excavation. Some human bone fragments and giant land snail shells also bear evidence of insect tunneling. This damage is consistent with termite activity, possibly linked to the active mound found just outside the main shelter in test pit 2. Termites impact archaeological sites in a variety of ways. They create pseudofacts that can mimic hearths, create subterranean cavities prone to collapse, and redistribute other sediment on the surface (McBrearty

1990). This activity complicates the location and interpretation of past living floors. Termites also affect the pH of soil, which either accelerates weathering and dissolution through increased acidity, or enhances preservation by creating alkaline soils (McBrearty 1990). Termites are common taphonomic agents at African archaeological sites, and provide a plausible explanation for some of the damage to the Mlambalasi skeletons.

The site was also affected by moving water, as suggested by sediment concretions and the carbonate coating on the human and faunal bone (also see Collins 2009: 105-106). Sediment concretions increased around level 7 (25-35 cm below datum or 64.4-74.4 cm below surface), indicating heightened water activity near the bedrock. Interaction with water also affected bone diagenesis. Although diagenetic parameters were not measured in this study, insufficient collagen was present in the B-1 fragments sent for radiocarbon dating. This could indicate collagen hydrolysis (Smith et al. 2006). In addition to localized water movement, yearly wet and dry season cycles could have a profound effect on the site hydrology. Excavations have only occurred during the dry season, so the effects of the wet season on the rock shelter are still unknown. There may be considerably increased water activity at points during the annual cycle. This may partially account for the concretions and displacement of artifacts.

The effects of gravity were observed in the position of B-1. The skeletal elements were distributed progressively down slope with increasing proximity to the edge of the shelter. When the proveniences of other artifacts such as stone tools and cores were plotted in relation to the remains, the same effect was observed. Although the interior of the shelter is mostly flat, drops in elevation were recorded around the two entrances. Gravity may further impact artifact displacement depending on the location of drainage channels during the wet season.

The vertical displacement and high degree of fragmentation of both bone and other artifacts suggests sediment compaction and trampling. The breadth and scope of archaeological deposits at the site indicate humans periodically occupied the rock shelter for thousands of years. This recurrent use would have added to the accumulation, compression, and displacement of sedimentary and cultural deposits.

Compaction is an inevitable geological process in which sediments progressively lose porosity due to pressure from overlying layers. By contrast, trampling results from human and animal movement, especially walking, that disturbs previously deposited artifacts on or near the ground surface. Trampling causes both physical breakage and spatial displacement of bone. It depends on the occurrence of cultural materials on the ground, the intensity of the trampling, and the nature of surface sediments (Schiffer 1987; Olsen and Shipman 1988). These factors combine to produce highly variable patterns of trampling that are site specific.

Physical and spatial modifications of archaeological bone, as well as the broader effects of trampling on cultural deposits, are well-explored topics in taphonomic literature (summarized in Olsen and Shipman 1988). Bone is more susceptible to breakage from trampling if it is already weathered, and if the element has thin cortical bone (Olsen and Shipman 1998). Contact with abrasive materials during trampling can create striations that may simulate butchery marks (Behrensmeyer et al. 1986; Shipman and Olsen 1988; Domínguez-Rodrigo et al. 2009). In terms of displacement, large objects tend to shift upwards in stratigraphic profiles while small objects are pressed downwards. All objects flow away from zones of heavy trampling such as footpaths (Schiffer 1987).

In the past, high levels of human bone fragmentation and displacement have been linked to cannibalism. One of the most infamous examples involves the Krapina site in Poland, a rock shelter discovered in the late 19th century with 800 Neandertal bone fragments. The remains were all isolated and disassociated, with no intact calottes, facial skeletons, or long bones (Trinkaus 1985). The original excavator interpreted the site as a place where cannibalistic Neandertals obtained brains and marrow for ritualistic or nutritional purposes. Craniocervical fragmentation, diaphyseal splitting, "cut marks," patterned preservation and breakage, burnt bone, and skeletal disassociation were cited as evidence for such practices (Trinkaus 1985: 203).

E. Trinkaus (1985) systematically reviewed this evidence and found it could all be explained by normal sediment compaction and bone diagenesis in a rock shelter environment. The cranial fragmentation, diaphyseal splitting, and patterned preservation were related to natural weak points in bone. The disassociation resulted from taphonomic agents and imprecise excavation techniques. He also found a considerable amount of overlap between the Krapina sample and alleged Neandertal "burials." For example, fragile and small bones like the vertebrae, ribs, scapulae, phalanges, and os coxae were well preserved (Trinkaus 1985: 212). Trinkaus' "burial hypothesis" for the Krapina site suggests the skeletons were protected soon after death, either by cultural practices like intentional burial or natural ones like rock shelter collapse, and then modified by taphonomic processes (1985: 212).

There are a number of similarities between the taphonomic patterns at Krapina and Mlambalasi (although cannibalism was never suggested in the latter case). The neurocranium of B-1 exhibits the same sharp breaks that Trinkaus attributed to sediment compaction with subsequent disassociation. The femora and tibiae are less preserved than smaller and denser long bones such as the radii, ulnae, and fibulae. The same types of elements are also missing from both samples, such as the proximal tibiae and fibulae, and the distal ulnae, radii, and femora. These are all consistent features of highly fragmented samples. Finally, there is good preservation of small, highly mobile elements such as the hand and foot bones, suggesting both samples were protected from carnivore scavenging and other taphonomic agents after death through some form of burial (Trinkaus 1985). Considering both sites are in rock shelter environments, it is plausible that some of the same processes of burial, trampling, and compaction were active.

Another factor that may have increased fragmentation of the B-1, B-2, and B-4 individuals is their position in what could be a triple burial. In their study of burial preservation at Lake Baikal, A.R. Lieverse and colleagues (2006) found that burial disturbance due to looting, exhumation, and additional interment increased direct damage to the skeletons. Single burials were significantly less fragmented than double and triple burials. This was partly because combined burials usually involved at least one sub-adult whose remains were more fragile. This may also explain the absence of other elements from the B-2 juvenile skeleton. However, given the artifact mobility at the site and the lack of any other skeletal elements from these individuals, it is perhaps more likely that the two isolated bones were introduced later on, only mimicking a triple burial.

Finally, the effects of past and present human behaviour cannot be disregarded. Prehistoric humans caused manifold disturbances to terrestrial fossil sites through their social behaviour, omnivorous diet, various living strategies, and highly destructive use of habitation sites (Fernández-Jalvo et al. 2011: 1300). Recurrent use of the rock shelter led to the accumulation of successive cultural layers, as well as trampling and disturbance of earlier deposits. This is illustrated by the location of an Iron Age hearth overtop the LSA burial. This use continues, as evidenced by modern charcoal graffiti on the shelter walls and the use of room 2 as an animal corral. Archaeologists are also taphonomic agents. The two test units and their backfilling created sinkholes that trapped mobile artifacts and caused sediment collapse during the 2010 excavation. Multiple excavations complicate site interpretation because the same methods and protocols cannot be exactly applied. Humans are a confounding factor in any investigation of the past, even when they endeavor to do the investigating.

7.6 Conclusions

Taphonomy seeks to understand the transition of organisms and objects from life and use to the archaeological record through the identification and study of potential biases. The field encompasses biostratinomy, the predominantly biological changes between death and burial, and diagenesis, the physical and chemical alterations between burial and discovery. Taphonomy is relevant to all archaeological research, particularly in complex cave and rock shelter environments that both attract deposits and modify them in a unique manner. Despite ongoing research into agents and traces, the taphonomic history of any site is always somewhat elusive. Consequently, the concept of equifinality remains paramount. Artifacts may reach the same final state via a plethora of trajectories, and researchers can only hazard a best guess.

The Mlambalasi human remains were assessed for articulation, completeness, fragmentation, and weathering. Only the B-1 skeleton could be evaluated for articulation since the other remains were not recovered *in situ* or the proveniences were not recorded. Even then, only the cranium, upper arms, clavicles, and vertebral column were articulated. The remains of all four skeletons were mostly incomplete with the exception of small, dense bones such as the carpals and tarsals. The single bones of the B-2 and B-4 individuals were surprisingly intact, perhaps explaining their isolated preservation. The sample is highly fragmented, although poor preservation and research methods complicated numerical quantification of the damage. The skeletons differed most in terms of weathering. The associated B-1, B-2, and B-4 skeletons are significantly more weathered than the presumably younger individual. In addition to general taphonomic assessment, several pseudopathologies were identified on the remains including cranial delamination caused by weathering, pseudo-lesions that were probably produced by termites, and dental staining and pitting associated with chemical and mechanical diagenesis.

The dynamic environment in the rock shelter undoubtedly contributed to the degradation of the deposits. Most significantly, fragmentation of the bones and other artifacts is likely due to the compaction of rocky, cobble-filed sediments and exacerbated by hydrological and gravitational forces. Simultaneously, bioturbation by burrowing animals, osteophagous and other insects, and humans modified the archaeological assemblage. Specifically, trampling by humans and animals likely caused physical weathering and breakage of bone, and redistributed artifacts throughout the layers. The cumulative and sometimes competitive traces left by these taphonomic agents paint a complicated picture of the post-depositional events at the site. Nevertheless, this history is an integral part of the holistic interpretation of the rock shelter.

Chapter 8: Discussion

Research on the Mlambalasi rock shelter is ongoing, as the majority of the units have yet to be excavated. The preceding chapters describe the excavations and recovered human remains in order to provide a foundation for continuing research. This chapter reviews the other sites in sub-Saharan Africa with archaeological human remains from the terminal Pleistocene and early Holocene. Where available, the osteological data from these sites are compared with the Mlambalasi skeletons. I then provide some preliminary interpretation of the site based on the present state of work.

8.1 Comparable Sites and Skeletons

There are very few archaeological sites and skeletons that belong to the Late Pleistocene in Africa. This is most likely the result of low population numbers due to a genetic bottleneck (Harpending et al. 1993). There could also be issues with poor preservation of bone during the ice ages. Mitochondrial DNA studies indicate a recovery in human populations during the LSA, after the LGM and increasingly into the Holocene era (Cox et al. 2009). In addition to population growth, the environmental conditions during the warmer, wetter phase aided in the preservation of archaeological materials, particularly organic materials such as human remains. Holocene LSA remains are also more common due to the simple fact of antiquity; they have had fewer millennia to decay when compared to earlier LSA and MSA finds.

Although they both fall under the umbrella of the LSA, archaeological human remains from the terminal Pleistocene and early Holocene must be considered separately. The predominant conditions 20,000 to 12,000 years ago were still glacial with severe cold and aridity characterizing many parts of Africa. This would have affected the environmental carrying capacities of many ecozones, as well as the preservation potential of archaeological sites. The B-1 skeleton from Mlambalasi falls into this category, rendering it comparatively rare. By contrast, early Holocene populations would have experienced overall warmer and wetter conditions, and are associated with larger skeletal samples concentrated in favourable environments around Lake Turkana in East Africa and the Cape Province in South Africa.

There are two major problems with comparing the Mlambalasi data to other sites in this region and time period. First of all, many of these sites were radiocarbon dated by R. Protsch, who was discredited for falsifying data (Protsch 1975; The Guardian 2005). Based on the re-dating of similar samples, Protsch's dates appear to be older than the true age. Consequently, sites like Lukenya Hill, which he dated to the terminal Pleistocene, may not actually fall into the time range considered in this study.

Secondly, osteometric data from these finds are often unavailable. Particularly for remains analyzed in the early to mid-20th century, fragmentary skeletons were seen as uninformative and excluded from site reports. Such studies also tended to focus on archaeological crania, and often involved intensive cranial reconstruction, even though the fragmentary postcranial remains were largely ignored. This bias towards craniometry stemmed from anthropological interest in race, and dividing early African populations into morphotypes such as Khoisanoid, Negroid, Caucasoid, and Mediterranean (Keith 1933; Bräuer 1978; Rightmire 1984). Although traditional race estimation techniques focus on the face, neurocranial shape is also an indicator of population history (Harvati and Weaver 2006; Hubbe et al. 2009). Furthermore, it is frequently used as a taxonomic indicator of hominin species (Lieberman 2008), so the tendency to preferentially collect this information is ingrained in palaeoanthropological research. Since there are no complete crania in the Mlambalasi sample, and extensive fragmentation prevents reconstruction, much of the published comparative data cannot be used.

Despite these setbacks, there are 25 dated sites in sub-Saharan Africa with relevant human skeletal samples (Table 8.1). This is not an exhaustive list of comparable sites, but rather those where sufficient information is available. Due to the dearth of skeletal material, isolated finds like the Mlambalasi remains must be compared to other material from diverse time periods and locations (Bräuer 1978). These do not necessarily represent related or similar populations, but rather the diversity in human groups from this broad time range. The comparable sites relevant to this study are divided into terminal Pleistocene, 20,000-12,000 years ago, and early Holocene, 12,000-4,500 years ago. Pastoralism appears in East Africa after 4,500 years ago, and becomes well established by 3,000 years ago (Phillipson 1977; Rightmire 1984; Schepartz 1987).

Site	Country	Approx. MNI	Approx. date BP	References
Terminal Pleistocene				
Lukenya Hill (GvJm-22)	Tanzania	1	17,770* – 9910	Gramly and Rightmire 1973; Gramly 1976
Iwo Eleru	Nigeria	1	16,300 – 11,700	Brothwell and Shaw 1971; Harvati et al. 2011
Mlambalasi	Tanzania	4	12,940 – 11,170**	Biittner et al. 2007; Sawchuk 2008
Early Holocene				
Elands Bay Cave	South Africa	10	10,860 – 9750**	Rightmire 1978; Morris 1992; Stynder et al. 2007
Matjes River	South Africa	> 80	10,120 – 4850**	Dreyer 1933; Rightmire 1978; Morris 1992; Sealy and Pfeiffer 2000; Stynder et al. 2007
Knysna Heads	South Africa	1	10,110	Morris 1992; Stynder et al. 2007
Tucker's Cave	South Africa	10	9830 – 9720**	Rightmire 1978; Morris 1992; Sealy and Pfeiffer 2000
Drury's Cave	South Africa	44	9720 – 6811**	Rightmire 1978; Morris 1992; Sealy and Pfeiffer 2000
Galana Boi	Kenya	55	9500 – 4000	Vondra et al. 1971; Vondra and Bowen 1978; Schepartz 1987
Von Bonde's Cave	South Africa	5	9270**	Rightmire 1978; Morris 1992; Sealy and Pfeiffer 2000
Oakhurst	South Africa	33	9100 – 4530**	Rightmire 1978; Morris 1992; Sealy and Pfeiffer 2000; Stynder et al. 2007
Mumbwa	Zambia	Several	~ 9000	Protsch 1977; Barham and Debenham 2000; Pearson et al. 2000
Ishango	Democratic Republic of Congo	12	9000-8000	de Heinzelin 1962; Brooks and Smith 1987; Schepartz 1987; Boaz et al. 1990; Orban et al. 2001
Lothagam	Kenya	23	9000 – 6000	Robbins 1972; Schepartz 1987; Robbins 2006

Site	Country	Approx. MNI	Approx. antiquity	References
Wilton Large Rock Shelter	South Africa	4	8260**	Morris 1992; Stynder et al. 2007
Gogoshiis Qabe	Somalia	14	8100+ – 5400	Brandt 1986, 1988
Kalemba	Zambia	5	8000 – 7000	de Villiers 1976
Loboi	Kenya	8	8000 – 6000	Farrand 1976; Schepartz 1987
Fish Hoek	South Africa	9	7179 – 7759**	Stynder et al. 2009
Robberg Penninsula	South Africa	5	6995 BP**	Rightmire 1978; Morris 1992; Stynder et al. 2007
Whitcher's Cave	South Africa	20	5960 – 4920**	Fitzsimons 1926; Turner 1970; Morris 1992; Sealy and Pfeiffer 2000
Darling District	South Africa	2	5830 BP**	Morris 1992; Stynder et al. 2007
Mumba-Höhle	Tanzania	18	4890 – 4860	Mehlman 1979, Bräuer 1980
Kangatotha	Kenya	1	4800	Coon 1971, Schepartz 1987
Kabua	Kenya	2	n.d.	Whitworth 1966
Kinto (Strauss)	Tanzania	3	n.d.	Bräuer 1981

* Date potentially inaccurate

** Based on radiocarbon dates for some individuals

Table 8.1 Comparable sub-Saharan African sites to Mlambalasi

The sites with terminal Pleistocene remains derive from East and West Africa. The skeletons are represented by a calvarium in three fragments from Kenya, and a very fragmentary but nearly complete individual from Nigeria. No cranial measurements were taken on the incomplete Lukenya Hill specimen, but the calvarium is described as heavy with a receding forehead and prominent frontal eminences (Gramly and Rightmire 1973; Gramly 1976). Shape analysis of the Iwo Eleru specimen suggests it is almost Neandertaloid, with an elongated cranial vault, flattened frontal and parietal bones, and forward projecting brow ridges (Harvarti et al. 2011). Unfortunately, the postcranial anatomy is poorly preserved and not described. The robusticity of both fragments is a departure from the gracile B-1 skeleton at Mlambalasi, but without further detail, no other comparisons can be made.

A third site, Kabua near Lake Turkana, may also fall into this time period. The degree of mineralization and fossilization prevents radiocarbon dating. However, the partial skull and mandible were recovered from well-stratified Late Pleistocene deposits associated with freshwater molluscs and other fauna that corroborate the relative date. The remains were also found near Kenya Stillbay LSA artifacts, further suggesting a Late Pleistocene or Epi-Pleistocene age range (Whitworth 1966). The cranium possesses a thick vault, a receding forehead with brow ridges and an inflated glabella, and a large mandible. These traits were originally emphasized as Neandertaloid (Whitworth 1966). However, subsequent analysis found that the specimens are similar to the Holocene Lake Turkana sample, and not representative of an archaic form (Schepartz 1987).

Comparable Holocene sites can be divided into three categories: East African skeletons associated with Lake Turkana; South African skeletons thought to be ancestral Khoesan; and miscellaneous isolated examples. Aside from Kabua, the archaeological sites around Lake Turkana include Galana Boi, Lothagam, Loboi, and Kangatotha, representing an age range from 9,500 – 4,800 BP. The archaeology found with the skeletal material, including a vast array of bone harpoons, suggests that these hunter-gatherers depended heavily on aquatic resources. These dense early Holocene fishing communities also bear some of the earliest examples of pottery and domesticated livestock in East Africa, demonstrating a shift to a more sedentary lifestyle (Schepartz 1987; Robbins 2006). Little osteometric data is available from these sites, but it has been suggested that these populations were generally tall, linear people (Schepartz 1987, 1988). However, much of the focus has revolved around whether they show any affinity to southern African Khoesan populations (Tobias 1965, 1972, 1978; Brothwell 1963; Nurse et al. 1985; Schepartz 1987, 1988; Morris 2002, 2003). L. Schepartz (1987) argues that any minor resemblances these skeletons may have to modern-day Khoesan are the same features that also link them to other eastern African populations during the Late Pleistocene and Holocene. Aside from being LSA, the archaeological materials from these sites are quite different than Mlambalasi and reflect broad-scale adaptation to lake resources. Given the lack of comparative data, it is difficult to speculate on any skeletal differences, and whether the Turkana populations were significantly taller and leaner.

The second category is comprised of South African sites such as Eland's Cave, Matjes River, Knysna Heads, Tucker's Cave, Drury's Cave, Von Bonde's Cave, Oakhurst, Wilton Large Rock Shelter, Fish Hoek, Robberg Peninsula, Whitcher's Cave, and Darling District. The dates for these sites range from 10,860 – 4,530 BP. Holocene LSA skeletons from South Africa are considered part of the ancestral population to the modern day Khoesan. In addition to other morphological traits on the skull, dentition, and pelvis, the small body size of the Khoesan is identifiable as early as 10,000 years ago and well established by the mid-Holocene (Sealy and Pfeiffer 2000; Pfeiffer and Sealy 2006; Pfeiffer 2007, 2009, n.d.; Kurki et al. 2010). Unfortunately, despite the vast number of LSA burials from the region, many skeletons from earlier excavations have been subsequently lost or misplaced in museum collections (Rightmire 1978; Morris 1992). Based on site descriptions and other published accounts, however, this material is the most consistent with the size and proportions of the B-1 individual from Mlambalasi (Keith 1933; Rightmire 1978; Sealy and Pfeiffer 2000).

The remaining sites do not share a strong regional or temporal affiliation. Two sites from Zambia, Mumbwa and Kalemba, date to approximately 9,000 – 7,000 BP. The LSA remains at Mumbwa consist of a tooth, pedal phalanx, and a fragmentary femur, while Kalemba has five partial individuals. Both the Mumbwa pedal phalanx and SK 5 at Kalemba are described as Khoisanoid (de Villiers 1976; Pearson et al. 2000).

Ishango in the Democratic Republic of Congo possesses at least 12 highly fragmentary skeletons about 9,000 years old that are associated with bone harpoons and the remnants of an early fishing culture similar to those around Lake Turkana (Brooks and Smith 1987). The human remains that have been analyzed are described as having Negroid morphology similar to modern local populations, although the long bones are quite slender (de Heinzelin 1962; Schepartz 1987). However, a recent study of the mandibles and dentition found that the individuals are not so much Negroid as they are large (Orban et al. 2001). The molar dimensions of Ishango A place it in the range of australopithecines despite its obvious human characteristics.

Eighteen individuals have been excavated from Mumba-Höhle in northern Tanzania. One is directly dated to 4,890 ± 70 BP, and at least one mineralized skeleton comes from an earlier layer (Mehlman 1979; Bräuer 1980). The skeletons are highly fragmentary, but are strikingly different from both Khoesan and contemporaneous East African populations. G. Bräuer (1980) suggests that the Mumba skeletons are evidence of a pre-Iron age incursion of Negroid populations to the area.

Kinto (formerly Strauss) Rock Shelter, located near Mumba by Lake Eyasi, yielded 3 individuals that also align with Negroid or Bantu populations based on multivariate comparisons (Bräuer 1981). The remains lacked collagen for radiocabon dating, but associated Wilton artifacts suggest an age range similar to Mumba.

Finally, the Gogoshiis Qabe rock shelter in Somalia produced 13 LSA individuals dated to 8,100 – 5,400 BP. There is also another, undated skeleton from terminal Pleistocene deposits (Brandt 1986, 1988; Schepartz 1987). Eleven of the individuals were virtually complete and in articulated primary burials. Another individual was in a secondary burial, and two individuals were represented only by teeth. The population appears to have been tall and relatively stocky with unique, ultra-dolichocephalic (or anteroposteriorally elongated) crania (Brandt 1988). Most descriptions of this well-preserved sample focus on the unusual mortuary practices observed, while the osteometric data remains unavailable.

Due to the fragmentary nature of the Mlambalasi skeletons and the unavailability of comparable data, the two best elements for specific comparison are the mandible and dentition. These are summarized in Tables 8.2 and 8.3. The LSA B-1 mandible from Mlambalasi is the most similar to the two Matjes river specimens, but this may be because the most comparative data is available from that site. The mandibles of southern African LSA skeletons and their descendant Khoesan population are quite distinct; the ascending rami tend to be square or boxy with similar values for the minimum width and height. By contrast, the alveolar processes are quite shallow and broad (Keith 1933). Based on visual and osteometric assessment, the B-1 mandible roughly follows this pattern, further aligning it with Khoesan morphology. However, the mandible also appears quite masculine (see Chapter 5), which may bias population comparisons with other samples. The B-3 mandible is smaller than the comparative specimens, but it is likely from a much younger, Iron Age population. The skeleton is incomplete and undated, and the associated Iron Age materials at Mlambalasi are not yet analyzed. A comparison of this skeleton to other East African Iron Age remains would be a fruitful direction for future study.

As with the mandible, it is difficult to compare the B-1 dentition due to the lack of available data on other specimens. The teeth are not considered large, although their dimensions are affected by the heavy wear. Southern African LSA and Khoesan skeletons tend to be microdont, and exhibit certain characteristic dental traits such as the "Bushman canine," defined by the presence of a mesial canine ridge (Scott and Turner 1997). Khoesan populations also show a low frequency of shoveling, which is also absent on the B-1 skeleton. Otherwise, the dentition is broadly similar to Kabua 1, which is also heavily worn. Dental attrition is a common prehistoric condition, however, and is also present on the LSA skeletons from Iwo Eleru, Ishango, Loboi, Whitcher's cave, and Matjes River (Fitzsimons 1926; Keith 1933; de Heinzelin 1962; Whitworth 1966; Brothwell and Shaw 1971; Farrand et al. 1976). Meaningful comparisons, both to East African and other populations, will require a broader sample and more data on individual teeth.

Contextualizing the Mlambalasi skeletal remains in East African prehistory is difficult for several reasons. The remains are highly fragmentary which, although not unusual for this region and time period, limits osteometric potential. This also affects comparative fragmentary skeletons, many of which were excavated several decades ago and dismissed offhand as too damaged to be described or committed to publication. The Mlambalasi sample is also extremely small.

Measure-ment	**Mlambalasi B-1***	**Mlambalasi B-3***	**Kalemba SK 2**	**Kalemba SK 5**	**Kangatotha**	**Kabua 1**	**Matjes River 1****	**Matjes River X****	**Ishango D**	**Ishango *a***
RAH 1	69.95	57.15	59	53	-	-	63	62	-	-
RAH 2	57.39	45.28	54	59	-	-	-	-	-	-
RMH	42.27	34.89	-	-	-	-	43	43	-	-
CRH	60.79	-	-	-	-	-	56	52	-	-
RAB	34.74	28.24	-	-	-	-	-	-	-	-
RMB	34.08	27.39	32	39.4	-	40	42	35.5	-	-
BCON	8.41	9.36	-	-	-	15	-	-	-	-
LCON	17.62	18.61	-	19.2	-	21	-	-	-	-
SYH	-	27.96	-	30.6	32?	40	34	35	36	30
SYB	12.02	16.22	-	-	-	-	17	13	-	-
FMH	-	29.31	-	-	-	18	-	-	-	-
FMB	-	11.38	-	-	-	-	-	-	-	-
M1/M2H	-	25.24	-	-	-	36	24	22	-	-
M1/M2B	-	13.34	-	-	-	19	19	15	-	-
P1/P2H	-	30.56	-	-	-	-	-	-	-	-

*Applicable measurements taken on left ramus

** Based on Keith 1933; current specimen numbers unknown

RAH 1 = condylar/max ramus height
RAH 2 = projective height
RHM = minimum height of the ramus
CHR = coronoid height
RAB = maximum ramus breadth
RMB = minimum ramus breadth
BCON = condyle antero-posterior diameter
LCON= condyle transversal diameter
SYH = symphysis height
SYB = symphysis breadth
FMH = height at mental foramen
FMB = breadth at mental foramen
M1/M2H = height between M1/M2
M1/M2B = breadth between M1/M2
P1/P2H = height between P1/P2

Table 8.2: Comparison of the Mlambalasi B-1 and B-3 mandibles with other specimens

Tooth	Mlambalasi B-1*†	Mumbwa	Kabua 1†	Matjes River MR 1	Matjes River M.R. X	Kangatotha	Ishango A	Ishango B	Ishango C ††	Ishango *a*
I^1	BL: 6.63	-	MD: 6.5 BL: 7.5	-	-	-	-	-	-	-
I^2	MD: 6.00 BL: 6.58	-	MD: 5.3 BL: 6.2	-	-	-	-	-	-	-
C	MD: 6.90 BL: 7.83	MD: 7.2 BL: 7.7	MD: 7.0 BL: 8.3	-	-	-	-	-	-	-
P^3	MD: 6.77 BL: 9.00	-	MD: 6.0 BL: 10.0	-	-	-	-	-	-	-
P^4	MD: 6.04 BL: 8.61	-	MD: 6.0 BL: 9.0	-	-	-	-	-	-	-
M^1	-	-	-	-	Combined MD: 29	-	-	-	-	-
M^2	MD: 9.70 BL: 9.85	-	-	-		-	-	-	-	-
M^3	MD: 10.42 BL: 8.45	-	-	-		-	-	-	-	-
I_1	MD: 5.10 BL: 5.73	-	-	-	-	-	-	-	-	-
I_2	BL: 5.89	-	BL: 5.7	-	-	-	-	-	-	-
C	BL: 6.98	-	BL: 7.4	-	-	-	-	-	-	-
P_3	MD: 6.22 BL: 7.58	-	BL: 8.0	-	-	-	-	-	-	-
P_4	BL: 7.47	-	BL: 9.0	-	-	-	-	-	-	-
M_1	-	-	-	MD: 11	MD: 10.2	MD: 12.1 BL: 11.5	-	MD: 11.5 BL: 11.2	-	MD: 13 BL: 11.9
M_2	-	-	MD: 12.0 BL: 12.2	MD: 10	MD: 10 6 BL: 9.5	MD: 10.9 BL: 11.2	MD: 13.5 BL:13	MD: 11.9 BL: 10.4	-	MD: 14.1 BL: 12.2
M_3	MD: 10.6 BL: 9.90	-	MD: 11.7 BL: 11.5	MD: >10	MD: 9.8	MD: 12.5 BL: 11.2	-	MD: 10.7 BL: 10.1	MD: 11 BL: 12	-

MD: mesiodistal maximum diameter	BL: buccolingual maximum diameter
* measurements taken on left side	** Based on Keith 1933; current specimen numbers unknown
† measurements affected by wear	†† measurements estimated

Table 8.3: Comparison of Mlambalasi B-1 dentition with other specimens

As excavations continue, and if additional remains are recovered, the population and cultural affinities of these skeletons will hopefully become clearer. This is a common problem in palaeoanthropology; isolated finds are often compared to incomplete skeletal remains from diverse localities that span many millennia. This practice is not intended to insinuate a population or biological affinity between prehistoric individuals, but rather offer some basis for preliminary comparisons. A more comprehensive review of comparable sites and skeletons will be possible following further excavations. Based on the available information, it appears Mlambalasi dates to a relatively unknown period in the terminal Pleistocene with few other archaeological skeletons. That being said, certain aspects of the B-1 skeleton, including the mandible and estimated small body size, align it with southern African LSA material. However, population assessment is extremely limited with a sample size of one, and may change with the discovery of additional individuals from this cultural horizon.

8.2 Preliminary Site Interpretation

The occupational deposits at Mlambalasi span the LSA, Iron Age, and the historic period. The oldest deposits in room 1 are from the terminal Pleistocene based on the material culture and radiocarbon dates surrounding the B-1 skeleton. The remains were recovered from a maximum depth of 90 cm below surface, only 20 cm above bedrock. Since it does not appear the burial is intrusive, this occupation likely reflects the earliest cultural horizon preserved in the rock shelter. The MSA artifacts recovered from test pit 2 and the slope outside the rock shelter suggest that there may have been even earlier occupations. These horizons appear to have slumped or been washed out of context on the side of the escarpment. Alternatively, they may be located closer to the drip-line of the shelter, under the large piece of roof fall that provides the partial fourth wall of room 1. Based on the present extent of excavations, the archaeological sequence at the site goes back at least 13,000 years.

The long LSA and Iron Age occupations at Mlambalasi are not homogeneous. The initial excavator, an Iron Age expert, noted that approximately the first 30 cm were commingled between historic and recent Iron Age deposits. Around 40 cm below surface, the archaeology begins to shift to a LSA occupation signified by a reduction of iron and pottery. Based on the continued, albeit reduced, presence of iron slag, this underlying level appears to represent an older Iron Age deposit.

The Stone Age occupation also appears to have changed over time. Based on preliminary lithic analysis, the stone tools become larger with increased depth, with the shift centered on the B-1 remains. This suggests the possibility of two LSA variants; an earlier, macrolithic version followed by a more microlithic industrial complex (Willoughby 2011, personal communication). This reduction in lithic artifact size is also seen at the Kalemba site in Zambia (Phillipson 1976), and may be connected to larger patterns of culture change. However, the LSA is also characterized by regional and temporal variability (Ambrose 2002).

There are tentative indications of biological population change at Mlambalasi. Although incomplete, the partial B-3 skeleton from the Iron Age is larger and more robust than the small individual from the Pleistocene LSA. This pattern appears throughout much of sub-Saharan Africa where larger, more robust Bantu-speaking populations migrated into the area around the start of the Iron Age. However, this observation is only based on two skeletons. These conclusions may be biased by sexual dimorphism, biological variability, and other traits that do not accurately reflect population affiliation. That said, the smaller individual possesses a very masculine mandible while the larger has a feminine one, weakening the argument that the differences are entirely caused by dimorphism. Further excavations of the rock shelter, along with analysis of the Iron Age material culture, will likely provide more insight into the possibility of population change at the site.

Occupation of the rock shelter appears to have been more or less consistent throughout time. Evidence of longer-term activities such as iron smelting and ostrich eggshell bead production suggests it was used for more than an opportunistic processing site in the Iron Age and LSA. Little is known about its historic period, but at present, the rock shelter appears to be used for short-term activities like tending goats. Ethnographic research on the Hadza in the Eyasi Basin, Tanzania also suggests rock shelters are preferentially used for crafts like bead stringing and arrow production. However, this use tends to be during the wet season, or for short term or overnight camps (Mabulla 2003). Ongoing analysis of the artifacts from the 2010 excavation may help determine more detailed usage patterns, and whether the occupations represent longer-term inhabitations or temporary camps.

In his analysis of the Matopos area, Zimbabwe, N. Walker divided LSA rock shelters into several categories (Walker 1995; Kusimba 2001). Small shelters ranging 3-9 m^2 were more likely to be used for temporary shelter. Medium sized shelters 10-19 m^2 could be inhabited by small foraging groups representing either nuclear families or foraging task forces. Larger shelters, 20-75 m^2, could accommodate a few related families, while small caves 75-120 m^2 were more suitable for hypothetical bands of 25 people. However, Walker based his analysis on ethnoarchaeological examples of open site use. A.Z.P. Mabulla (2003) observed a Hadzabe family of six occupy a 47.4 m^2 shelter for six months, suggesting the possibility of more fluid usage of rock shelters. At roughly 8 x 12 m or 96 m^2, the Mlambalasi rock shelter would provide ample space for a small band or series of interrelated families. Lithic analysis of test pit 1 from Mlambalasi also suggests that the LSA occupants were more sedentary, based on their preferential selection of local raw materials (Biittner 2011).

It is apparent that the rock shelter was also periodically used for mortuary purposes. The human remains derive from at least two different periods: the terminal Pleistocene LSA and a recent Iron Age. The use of rock shelters and caves as mortuary sites is found in many archaeological contexts around the world. This is partly due to the inherent nature of these features; they disproportionately preserve archaeological deposits, especially organic remains, over other types of sites (Farrand 1985). Humans are also undeniably attracted to caves and rock shelters, and uses of these natural spaces are varied and fluid (Straus 1979; Barker et al. 2005; Pannell and O’Connor 2005). They represent natural landmarks, and often attract attention from successive inhabitants of a region. This contributes to the repeated use of caves and rock shelters as places of inhabitation and inhumation over time, as the case appears to be with Mlambalasi.

Mlambalasi may have been considered particularly attractive due to the large piece of roof fall that provides superior protection from the elements, and its elevated position on the landscape ideal for spotting game. These are important criteria for shelter selection among the Hadza (Mabulla 2003). Given these advantages, the rock shelter likely endured repeated cycles of occupation, burial, and abandonment that gradually created the long archaeological sequence observed. Furthermore, this process may extend into the recent past. The rock shelter is well known as the location where Chief Mkwawa made his last stand and ultimately killed himself rather than surrender to the German colonial forces. The cultural memory of this event, combined with the national Uhuru Monument and Mkwawa's tomb, attest to the rock shelter's continued relevance as a place of mortuary significance.

Ongoing excavations at Mlambalasi will address a number of questions regarding the history of mortuary behaviour at this site. If many more individuals are discovered, the site may take on new meaning as a cemetery or other ritualistic place. S. Hall (2000: 140) defines a cemetery as "a significant number of contiguous burials with a sense of boundedness related to some landform, where burial density falls off rapidly at the edge." Rock shelters provide a natural sense of boundedness, which may contribute to their attractiveness as interment sites. Alternatively, complete excavation may suggest that the individuals recovered so far are unrelated, and that this site was used for isolated burials by diverse peoples. Given its highly visible and well-sheltered location on the landscape, the space may have repeatedly attracted human groups.

At this time, the mortuary behaviours associated with these remains are unknown. The B-1 skeleton was tucked under a large rock, which suggests it was intentionally buried. The overlying rocks may constitute a further gesture of burial or concealment, although this is impossible to know given that they are of the same material as the rock shelter. The other individuals were incomplete and found out of context, and provide no other details on cultural behaviour. In general, further research is required to investigate how the rock shelter was used, what, if any, relationship these remains have with one another, mortuary activity at the site, and how all of this pertains to the archaeological sequence.

8.3 Conclusions

There are few terminal Pleistocene sites in sub-Saharan African with which to compare the Mlambalasi material. This is likely due to a combination of low population densities and poor archaeological preservation during the ice ages. The sites that have been identified are further limited by a lack of secure dating as well as published osteometric data from the associated skeletons. Nevertheless, there are 25 sites from the Late Pleistocene to early Holocene, 20,000 – 4,500 years ago, which are broadly comparable with this sample. They are divided into terminal Pleistocene sites, Holocene fishing sites nearby Lake Turkana, southern African sites associated with the Khoesan, and other miscellaneous specimens.

Based on the data available, the B-1 skeleton bears similarities to a number of fossils, but particularly those from the early Holocene in southern Africa. The skeleton may differ dramatically from other LSA remains in East Africa, which tend to be described as tall and stocky. However, the sample size from Mlambalasi is very small, so this individual may represent an atypical phenotype. This preliminary assessment may change if additional individuals with significantly different body proportions are recovered during upcoming field seasons. B-3 was included in these measurements where applicable but cannot be compared to remains from this earlier time period. Comparable Iron Age populations are not yet known since the skeleton is incomplete and undated. Given the long sequence of Iron Age deposits at the site, the relevant time periods and populations are unclear.

Based on excavations to date, two things are apparent: that the site has a long chronological sequence, and that it was repeatedly used over time for both habitation and mortuary activities. The sequence spans the LSA, Iron Age, and historic period with no obvious interregnums. There is likely an even older, MSA component on the anterior slope. The inhabitants of this rock shelter likely used it as a camp, either short or long term, based on evidence of food preparation, bead production, and iron smelting. At least at certain intervals, people were also buried there. Although there is no obvious record of abandonment, it is possible that the rock shelter was periodically used and deserted by a number of successive groups. This intermittently occurred for at least 13,000 years, producing the long stratigraphic record revealed through archaeological excavation. These patterns of use extend into historical and contemporary times. The rock shelter is still meaningful to present-day Tanzanians, both locally and nationally, due to its affiliation with Chief Mkwawa. Meanwhile, the space continues to be used by local Maasai and Hehe populations for pastoral and social activities. Mlambalasi continues to evolve and accumulate deposits. This will undoubtedly influence interpretation as the various purposes for and meanings of the site are revealed.

Chapter 9: Conclusions

9.1 Introduction

The major objectives of this study were to re-excavate the Mlambalasi site to find additional skeletal material, and to gather all the remains recovered from 2002 – 2010 in order to holistically interpret them and their archaeological context. I achieved these aims through my fieldwork in 2010 and subsequent osteological analysis of the complete skeletal collection. Although a large volume of artifacts has been recovered, the majority of the rock shelter remains unexcavated. There is significantly more work to be done at this site, which may entail recovery of additional skeletal materials. However, the skeletons recovered thus far still provide intriguing insight into the LSA and Iron Age populations that inhabited the rock shelter.

9.2 Major Research Findings

The two major research questions investigated were: a) who are these individuals; and, b) how did they become incorporated into the archaeological deposits in this rock shelter? Within this framework, I specifically asked:

1. *What remains are present?*
2. *What is the Minimum Number of Individuals (MNI)?*
3. *From what context were they recovered?*
4. *With which time period and culture are they associated?*
5. *What relationship (if any) do the individuals have to one another?*
6. *What are the characteristics of these individuals?*

7. *What taphonomic processes affected these individuals after interment in the rock shelter?*
8. *What do these individuals reveal about prehistoric occupations at this site?*

My findings are as follows.

Over three field seasons, approximately 1600 fragments of human bone weighing 1.690 kg were recovered from the Mlambalasi site. Of these, 922 were identified to a specific skeletal element. They represent the commingled cranial and postcranial remains of at least four individuals: three adults and a juvenile.

Two adults and a juvenile were associated with LSA artifacts including lithics, faunal remains, shell fragments, and ostrich eggshell beads. They were found near the back of the shelter in a burial context that has been radiocarbon dated to the terminal Pleistocene. The nearly complete B-1 adult appears to have been the main focus of this interment. The skeleton was found lying on its back in what was likely a flexed or semi-flexed position. The skull was resting on its right side facing north. A number of artifacts, mostly lithics, were incorporated into the burial fill although none were obvious grave goods, except perhaps the beads. However, they may have also been part of the individual’s clothing or personal effects. Although the skeleton’s position and preservation suggests it was buried at the time of death, there are no other indications of mortuary ritual.

The other two associated skeletons are represented by single skeletal elements so their burial position could not be inferred. The B-2 juvenile consists of a manubrium fragment, while the B-4 adult is defined by fused right and left maxillae with one grossly carious incisor. Given the fine-grained sediments in the rock shelter, it is plausible that these are intrusive elements from yet-unexcavated burials. Conversely, the rest of them may not have been preserved. Further excavations are required to determine if any other components of these two skeletons are present.

The last adult was partially excavated in 2002 by Paul Msemwa from a context he interpreted as recent Iron Age (Msemwa 2002). The diminished degree of bone surface weathering also suggests it is from a later time period, and probably unrelated to the other skeletons. It was discovered closer to the mouth of rock shelter, on the other side of a large boulder that prevented commingling with the other individuals. Although additional material from this individual was excavated in 2010, only the cranium, upper limbs, and partial thorax have been recovered. Msemwa did not mention a burial position or grave architecture, and the subsequent excavation found the material out of context. If the lower body of this individual is recovered and *in situ,* it may provide insight into mortuary behaviour.

The B-1 skeleton is the most complete, and consequently provides the most osteobiographical information. This individual is likely a middle aged adult of indeterminate sex. Stature and body mass estimations suggest this individual would have been quite small: around 161 cm and 44 kg if male, and 157 cm and 48 kg if female. If male, this individual falls into the range of southern African LSA populations and the modern day Khoesan (Sealy and Pfeiffer 2000; Truswell and Hansen 1976). This is provocative given that a link between eastern and southern African LSA populations has already been proposed (Tobias 1965, 1972, 1978; Brothwell 1963; Nurse et al. 1985). However, these estimates may be biased by the fragmentary condition of the remains. Additionally, this individual may not be representative of his or her larger population.

This skeleton also exhibits a range of pathological changes, particularly on the dentition. These include extensive wear, chronic dental caries, various enamel defects, and a periapical cemental dysplasia on a lower premolar. Other pathological changes include a bony growth on the right petrous pyramid that is likely an osteoma, a missing right pterygoid process that may indicate infection, cancer, or facial trauma, and a possible non-union fracture of a manal phalanx. Certain elements, like the mandible, are also slightly asymmetrical. Although the condition of the remains renders it difficult to compile osteobiographical information, this skeleton represents an interesting case study on body proportions and health in the terminal Pleistocene.

Little information is available on the B-2 and B-4 skeletons given their incredibly limited recovery. The B-2 manubrium is consistent in size with an older child around 8-10 years old. However, the fragment is incomplete and the characteristics of this population are unknown, so a confident age assessment cannot be made. The B-4 maxillae are fully adult and exhibit a grossly carious right lateral incisor and an associated periapical abscess or periodontal cyst. Based on the condition of the fragment, it is unclear whether the lesion represented an active infection at the time of death. It is interesting that this fragment, which was found with the B-1 skeleton, exhibits similar severe dental disease. Caries are considered atypical in pre-agricultural societies, which are more often characterized by wear. If these skeletons come from the same time period, it could suggest this population followed a cariogenic diet or had a biological predisposition to this dental disease. The unusual concentration of the lesions on the anterior teeth could indicate consumption of sticky foods or cultural use of that part of the dentition. Further investigation into this pattern would be a useful contribution to the literature on Palaeolithic diet.

The Iron Age skeleton, B-3, is more complete but still offers little osteobiographical information. The adult individual is possibly female based on the characteristics of the mandible, and is surprisingly robust when compared to the other skeletons in the rock shelter. This is superficially consistent with the pattern at many other sub-Saharan African sites, where larger, Bantu-speaking migrants replace gracile LSA populations. However, as with the B-1 skeleton, this individual is very fragmentary and may constitute an unusual phenotype. Recovery of additional material from this individual, particularly the lower limbs, would be useful in determining body size and testing the hypothesis of a population change.

There are also several isolated fragments that could not be confidently attributed to one of the aforementioned individuals. These were mostly recovered from the disturbed backfill of test pit 1 and therefore lack context. There are some indications that at least one of these fragments may belong to a yet-undiscovered individual. However, this cannot be confirmed based on the present extent of excavations. Future research at the site will address the possibility of additional, unexcavated individuals.

All the remains were affected by a series of taphonomic factors, including sediment compaction, trampling, moving water, gravity, and a range of bioturbation agents. These processes are responsible for the significant fragmentation and weathering of the sample, as well as the carbonate coating found on the majority of the remains. The associated B-1, B-2, and B-4 skeletons were significantly more weathered than B-3, presumably due to greater antiquity. Several pseudopathologies were also identified on the B-1 and B-3 individuals, including cranial delamination caused by weathering, pseudo-lesions excavated by osteophagous insects, and dental staining and pitting due to chemical and mechanical diagenesis.

Although fragmentary and largely incomplete, these skeletons suggest several things about prehistoric human occupations at the rock shelter. Based on the few comparable skeletal samples, the B-1 individual at Mlambalasi does not conform to the typical tall, robust, and linear body proportions of many other East African LSA populations. Instead, this individual appears to have more in common with the small-bodied southern African populations that are considered ancestral to the Khoesan. However, more information on the LSA population at Mlambalasi, as well as osteometric data from comparable sites, is required to properly investigate this emerging pattern. Comparisons of the gracile B-1 and robust B-3 skeletons also suggest there may be a population change at this site related to the incursion of Iron Age peoples. However, it is also difficult to reach this conclusion based on two skeletons. Additional evidence is required to properly address these possibilities.

The rock shelter possesses a long archaeological sequence spanning the LSA, Iron Age, and historic period with no obvious abandonments. This suggests that various groups repeatedly occupied the site for over 10,000 years. The recovered material culture provides evidence for inhabitation including food processing, bead production, and iron smelting. Therefore, it is unlikely that the rock shelter was exclusively used as an opportunistic activity site like a processing camp. Further analysis of the artifacts is required to determine whether these occupations were long or short term.

In addition to inhabitation, the rock shelter was periodically used for mortuary activities. The B-1 and B-3 individuals definitely derive from different cultural horizons, even if the provenances of B-2 and B-4 are ambiguous. If more individuals are recovered from this site, this may suggest it was used like a cemetery. The burials could also be unrelated, indicating repeated cycles of occupation, interment, and abandonment over successive millennia. Differentiating between these possibilities, as well as investigating other patterns of use, will require more exhaustive excavation of the rock shelter to determine the extent of the archaeological deposits.

9.3 Problems and Limitations of Research

The main limitations of this study are the poor preservation, the small sample size and lack of contextual data, and the preliminary nature of the research. The Mlambalasi skeletons are highly fragmented, weathered, covered in concretions, and commingled with one another and faunal remains. The degree of fragmentation made it difficult to identify individual skeletal elements, as well as attribute those elements to specific individuals. Many of fragments were also too heavily degraded to be refit, preventing the reconstruction of the skulls, pelves, and long bones. The bone surfaces are fragile and flakey due to heavy weathering, which makes it difficult to observe bony landmarks and other features. Furthermore, all of the remains are coated in a carbonate material, further obscuring any characteristics and limiting osteological data collection. B. Collins (2009) encountered the same problem with the faunal remains from test pit 1. I had some success removing the concretions on the tooth enamel with distilled water and soft brushes, but treatment of the entire skeletal collection would be very time consuming and potentially destructive.

Interpretation was limited by the small sample size at this site. As discussed, the B-1 and B-3 individuals hint at interesting population developments through time. The B-1 skeleton appears to be small-bodied, and may contribute to the long-standing debate on the presence of Khoesan-like people in East Africa. The B-3 individual suggests a larger bodied population arrived during the Iron Age, perhaps related to the migration of Bantu-speaking people. However, these possibilities remain hypothetical due to the lack of other individuals from those cultural horizons. Both skeletons may be anomalous compared to their respective larger populations, and so such interpretations remain tentative. Comparison of these skeletal remains to other sites in sub-Saharan Africa would also be improved by larger osteological data sets. Due to time constraints, I relied only on published site reports, articles, and books for descriptions of this material. However, correspondence with the original excavations, as well as travel to view these collections, would provide more data on comparable samples and perhaps broader demographic patterns in the Iron Age and LSA.

Although the preservation of the remains is unlikely to improve in other areas of the site, the problem of small sample size may be resolved by additional excavation. Given that B-2, B-3, and B-4 are only partial skeletons, there is a reasonable possibility that additional elements of these individuals will be recovered in the future. This would increase the osteometric and osteobiographical data available for this sample, and perhaps resolve questions regarding archaeological context and biological affiliation raised in this thesis. Furthermore, if additional individuals are recovered from the unexcavated units, they may provide greater clarity on the nature of these LSA and Iron Age populations. Further excavations by IRAP are scheduled for 2012 and possibly 2014. An objective of the upcoming 2012 field season is to collect more samples for chronometric dating in order to establish a comprehensive chronology for the site. Additional dates will also help confirm or establish the antiquity of these individuals, and better contextualize them within the various cultural horizons.

9.4 Ongoing and Future Research

In addition to completing further excavations and establishing the chronology of the site, more research should be conducted on the existing skeletal collection. In particular, it would be useful to investigate the extent and nature of diagenetic alteration. Our attempt to directly radiocarbon date the B-1 skeleton was unsuccessful due to a lack of preserved collagen. Determination of the dominant diagenetic trajectory in this skeletal sample may provide clues on successful dating methods, as well as other potential applications of research (Smith et al. 2006). For example, given the carious lesions on the B-1 and B-4 individuals, it would be interesting to determine if any food sources could have contributed to the disease. However, most stable isotope studies used for palaeodietary reconstruction rely on carbon and nitrogen signatures found in collagen (Schoeninger and Moore 1992). Determining the collagen and hydroxyapatite composition of the dentition and bones may identify what methods would be successful for further inquiry.

Recently, X-ray fluorescence (XRF) techniques were used to scan the left upper lateral incisor from B-1 as well as intermediate proximal phalanges from B-1, B-3, and one of uncertain affiliation (see Chapter 6). The samples were scanned with a Bruker Tracer III V+ at both 8 and 40 Kv. Both the tooth and the phalanges were enriched in strontium and zirconium, as was a sample of sediment from around the B-1 cranium. Although further research is necessary to properly interpret these results, they may suggest considerable exchange between the remains and the surrounding sediment. Further use of XRF technology may prove useful in examining taphonomic processes at the site.

Histological study via thin sectioning would also shed light onto taphonomic processes operating on a microscopic level (Hedges and Millard

1995; Nielsen-Marsh and Hedges 2000; Hedges 2002; Smith et al. 2006). If any of the remains preserve their original histological structure, they may be more useful for chemical and isotopic studies than the degraded cortical bone submitted for radiocarbon analysis. This would also help determine the extent of fossilization of the remains, and any differences between the individuals in terms of preservation. For example, the B-3 bones are significantly less weathered than B-1, B-2, and B-4. This could mean collagen is still present in the internal structures of the cortical bone. Thin sectioning would also provide data on any microbial or fungal attack, which is another indicator of diagenetic trajectory (Smith et al. 2006).

Research on this sample is in the initial stages. Since I am the original excavator of the majority of this sample, and this is the first time the skeletons have been interpreted together, the objective of this study was to provide the basic osteological foundation for future research. However, additional investigations into the preservation of this sample will be necessary to determine what other methods can be applied, and what future research questions can be addressed in doing so.

9.5 Final Remarks

This research contributes to the palaeoanthropological discourse by introducing a new skeletal sample from a poorly known region and time period. There are few sites and skeletons that date to the terminal Pleistocene, conceivably due to low population densities and poor preservation conditions during the ice ages. However, this could also be a product of current research foci. The Iringa Region in southern Tanzania possesses hundreds of granitoid rock shelters like Mlambalasi that may preserve rich archaeological sequences (summary of recent surveys in Biittner 2011). Considering that this region also may have contained refugia during glacial periods, it should be targeted for future studies. Upcoming excavations by IRAP at Mlambalasi, as well as other rock shelter sites in the Iringa Region, have great potential to expand our knowledge of human evolution and adaptations during the Pleistocene and Holocene in East Africa.

The Mlambalasi rock shelter is a significant place, both for its archaeological potential and its continued use by and meaning for local populations. Its concealed location halfway up the escarpment has been exploited by human groups for over 10,000 years as a place of shelter, activity, ritual, colonial rebellion, and most recently, academic study. During fieldwork in 2010, it was hard not to notice what a pleasant, sheltered environment it provided for excavating. It is hard to imagine that it would have been any less hospitable during the last several millennia, perhaps even during the trying conditions of glacial Africa. Accordingly, the local Maasai and other Tanzanians continue to make use of this place. Hopefully, future research at this site will not only reveal its history to anthropologists and scholars, but also relate that knowledge and meaning to those for whom it holds significance today.

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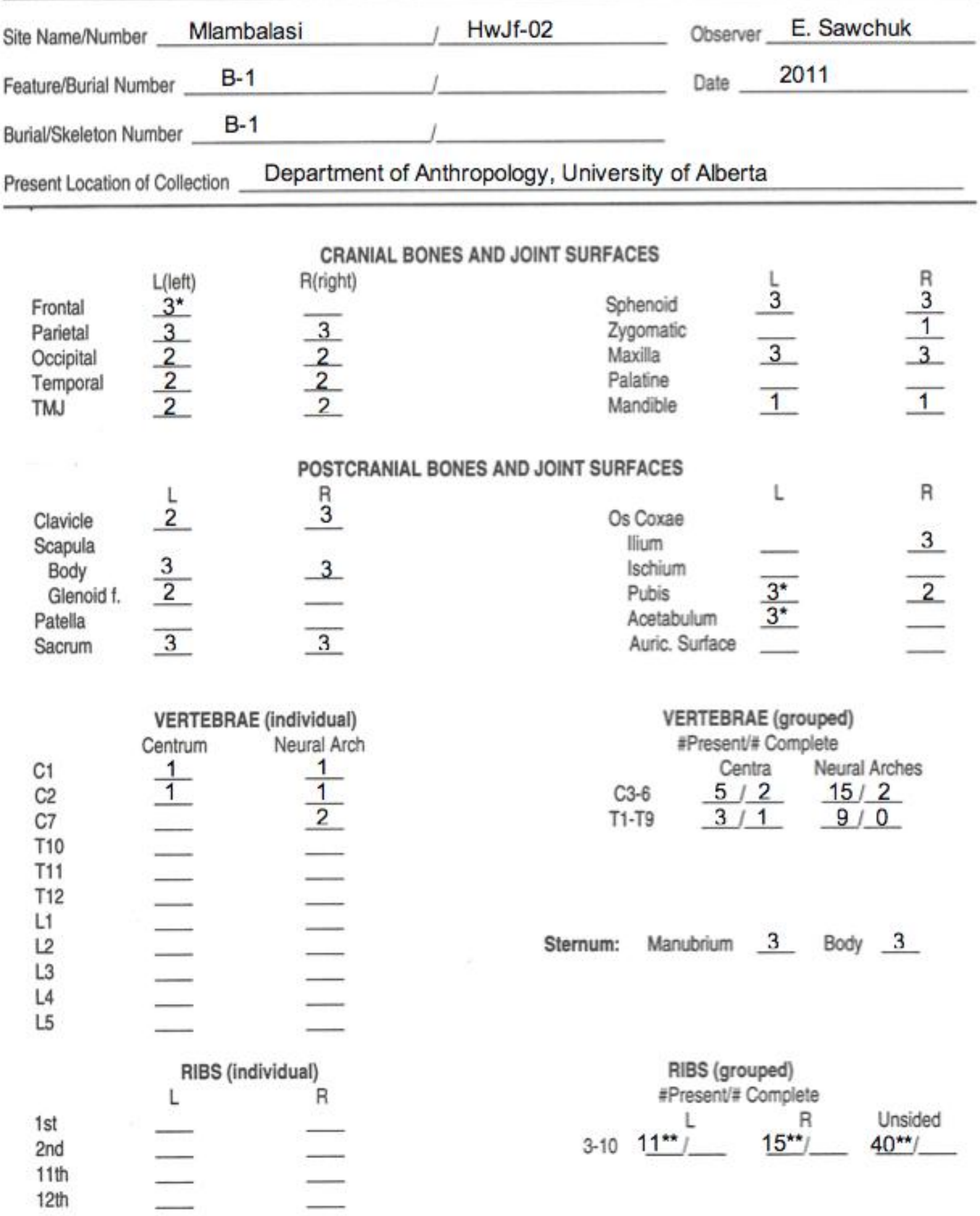
Appendix A: Skeletal Inventory

Inventory Recording Form for Complete Skeletons[3]



Site Name/Number Mlambalasi / HwJf-02 Observer E. Sawchuk

Feature/Burial Number B-1 / Date 2011

Burial/Skeleton Number B-1 /

Present Location of Collection Department of Anthropology, University of Alberta

CRANIAL BONES AND JOINT SURFACES

	L(left)	R(right)		L	R
Frontal	3*		Sphenoid	3	3
Parietal	3	3	Zygomatic		1
Occipital	2	2	Maxilla	3	3
Temporal	2	2	Palatine		
TMJ	2	2	Mandible	1	1

POSTCRANIAL BONES AND JOINT SURFACES

	L	R		L	R
Clavicle	2	3	Os Coxae		
Scapula			Ilium		3
Body	3	3	Ischium		
Glenoid f.	2		Pubis	3*	2
Patella			Acetabulum	3*	
Sacrum	3	3	Auric. Surface		

VERTEBRAE (individual)

	Centrum	Neural Arch
C1	1	1
C2	1	1
C7		2
T10		
T11		
T12		
L1		
L2		
L3		
L4		
L5		

VERTEBRAE (grouped)

#Present/# Complete

	Centra	Neural Arches
C3-6	5 / 2	15 / 2
T1-T9	3 / 1	9 / 0

Sternum: Manubrium 3 Body 3

RIBS (individual)

	L	R
1st		
2nd		
11th		
12th		

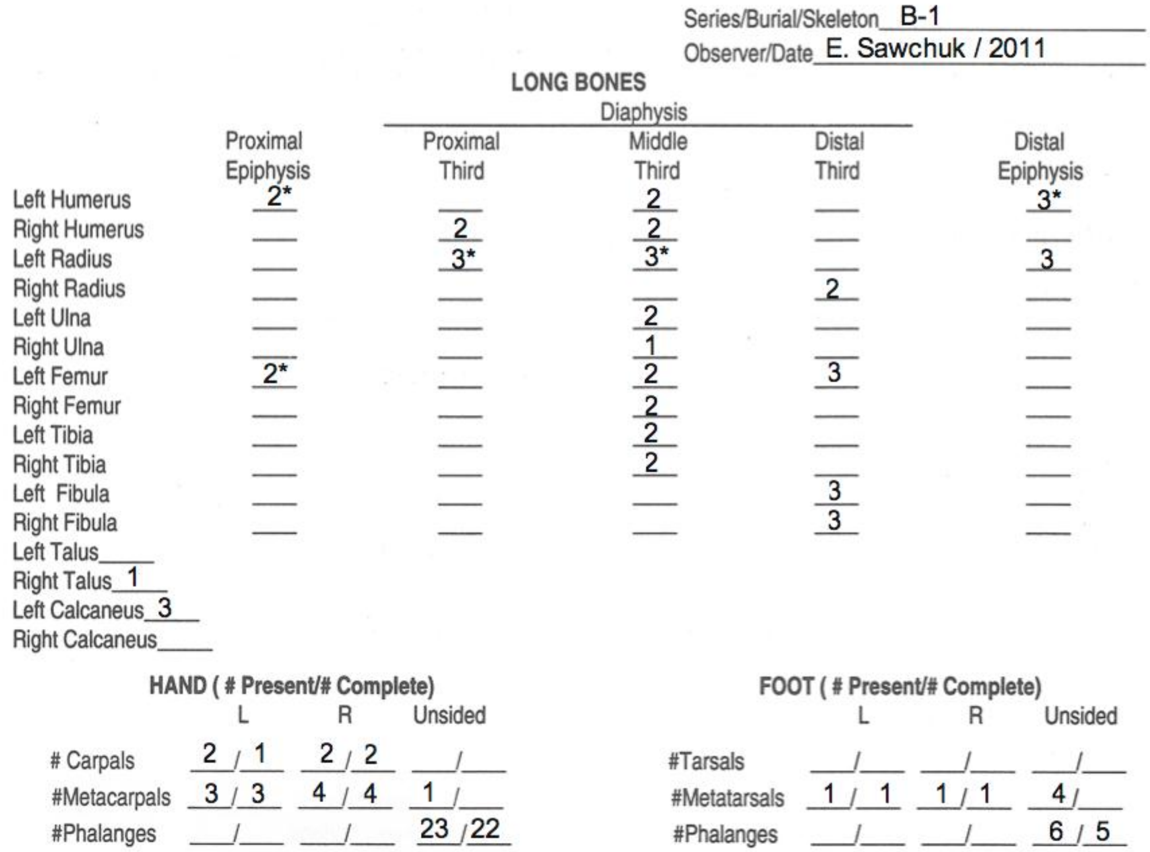
RIBS (grouped)

#Present/# Complete

	L	R	Unsided
3-10	11**/	15**/	40**/

---

[3] Buikstra and Ubelaker 1994: Attachment 1



Series/Burial/Skeleton B-1
Observer/Date E. Sawchuk / 2011

LONG BONES

	Proximal Epiphysis	Diaphysis Proximal Third	Diaphysis Middle Third	Diaphysis Distal Third	Distal Epiphysis
Left Humerus	2*		2		3*
Right Humerus		2	2		
Left Radius		3*	3*		3
Right Radius				2	
Left Ulna			2		
Right Ulna			1		
Left Femur	2*		2	3	
Right Femur			2		
Left Tibia			2		
Right Tibia			2		
Left Fibula				3	
Right Fibula				3	

Left Talus_____
Right Talus 1
Left Calcaneus 3
Right Calcaneus_____

HAND (# Present/# Complete)

	L	R	Unsided
# Carpals	2 / 1	2 / 2	/
#Metacarpals	3 / 3	4 / 4	1 /
#Phalanges	/	/	23 /22

FOOT (# Present/# Complete)

	L	R	Unsided
#Tarsals	/	/	/
#Metatarsals	1 / 1	1 / 1	4 /
#Phalanges	/	/	6 / 5

* Side uncertain
** Fragment number
Completeness: 1: >75% present; 2: 75-25% present; 3: <25% present

Comments: Overall, the skeleton is very fragmentary. Some of the elements coded 3 (or poorly preserved) represent >5-10% of the total bone. In particular, the skull, pelvis, and long bones are shattered and of little osteometric utility. Only elements that were confidently identified and associated with this skeleton are included on this form. Siding is uncertain for elements marked with an asterisk. For full catalogue, see Appendix C.

Inventory Recording Form for Commingled Remains and Isolated Bones[4]

Bone	Side	Segment	Complete-ness	MNI	Ct/Wt (g)	Age	Sex
B-2							
Manubrium	M		1	1	1 / 1.87	C	?
B-3							
Unidentified cranial vault			3	1	19 / 52.5	Ad	F?
Occipital	?		3	1	1 / 3.82	Ad	F?
Fused occipital & temporal	R		3	1	1 / 10.25	Ad	F?
Frontal (orbit)	?		3	1	1 / 5.41		
Mandible	L		2	1	2 / 23.1	Ad	F?
Clavicle	R		3	1	1 / 4.48	Ad	F?
Vertebra		NA	3	1	1 / 0.36	Ad	F?
Ribs 3-10			3	1	4 / 4.97	Ad	F?
Radius	R	PE, D1/3	3	1	3 / 11.56	Ad	F?
Radius	L	PE, DE	3	1	2 / 19.47	Ad	F?
Ulna	R	D 1/3	3	1	3 / 10.43	Ad	F?
Ulna	L	P 1/3, DE	3	1	2 / 8.37	Ad	F?
Ulna	?	M 1/3	3	1	1 / 3.22	Ad	F?
Radius or ulna	?	M 1/3	3	1	3 / 10.65	Ad	F?
Metacarpals		PE, P1/3, M1/3	3	1	5 / 6.09	Ad	F?
Carpals			1	1	2 / 2.65	Ad	F?
Hand phalanges			1,2,3	1	11 / 9.85	Ad	F?
Tarsals			1	1	1 / 1.92	Ad	F?
Feet phalanges			1,3		3 / 1.55	Ad	F?
B-4							
Maxillae	B		2	1	1 / 3.51	Ad	?

Side: L: left; R: right; B: both; M: midline; ?: unsidable

Segment: PE: proximal epiphysis; P1/3: proximal third of diaphysis; M1/3: middle third of diaphysis; D1/3: distal third of diaphysis DE: distal epiphysis; B: vertebral body of centrum; NA: neural arch

Completeness: 1: >75% present; 2: 75-25% present; 3: <25% present

Age/Sex: C: child 3-12; Ad: adult; F?: possible female; ?: indeterminate

---

[4] Modified from Buikstra and Ubelaker 1994: Attachment 2

Appendix B: Osteometric Data

Description	**B-1 (mm)**	**B-3 (mm)**	**Martin number**	**Other sources**
Mandible				
Height of the mandibular ramus in position	L: 69.95	L: 57.15	M.70	-
Height of the mandibular ramus in projection	L: 57.39 R: 59.98	L: 45.28	M.70a	-
Minimal Height of the mandibular ramus	L: 42.27 R: 46.85	L: 34.89	M.70(2)	-
Breadth of the mandibular ramus (perpendicular to M.70)	L: 34.74 R: 34.17	L: 28.24	M.71	-
Minimal Breadth of the mandibular ramus	L: 34.08 R: 33.29	L: 27.39	M.71a	-
Condyle antero-posterior diameter	L: 8.41 R: 8.25	L: 9.36	-	-
Condyle transversal diameter	L: 17.62 R: 18.71	L: 18.61	M.71b	-
Height of the corpus at symphysis	-	27.96	M.69	-
Thickness of corpus at symphysis	12.02	16.22	-	Olivier 1960
Height of the corpus at mental foramen	-	29.31	M.69(1)	-
Thickness of corpus at mental foramen	-	11.38	M.69(3)	-
Height of the corpus between M1 and M2	-	25.24	M.69(2)	-
Thickness of corpus between M1 and M2	-	13.34	M.69b	-
Height of the corpus between P1 and P2	-	30.56	-	-
Clavicle				
Midshaft circumference	L: 36	-	M.6	-
Midshaft height	L: 9.22	-	M.4	-
Midshaft breadth	L: 11.12	-	M.5	-
Breadth of the acromial extremity	-	R: 20.94	M.7(4)	-
Height of the acromial extremity	-	R: 8.66	M.7(3)	-
Ulna				
Minimum circumference	L: 41 R: 37	-	M.3	-
Minimal diameter at midshaft	L: 11.05 R: 10.19	-	-	-
Maximal diameter at midshaft	L: 10.47 R: 12.67	-	-	-
Antero-posterior diameter at midshaft	L: 10.21 R: 9.68	-	M.11	-
Transversal diameter at midshaft	L: 11.37 R: 10.76	-	M.12	-
Antero-posterior diameter of the distal extremity	-	L: 11.79	M.11a	-

Transversal diameter of the distal extremity	-	L: 12.40	M.12a	-
Radius				
Minimal circumference beneath the radial tuberosity	-	R: 37		-
Midshaft circumference	-	R: 45	M.5(5)	-
Length of the neck	-	L: 18.17 R: 19.37	M.1a	-
Neck circumference	-	L: 4.1 R: 3.7	M5(4)	-
Transversal diameter of the neck	-	L: 9.01 R: 11.75	M.4(2)	-
Antero-posterior diameter of the neck	-	L: 11.08 R: 11.09	M.5(2)	-
Maximal diameter of the neck	-	L: 12.41 R: 12.27	-	Hambucken 1993
Antero-posterior diameter of the proximal head	-	L: 17.83	M.5(1)	-
Circumference at the radial tuberosity	-	L: 45 R: 47	-	Hambucken 1993
Transversal diameter at the radial tuberosity	-	L: 13.30 R: 13.36	-	Senut 1981
Length of the radial tuberosity	-	L: 17.52 R: 18.87	-	Senut 1981
Breadth of the radial tuberosity	-	L: 10.83 R: 11.97	-	Senut 1981
Breadth of the distal extremity	-	L: 26.65	M.5(6)	-
Lunate				
Maximal length	R: 14.46	R: 15.28	M.1	-
Maximal breadth	R: 11.90	R: 12.37	M.2	-
Maximal height	R: 8.14	R: 10.15	M.3	-
Trapezium				
Maximal length	L: 13.32	R: 15.82	M.1	-
Maximal breadth	-	R: 21.76	M.2	-
Maximal height	-	-	M.3	-
Height of articular surface for the MTC1	L: 9.68	R: 12.01	M.5	-
Length of the tubercle	-	R: 6.2	-	Trinkaus, 1983
Thickness of the tubercle	-	R: 5.45	-	Trinkaus, 1983
Scaphoid				
Maximal length	R: 20.42	-	M.1	-
Maximal breadth	R: 11.17	-	M.2	-
Maximal height	R: 9.53	-	M.3	-
Femur				
Vertical diameter of the head	37.73	-	M.18	-
Antero-posterior diameter of the head	-	-	M.19	-
Circumference of the head	11.2	-	M.20	-

Measurement	**L 1st MC**	**R 1st MC**	**L 2nd MC**	**R 3rd MC**	**R 4th MC**	**L 5th MC**	**R 5th MC**	**R 1st MT**	**L 5th MT**
Maximum length	46.45	-	-	-	-	-	52.57	-	-
Articular length	45.21	-	-	-	-	-	52.44	-	-
Proximal height	13.77	-	-	-	-	8.98	-	-	-
Proximal breadth	12.70	12.63	-	-	-	12.82	11.30	-	-
Medial height	8.66	8.32	7.78	7.90	7.84	6.24	6.48	11.20	6.79
Medial breadth	9.29	9.92	7.21	8.16	7.87	6.62	7.04	11.65	6.53
Distal height	11.14	-	-	-	-	-	11.10	-	-
Distal breadth	11.97	-	-	-	9.36	8.70	9.38	-	-

MC: metacarpal; MT: metatarsal

B-1 metacarpal and metatarsal data

Measurement	**Specimen 1**	**S2**	**S3**	**S4**	**S5**	**S6**
Maximum length	-	-	-	-	-	-
Articular length	-	-	-	-	-	-
Proximal height	10.11	-	9.28	-	10.34	-
Proximal articular height	-	-	8.50	-	9.20	-
Proximal breadth	13.03	-	14.91	-	14.76	14.74
Proximal articular breadth	-	-	9.99	-	11.44	-
Medial height	5.78	6.04	-	5.65	-	5.87
Medial breadth	8.08	8.70	-	8.32	-	8.50
Distal height	5.48	-	-	-	-	6.20
Distal breadth	-	-	-	-	-	10.62
Distal articular breadth	-	-	-	-	-	8.68

B-1 proximal manal phalanges data

Measurement	**Specimen 1**	**S2**	**S3**
Maximum length	-	-	-
Articular length	-	-	-
Proximal height	12.4	-	-
Proximal articular height	9.80	-	-
Proximal breadth	15.77	-	-
Proximal articular breadth	11.89	-	-
Medial height	6.40	-	-
Medial breadth	9.25	-	-
Distal height	-	11.05	8.23
Distal breadth	-	-	12.00
Distal articular breadth	-	-	11.22

B-3 proximal manal phalanges data

Measurement	Specimen 1	S2	S3	S4	S5	S6	S7
Maximum length	28.48	20.53	23.93	-	-	-	-
Articular length	28.15	19.57	28.49	-	-	-	-
Proximal height	7.90	6.94	-	-	-	-	-
Proximal articular height	6.10	4.57	-	-	-	-	-
Proximal breadth	11.84	9.5	12.21	-	-	-	-
Proximal articular breadth	9.81	7.95	9.20	-	-	-	-
Medial height	4.45	3.5	4.88	4.19	3.91	4.85	4.12
Medial breadth	7.44	5.68	7.22	6.39	5.7	6.87	5.82
Distal height	4.12	3.47	4.33	3.78	3.52	-	-
Distal breadth	8.92	7.19	9.31	8.66	7.30	-	-
Distal articular breadth	7.62	6.82	7.83	7.85	6.99	-	-

B-1 intermediate manal phalanges data

Measurement	Specimen 1	S2
Maximum length	26.37	23.79
Articular length	25.89	21.73
Proximal height	9.56	9.31
Proximal articular height	5.63	7.44
Proximal breadth	13.16	12.09
Proximal articular breadth	11.5	10.09
Medial height	-	5.12
Medial breadth	-	7.27
Distal height	5.36	5.05
Distal breadth	10.14	9.62
Distal articular breadth	8.76	8.6

B-3 intermediate manal phalanges data

Measurement	Specimen 1	S2	S3	S4	S5	S6	S7	S8	S9
Maximum length	-	14.70	21.83	15.78	17.24	15.97	16.24	16.66	15.35
Articular length	-	14.38	21.20	15.12	16.84	15.85	15.64	16.33	15.13
Proximal height	6.61	4.72	-	4.93	5.16	5.95	-	5.29	4.59
Proximal articular height	5.14	3.47	-	4.67	4.46	5.48	-	4.57	4.23
Proximal breadth	12.35	7.4	12.24	8.19	8.32	8.84	8.99	8.51	6.67
Proximal articular breadth	10.08	6.62	10.01	7.5	7.24	8.14	8.31	7.05	6.34
Medial height	3.69	3.05	3.68	3.42	3.74	3.4	3.77	3.27	2.66
Medial breadth	6.69	3.6	6.58	3.92	4.34	4.18	4.41	4.42	3.06
Distal height	-	2.72	3.51	2.18	3.30	2.89	-	2.98	2.62
Distal breadth	-	4.37	604	5.25	5.82	5.40	3.04	-	4.22
Distal articular breadth	-	-	-	-	-	-	-	-	-

B-1 distal manal phalanges data

Measurement	**B-1 Specimen 1**	**B-1 S2**	**B-1 S3**	**B-3 S1**
Maximum length	-	31.46	-	-
Articular length	-	29.79	-	-
Proximal height	9.50	10.18	-	11.29
Proximal articular height	7.70	9.03	6.85	9.83
Proximal breadth	10.00	13.83	13.21	10.97
Proximal articular breadth	8.40	10.58	9.00	9.55
Medial height	-	5.38	-	-
Medial breadth	-	7.35	-	-
Distal height	-	5.73	-	-
Distal breadth	-	10.51	-	-
Distal articular breadth	-	10.37	-	-

B-1 and B-3 proximal pedal phalanges data

Measurement	**B-1 Specimen 1**	**B-1 S2**	**B-3 S1**
Maximum length	12.21	11.11	-
Articular length	11.55	10.90	-
Proximal height	6.50	5.80	-
Proximal articular height	4.76	4.95	-
Proximal breadth	7.42	7.55	-
Proximal articular breadth	7.13	7.08	-
Medial height	3.75	3.56	-
Medial breadth	5.22	5.89	-
Distal height	4.27	3.84	4.19
Distal breadth	6.58	6.90	9.81
Distal articular breadth	6.30	6.75	-

B-1 and B-3 intermediate pedal phalanges data

Tooth number[5]	Tooth description	Mesiodistal maximum diameter†	Mesiodistal cervical diameter	Buccolingual maximum diameter†	Buccolingual cervical diameter	Crown height†	Root length	Crown module	Crown index	Robustness index
1	Right M^3	8.65	6.56	11.03	10.44	4.64	13.97	9.84	127	95.41
2	Right M^2	9.95	7.99			4.19				
3	Right M^{1*}		7.17			2.95	14.98			
4	Right PM^4	5.69	7.77	8.61	4.91	3.91		7.15	151	48.99
5	Right PM^3	6.31	7.56	8.77	4.94	4.32		7.54	138	55.34
6	Right C^1			7.89	7.59	5.80	13.09**			
8	Right I^1			6.51	6.07	5.10	17.07			
9	Left I^1			6.63	6.08	7.20	15.22			
10	Left I^2	6.00	5.08	6.58	6.86	4.78	17.79	6.29	109	39.48
11	Left C^1	6.90		7.83	7.57	4.81	15.30**	7.37	113	54.03
12	Left PM^3	6.77		9.00		3.98		7.89	132	60.93
13	Left PM^4	6.04		8.61	7.97	4.17		7.33	142	52.00
14	Left M^{1*}					2.59	12.70			
15	Left M^2	9.70		9.85	8.63	4.24		9.78	101	95.55
16	Left M^3	10.42	9.90	8.45	6.80	4.74		9.44	81	88.05
17	Left M_3	10.60	9.68	9.90	8.94	4.49		10.1	93	104.94
20	Left PM_4			7.47	6.59	2.51	15.04			
21	Left PM_3	6.22	5.21	7.58	6.39	2.43	14.96	6.90	121	47.15
22	Left C_1			6.98	7.05	4.56	15.56**			
23	Left I_2			5.89	5.81	5.50	15.05			
24	Left I_1	5.10	3.63	5.73	5.80	5.62	15.10**	5.42	112	29.22
27	Right C_1			5.95	5.97	5.25				
28	Right PM_3	6.50	6.61	7.32	4.80	3.26	17.53	6.91	112	47.58
29	Right PM_4		5.06	7.71	6.79	3.80	19.92			
30	Right M_1					3.04	14.47			
32	Right M_3	10.13	8.75	9.60	8.61	5.06		9.87	94	97.25

* uncertain left or right
** root tip damaged
† measurements affected by attrition
Crown module = mesiodistal diameter + buccolingual diameter / 2
Crown index = buccolingual diameter / mesodistal diameter X 100
Robustness index = mesiodistal diameter x buccolingual diameter

B-1 dental measurements

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[5] Numbering system recommended by J.E. Buikstra and D.H. Ubelaker (1994)

Appendix C: Catalogue of Skeletal Remains

Bone #	Description	Count	Weight (g)	Complete-ness	Affiliation	Unit/ Feature	Quad/ Provenience	Level/ Depth	Date
2002.01	cranial fragments	3	14.59	3	B-3	Trench 1	-	2	22-Sep-2002
2002.02	occipital fragment	1	3.82	3	B-3	Trench 1	-	3	22-Sep-2002
2002.03	mandibular corpus, L	1	13.64	2	B-3	Trench 1	-	2	22-Sep-2002
2002.04	mandible, L ascending ramus	1	9.46	2	B-3	Trench 1	-	2	22-Sep-2002
2002.05	radius, L, PE	1	6.79	3	B-3	Trench 1	-	2	22-Sep-2002
2002.06	radius, L, DE	1	10.01	3	B-3	Trench 1	-	2	22-Sep-2002
2002.07	radius, R, PE	2	5.9	3	B-3	Trench 1	-	2	22-Sep-2002
2002.08	radius, R, D 1/3	1	5.69	3	B-3	Trench 1	-	2	22-Sep-2002
2002.09	ulna, L, P 1/3	1	6.53	3	B-3	Trench 1	-	2	22-Sep-2002
2002.10	ulna, L, DE	1	1.84	3	B-3	Trench 1	-	2	22-Sep-2002
2002.11	ulna, R, D 1/3	2	7.52	3	B-3	Trench 1	-	2	22-Sep-2002
2002.12	ulna, R, D 1/3	1	2.91	3	B-3	Trench 1	-	1	22-Sep-2002
2002.13	ulna, unsided, M 1/3	1	3.22	3	B-3	Trench 1	-	2	22-Sep-2002
2002.14	radius or ulna shaft fragments, unsided	3	10.65	3	B-3	Trench 1	-	1	22-Sep-2002
2002.15	clavicle, R, acromial extremity	1	4.48	3	B-3	Trench 1	-	2	22-Sep-2002
2002.16	rib, L	1	1.64	3	B-3	Trench 1	-	2	22-Sep-2002
2002.17	1st metacarpal, L, PE	1	0.96	3	B-3	Trench 1	-	2	22-Sep-2002
2002.18	3rd metacarpal, R, M 1/3	1	1.84	2	B-3	Trench 1	-	2	22-Sep-2002
2002.19	4th metacarpal, L, P 1/3	1	1.07	2	B-3	Trench 1	-	2	22-Sep-2002
2002.20	metacarpal shaft, unsided	1	1.37	3	B-3	Trench 1	-	2	22-Sep-2002
2002.21	proximal manal phalanx, P 1/3	1	1.86	1	B-3	Trench 1	-	2	22-Sep-2002
2002.22	proximal manal phalanx, PE	1	0.5	3	B-3	Trench 1	-	2	22-Sep-2002
2002.23	proximal manal phalanx, DE	1	0.97	3	B-3	Trench 1	-	2	22-Sep-2002
2002.24	intermediate manal phalanx	1	1.08	1	B-3	Trench 1	-	2	22-Sep-2002
2002.25	proximal pedal phalanx (2-5), P 1/3	1	1.11	2	B-3	Trench 1	-	2	22-Sep-2002

2002.26	unidentifiable fragments	4	1.23	3	B-3	Trench 1	-	2	22-Sep-2002
2006.01	proximal manal phalanges	6	10.97	1,2	B-1	TP 1	-	85-87 cm b.s.	4-Aug-2006
2006.02	intermediate manal phalanges	8	5.91	1	B-1	TP 1	-	85-87 cm b.s.	4-Aug-2006
2006.03	distal manal phalanges	9	2.8	1	B-1	TP 1	-	85-87 cm b.s.	4-Aug-2006
2006.04	proximal pedal phalanges	3	3.32	1,1,2	B-1	TP 1	-	85-87 cm b.s.	4-Aug-2006
2006.05	intermediate pedal phalanx	1	0.24	1	B-1	TP 1	-	-	4-Aug-2006
2006.06	1st metacarpal, L	1	3.18	1	B-1	TP 1	-	85-87 cm b.s.	4-Aug-2006
2006.07	1st metacarpal, R	1	1.83	1	B-1	TP 1	-	85-87 cm b.s.	4-Aug-2006
2006.08	2nd metacarpal, L	1	3.44	1	B-1	TP 1	-	85-87 cm b.s.	4-Aug-2006
2006.09	3rd metacarpal, R	1	3.4	1	B-1	TP 1	-	85-87 cm b.s.	4-Aug-2006
2006.10	4th metacarpal, R	1	3.75	1	B-1	TP 1	-	85-87 cm b.s.	4-Aug-2006
2006.11	5th metacarpal, R	1	2.12	1	B-1	TP 1	-	85-87 cm b.s.	4-Aug-2006
2006.12	5th metacarpal, R	1	1.8	1	B-1	TP 1	-	85-87 cm b.s.	4-Aug-2006
2006.13	metacarpal, DE	2	0.79	3	B-1	TP 1	-	-	4-Aug-2006
2006.14	1st metatarsal, R, M 1/3	1	3.14	1	B-1	TP 1	-	70-75 cm b.s.	4-Aug-2006
2006.15	5th metatarsal, L	1	1.64	1	B-1	TP 1	-	85-87 cm b.s.	4-Aug-2006
2006.16	metatarsals	4	4.48	2	B-1	TP 1	-	85-87 cm b.s.	4-Aug-2006
2006.17	metacarpals or metatarsals	2	1.47	2,3	B-1	TP 1	-	85-87 cm b.s.	4-Aug-2006
2006.18	trapezium, L	1	0.87	1	B-1	TP 1	-	-	4-Aug-2006
2006.19	lunate, R	1	0.65	1	B-1	TP 1	-	85-87 cm b.s.	4-Aug-2006
2006.20	scaphoid, R	1	0.88	1	B-1	TP 1	-	85-87 cm b.s.	4-Aug-2006
2006.21	talus, R	1	3.4	1	B-1	TP 1	-	70-75 cm b.s.	4-Aug-2006
2006.22	calcaneus, L	2	1.32	3	B-1	TP 1	-	85-87 cm b.s.	4-Aug-2006
2006.23	femur, R, M 1/3	6	28.46	2	B-1	TP 1	-	85-87 cm b.s.	4-Aug-2006
2006.24	humerus, DE	1	1.1	3	B-1	TP 1	-	-	4-Aug-2006
2006.25	ulna, R, M 1/3	2	19.41	1	B-1	TP 1	-	85-87 cm b.s.	4-Aug-2006
2006.26	ulna, L, M 1/3	1	8.13	2	B-1	TP 1	-	85-87 cm b.s.	4-Aug-2006
2006.27	radius, R, D 1/3	2	13.12	2	B-1	TP 1	-	85-87 cm b.s.	4-Aug-2006
2006.28	radius, L, DE	1	1.37	3	B-1	TP 1	-	85-87 cm b.s.	4-Aug-2006
2006.29	radius, M 1/3	3	12.15	3	B-1	TP 1	-	85-87 cm b.s.	4-Aug-2006
2006.30	radius or ulna. M 1/3	4	19.26	3	B-1	TP 1	-	85-87 cm b.s.	4-Aug-2006
2006.31	femur, L, M 1/3	1	21.57	2	B-1	TP 1	-	85-87 cm b.s.	4-Aug-2006
2006.32	femur, L, D 1/3	1	13.42	3	B-1	TP 1	-	85-87 cm b.s.	4-Aug-2006
2006.33	femur, PE	1	9.94	3	B-1	TP 1	-	85-87 cm b.s.	4-Aug-2006

2006.34	femur – Greater trochanter, P 1/3	1	4.04	3	B-1	TP 1	-	85-87 cm b.s.	4-Aug-2006
2006.35	femur – Intercondylar fossa, DE	1	1.29	3	B-1	TP 1	-	85-87 cm b.s.	4-Aug-2006
2006.36	tibia, R, M 1/3	7	37.23	2	B-1	TP 1	-	70-75 cm b.s.	4-Aug-2006
2006.37	tibia, L, M 1/3	4	28.07	2	B-1	TP 1	-	70-75 cm b.s.	4-Aug-2006
2006.38	tibia, M 1/3	3	29.28	3	B-1	TP 1	-	85-87 cm b.s.	4-Aug-2006
2006.39	fibula, L, D 1/3	1	2.88	3	B-1	TP 1	-	85-87 cm b.s.	4-Aug-2006
2006.40	fibula, R, D 1/3	1	4.13	3	B-1	TP 1	-	70-75 cm b.s.	4-Aug-2006
2006.41	ilium	1	3.06	3	B-1	TP 1	-	85-87 cm b.s.	4-Aug-2006
2006.42	ilium, right greater sciatic notch	1	1.54	3	B-1	TP 1	-	85-87 cm b.s.	4-Aug-2006
2006.43	inferior pubic ramus, R	1	1.24	2	B-1	TP 1	-	85-87 cm b.s.	4-Aug-2006
2006.44	inferior pubic ramus	1	0.57	3	B-1	TP 1	-	85-87 cm b.s.	4-Aug-2006
2006.45	acetabulum	3	10.21	3	B-1	TP 1	-	85-87 cm b.s.	4-Aug-2006
2006.46	ischium	1	0.44	3	B-1	TP 1	-	-	4-Aug-2006
2006.47	os coxa	4	2.22	3	B-1	TP 1	-	70-75, 85-87 cm b.s.	4-Aug-2006
2006.48	sacrum	20	17.46	3	B-1	TP 1	-	85-87 cm b.s.	4-Aug-2006
2006.49	manubrium	1	1.87	1	B-2	TP 1	-	85-87 cm b.s.	4-Aug-2006
2006.50	rib, R	2	7.17	2	B-1	TP 1	-	85-87 cm b.s.	4-Aug-2006
2006.51	rib, L	1	1.43	3	B-1	TP 1	-	85-87 cm b.s.	4-Aug-2006
2006.52	rib	6	2.61	3	B-1	TP 1	-	85-87 cm b.s.	4-Aug-2006
2006.53	1st coccygeal vertebra (fused to sacrum)	1	1.88	2	B-1	TP 1	-	85-87 cm b.s.	4-Aug-2006
2006.54	vertebrae, B	1	0.5	3	B-1	TP 1	-	85-87 cm b.s.	4-Aug-2006
2006.55	vertebra – posterior superior articular facet	1	0.21	3	B-1	TP 1	-	-	4-Aug-2006
2006.56	thoracic vertebra – lamina and posterior superior articular facet	1	1.08	3	B-1	TP 1	-	85-87 cm b.s.	4-Aug-2006
2006.57	vertebra, spinous process	1	0.27	3	B-1	TP 1	-	85-87 cm b.s.	4-Aug-2006
2006.58	thoracic vertebra, right transverse process	2	0.99		B-1	TP 1	-	-	4-Aug-2006
2006.59	pubis, R	1	0.55	3	B-1	TP 1	-	-	4-Aug-2006
2006.60	unidentified bone 0-5 mm	26	0.47	3	B-1	TP 1	-	-	4-Aug-2006

2006.61	unidentified long bone 10-15 mm	100	15.5	3	B-1	TP 1	-	-	4-Aug-2006
2006.62	unidentified long bone 15-20 mm	66	22.76	3	B-1	TP 1	-	70-75, 85-87 cm b.s.	4-Aug-2006
2006.63	unidentified long bone 20-25 mm	48	27.56	3	B-1	TP 1	-	70-75, 85-87 b.s.	4-Aug-2006
2006.64	unidentified long bone 25-50 mm	63	95.21	3	B-1	TP 1	-	70-75, 85-87 cm b.s.	4-Aug-2006
2006.65	unidentified long bone 50-100 mm	7	26.77	3	B-1	TP 1	-	85-87 cm b.s.	4-Aug-2006
2006.66	unidentifiable bone 5-10 mm	111	5.62	3	B-1	TP 1	-	-	4-Aug-2006
2006.67	unidentifiable bone 10-15 mm	10	1.48	3	B-1	TP 1	-	-	4-Aug-2006
2006.68	unidentified bone 15-20 mm	19	6.41	3	B-1	TP 1	-	85-87 cm b.s.	4-Aug-2006
2006.69	miscellaneous postcranial 20-25 mm	8	4.94	3	B-1	TP 1	-	85-87 cm b.s.	4-Aug-2006
2006.70	miscellaneous postcranial 25-50 mm	8	9.09	3	B-1	TP 1	-	70-75, 85-87 cm b.s.	4-Aug-2006
2006.71	probable pubis	1	0.28	3	B-1	TP 1	-	70-100 cm b.s.	4-Aug-2010
2006.72	probable acetabulum	1	2.54	3	B-1	TP 1	-	85-87 cm b.s.	4-Aug-2010
2006.73	probable ilium	1	1.54	3	B-1	TP 1	-	70-100 cm b.s.	4-Aug-2010
2006.74	probably ilium	1	0.46	3	B-1	TP 1	-	85-87 cm b.s.	4-Aug-2010
2010.01.01	scapula, L axillary border	1	2.38	3	B-1	B-1	85N 106E	33 cm b.d.	10-Aug-2010
2010.01.02	scapula, vertebral border	1	0.99	3	B-1	B-1	85N 106E	33 cm b.d.	10-Aug-2010
2010.01.03	unidentifiable	3	0.68	3	B-1	B-1	85N 106E	33 cm b.d.	10-Aug-2010
2010.02.01	rib	1	1.6	3	B-1	B-1	78N 100E	36 cm b.d.	10-Aug-2010
2010.02.02	probable rib fragments	6	0.66	3	B-1	B-1	78N 100E	36 cm b.d.	10-Aug-2010
2010.03.01	rib, unsided	1	1.65	3	B-1	B-1	74N 95E	38 cm b.d.	10-Aug-2010
2010.03.02	probable broken rib fragments	16	3.5	3	B-1	B-1	74N 95E	38 cm b.d.	10-Aug-2010
2010.05.01	scapula, L, glenoid fossa	1	1.83	3	B-1	B-1	92N 111E	29 cm b.d.	10-Aug-2010
2010.05.02	scapula fragment	1	1.36	3	B-1	B-1	92N 111E	29 cm b.d.	10-Aug-2010
2010.06.01	humerus, L, midshaft	1	14.22	3	B-1	B-1	91-86N 113-94E	30-37 cm b.d.	10-Aug-2010
2010.06.02	probable humerus, radius or ulna fragments	8	13.81	3	B-1	B-1	91-86N 113-94E	30-37 cm b.d.	10-Aug-2010

2010.06.03	unidentifiable shards	-	17	3	B-1	B-1	91-86N 113-94E	30-37 cm b.d.	10-Aug-2010
2010.06.04	transverse process	1	0.43	3	B-1	B-1	91-86N 113-94E	30-37 cm b.d.	10-Aug-2010
2010.06.05	rib fragments	9	3.29	3	B-1	B-1	91-86N 113-94E	30-37 cm b.d.	10-Aug-2010
2010.06.06	unidentifiable bone fragments	-	7.31	3	B-1	B-1	91-86N 113-94E	30-37 cm b.d.	10-Aug-2010
2010.07.01	unidentifiable	5	0.34	3	B-1	B-1	96N 100E	31 cm b.d.	10-Aug-2010
2010.09.01	mandible, L ascending ramus	1	13.54	2	B-1	B-1	105N 119E	23.8 cm b.d.	10-Aug-2010
2010.09.02	mandible, body	1	9.57	2	B-1	B-1	105N 119E	23.8 cm b.d.	10-Aug-2010
2010.09.03	mandible, L posterior body	1	2.47	3	B-1	B-1	105N 119E	23.8 cm b.d.	10-Aug-2010
2010.09.04	mandible, L body fragment	1	0.56	3	B-1	B-1	105N 119E	23.8 cm b.d.	10-Aug-2010
2010.09.05	scapula, R, between glenoid and acromion process (paired with 2010.19.01)	1	7.11	3	B-1	B-1	105N 119E	23.8 cm b.d.	10-Aug-2010
2010.09.06	occipital, R squama around foramen magnum	1	17.27	2	B-1	B-1	105N 119E	23.8 cm b.d.	10-Aug-2010
2010.09.07	temporal, R, external auditory meatus	1	4.74	3	B-1	B-1	105N 119E	23.8 cm b.d.	10-Aug-2010
2010.09.08	occipital, L squama	1	7.05	3	B-1	B-1	105N 119E	23.8 cm b.d.	10-Aug-2010
2010.09.09	occipital, L lateral part, inside foramen magnum (paired with 2010.09.10)	1	3.06	3	B-1	B-1	105N 119E	23.8 cm b.d.	10-Aug-2010
2010.09.10	occipital lateral part, R, inside foramen magnum (paired with 2010.09.09)	1	2.15	3	B-1	B-1	105N 119E	23.8 cm b.d.	10-Aug-2010
2010.09.11	atlas, L arch	1	3.16	2	B-1	B-1	105N 119E	23.8 cm b.d.	10-Aug-2010
2010.09.12	atlas, R arch	1	1.34	3	B-1	B-1	105N 119E	23.8 cm b.d.	10-Aug-2010
2010.09.13	cervical vertebra, R pedicle	1	0.9	3	B-1	B-1	105N 119E	23.8 cm b.d.	10-Aug-2010
2010.09.14	axis, L arch with partial dens	1	2.16	2	B-1	B-1	105N 119E	23.8 cm b.d.	10-Aug-2010
2010.09.15	axis, R arch	1	1.2	3	B-1	B-1	105N 119E	23.8 cm b.d.	10-Aug-2010
2010.09.16	cervical vertebrae, L pedicle	1	0.6	3	B-1	B-1	105N 119E	23.8 cm b.d.	10-Aug-2010
2010.09.17	maxilla, R, frontal process	1	4.42	2	B-1	B-1	105N 119E	23.8 cm b.d.	10-Aug-2010
2010.09.18	maxilla, L, frontal process	1	1.52	3	B-1	B-1	105N 119E	23.8 cm b.d.	10-Aug-2010
2010.09.19	maxilla, R maxillary sinus	1	3.17	3	B-1	B-1	105N 119E	23.8 cm b.d.	10-Aug-2010

2010.09.20	maxillae, R and L, alveolar process with RI^2	1	3.51	2	B-4	B-1	105N 119E	23.8 cm b.d.	10-Aug-2010
2010.09.21	maxillae - alveolar process	4	3.64	3	B-1	B-1	105N 119E	23.8 cm b.d.	10-Aug-2010
2010.09.22	occipital, L squama (refits with 2010.09.06 and 2010.09.08)	1	25.98	2	B-1	B-1	105N 119E	23.8 cm b.d.	10-Aug-2010
2010.09.23	probable occipital squama fragments	2	4.92	3	B-1	B-1	105N 119E	23.8 cm b.d.	10-Aug-2010
2010.09.24	temporal, L petrous pyramid	1	6.43	2	B-1	B-1	105N 119E	23.8 cm b.d.	10-Aug-2010
2010.09.25	temporal, R petrous pyramid, pathological	1	8.22	2	B-1	B-1	105N 119E	23.8 cm b.d.	10-Aug-2010
2010.09.26	rib, R, medial end, probable termite damage	1	1.23	3	B-1	B-1	105N 119E	23.8 cm b.d.	10-Aug-2010
2010.09.27	rib, unsided, probable termite damage	1	1.15	3	B-1	B-1	105N 119E	23.8 cm b.d.	10-Aug-2010
2010.09.28	sphenoid, R lesser wing	1	0.73	3	B-1	B-1	105N 119E	23.8 cm b.d.	10-Aug-2010
2010.09.29	sphenoid, greater wing fragment	1	1.11	3	B-1	B-1	105N 119E	23.8 cm b.d.	10-Aug-2010
2010.09.30	temporal, L, mastoid area	1	1.68	3	B-1	B-1	105N 119E	23.8 cm b.d.	10-Aug-2010
2010.09.31	temporal, R, mastoid process	1	1.11	3	B-1	B-1	105N 119E	23.8 cm b.d.	10-Aug-2010
2010.09.32	temporal, R, proximal zygomatic process	1	0.46	3	B-1	B-1	105N 119E	23.8 cm b.d.	10-Aug-2010
2010.09.33	frontal, eye orbit fragment	1	1.17	3	B-1	B-1	105N 119E	23.8 cm b.d.	10-Aug-2010
2010.09.34	frontal, frontal crest	1	2.78	3	B-1	B-1	105N 119E	23.8 cm b.d.	10-Aug-2010
2010.09.35	parietal, R, sphenoidal angle	1	5.6	3	B-1	B-1	105N 119E	23.8 cm b.d.	10-Aug-2010
2010.09.36	parietal, unsided	1	2.62	3	B-1	B-1	105N 119E	23.8 cm b.d.	10-Aug-2010
2010.09.37	probable temporal fragments (mastoid air cells present)	11	3.35	3	B-1	B-1	105N 119E	23.8 cm b.d.	10-Aug-2010
2010.09.38	occipital squama, around foramen magnum	1	1.82	3	B-1	B-1	105N 119E	23.8 cm b.d.	10-Aug-2010
2010.09.39	probable temporal squama	1	1.35	3	B-1	B-1	105N 119E	23.8 cm b.d.	10-Aug-2010
2010.09.40	temporal, L mandibular fossa	1	2.52	3	B-1	B-1	105N 119E	23.8 cm b.d.	10-Aug-2010
2010.09.41	temporal, R tympanic	1	0.92	3	B-1	B-1	105N 119E	23.8 cm b.d.	10-Aug-2010
2010.09.42	temporal and occipital, R, fused with lambdoidal suture present	1	8.88	3	B-1	B-1	105N 119E	23.8 cm b.d.	10-Aug-2010

2010.09.43	temporal, squama unsided	1	2.72	3	B-1	B-1	105N 119E	23.8 cm b.d.	10-Aug-2010
2010.09.44	temporal, squama unsided	1	0.83	3	B-1	B-1	105N 119E	23.8 cm b.d.	10-Aug-2010
2010.09.45	temporal, L mastoid process	1	1	3	B-1	B-1	105N 119E	23.8 cm b.d.	10-Aug-2010
2010.09.46	sphenoid, L greater wing	1	0.36	3	B-1	B-1	105N 119E	23.8 cm b.d.	10-Aug-2010
2010.09.47	sphenoid, L greater wing	1	1.31	2	B-1	B-1	105N 119E	23.8 cm b.d.	10-Aug-2010
2010.09.48	sphenoid, R greater wing	1	0.81	3	B-1	B-1	105N 119E	23.8 cm b.d.	10-Aug-2010
2010.09.49	sphenoid, probable greater wing	1	0.34	3	B-1	B-1	105N 119E	23.8 cm b.d.	10-Aug-2010
2010.09.50	maxilla, R alveolar process	1	0.77	3	B-1	B-1	105N 119E	23.8 cm b.d.	10-Aug-2010
2010.09.51	probable parietal	1	1.61	3	B-1	B-1	105N 119E	23.8 cm b.d.	10-Aug-2010
2010.09.52	unidentifiable cranial sinus fragments	6	2.45	3	B-1	B-1	105N 119E	23.8 cm b.d.	10-Aug-2010
2010.09.53	maxilla fragment, unsided	1	1.57	3	B-1	B-1	105N 119E	23.8 cm b.d.	10-Aug-2010
2010.09.54	temporal, R, carotid canal	1	2.25	3	B-1	B-1	105N 119E	23.8 cm b.d.	10-Aug-2010
2010.09.55	cranial vault fragments with suture edges	9	7.22	3	B-1	B-1	105N 119E	23.8 cm b.d.	10-Aug-2010
2010.09.56	cranial vault fragment with fused suture lines	1	0.87	3	B-1	B-1	105N 119E	23.8 cm b.d.	10-Aug-2010
2010.09.57	cranial vault fragments with root damage	3	2.15	3	B-1	B-1	105N 119E	23.8 cm b.d.	10-Aug-2010
2010.09.58	cervical vertebra, R pedicle and half body	1	2.14	2	B-1	B-1	105N 119E	23.8 cm b.d.	10-Aug-2010
2010.09.59	scapula, L scapular notch.	1	1.48	3	B-1	B-1	105N 119E	23.8 cm b.d.	10-Aug-2010
2010.09.60	manubrium, R clavicular notch	1	1.95	3	B-1	B-1	105N 119E	23.8 cm b.d.	10-Aug-2010
2010.09.61	probable vertebra, transverse process	1	0.32	3	B-1	B-1	105N 119E	23.8 cm b.d.	10-Aug-2010
2010.09.62	probable rib	1	0.26	3	B-1	B-1	105N 119E	23.8 cm b.d.	10-Aug-2010
2010.09.63	cranial fragments, unidentified	45	45.37	3	B-1	B-1	105N 119E	23.8 cm b.d.	10-Aug-2010
2010.09.64	cranial fragments, unidentified	>100	96.33	3	B-1	B-1	105N 119E	23.8 cm b.d.	10-Aug-2010
2010.09.65	scapula, unsided, scapular spine	1	2.35	3	B-1	B-1	105N 119E	23.8 cm b.d.	10-Aug-2010
2010.09.66	sphenoid, R greater wing, likely pathological	1	5.81	3	B-1	B-1	105N 119E	23.8 cm b.d.	10-Aug-2010
2010.09.67	sphenoid, L greater wing	1	4.65	3	B-1	B-1	105N 119E	23.8 cm b.d.	10-Aug-2010

2010.09.68	I^2 L	1	0.79	1	B-1	B-1	105N 119E	23.8 cm b.d.	10-Aug-2010
2010.09.69	I_1 L	1	0.49	1	B-1	B-1	105N 119E	23.8 cm b.d.	10-Aug-2010
2010.09.70	I_2 L	1	0.54	1	B-1	B-1	105N 119E	23.8 cm b.d.	10-Aug-2010
2010.09.71	C^1 L	1	0.92	1	B-1	B-1	105N 119E	23.8 cm b.d.	10-Aug-2010
2010.09.72	C^1 R	1	0.9	1	B-1	B-1	105N 119E	23.8 cm b.d.	10-Aug-2010
2010.09.73	C_1 L	1	0.76	1	B-1	B-1	105N 119E	23.8 cm b.d.	10-Aug-2010
2010.09.74	C_1 R	1	0.38	2	B-1	B-1	105N 119E	23.8 cm b.d.	10-Aug-2010
2010.09.75	P^4 L	1	0.55	2	B-1	B-1	105N 119E	23.8 cm b.d.	10-Aug-2010
2010.09.76	P^3 L	2	0.6	2	B-1	B-1	105N 119E	23.8 cm b.d.	10-Aug-2010
2010.09.77	P_4 R	1	0.76	1	B-1	B-1	105N 119E	23.8 cm b.d.	10-Aug-2010
2010.09.78	P_3 R	1	0.67	1	B-1	B-1	105N 119E	23.8 cm b.d.	10-Aug-2010
2010.09.79	P_4 L	1	0.63	1	B-1	B-1	105N 119E	23.8 cm b.d.	10-Aug-2010
2010.09.80	P_3 L	1	0.63	1	B-1	B-1	105N 119E	23.8 cm b.d.	10-Aug-2010
2010.09.81	unidenfiable molar fragment, probably upper	4	0.53	2	B-1	B-1	105N 119E	23.8 cm b.d.	10-Aug-2010
2010.09.82	M^1 unsided root fragment (refits with 2010.09.83)	2	0.38	2	B-1	B-1	105N 119E	23.8 cm b.d.	10-Aug-2010
2010.09.83	unsided M^1 (refits with 2010.09.82)	1	0.46	3	B-1	B-1	105N 119E	23.8 cm b.d.	10-Aug-2010
2010.09.84	unsided M^1	3	0.55	2	B-1	B-1	105N 119E	23.8 cm b.d.	10-Aug-2010
2010.09.85	M^2 L	4	0.6	1	B-1	B-1	105N 119E	23.8 cm b.d.	10-Aug-2010
2010.09.86	unidentifiable molar, less wear than B-1 dentition	2	0.67	2	?	B-1	105N 119E	23.8 cm b.d.	10-Aug-2010
2010.09.87	M^3 L	1	0.76	2	B-1	B-1	105N 119E	23.8 cm b.d.	10-Aug-2010
2010.09.88	M^3 R	1	0.95	1	B-1	B-1	105N 119E	23.8 cm b.d.	10-Aug-2010
2010.09.89	M_3 R	1	0.87	2	B-1	B-1	105N 119E	23.8 cm b.d.	10-Aug-2010
2010.09.90	M_3 L	1	0.95	2	B-1	B-1	105N 119E	23.8 cm b.d.	10-Aug-2010
2010.09.91	molar tooth root fragments	11	1.12	3	B-1	B-1	105N 119E	23.8 cm b.d.	10-Aug-2010
2010.09.92	crown fragments	5	0.78	3	B-1	B-1	105N 119E	23.8 cm b.d.	10-Aug-2010
2010.09.93	lower molar roots	3	1.4	3	B-1	B-1	105N 119E	23.8 cm b.d.	10-Aug-2010
2010.10.01	proximal R humerus	1	16.94	2	B-1	B-1	112-114N 105-83E	32-40 cm b.d.	11-Aug-2010
2010.10.02	humerus, R, M 1/3	1	9.96	3	B-1	B-1	112-114N 105-83E	32-40 cm b.d.	11-Aug-2010
2010.10.03	probable humerus fragments	10	9.23	3	B-1	B-1	112-114N 105-83E	32-40 cm b.d.	11-Aug-2010

2010.10.04	unidentifiable	>20	2.5	3	B-1	B-1	112-114N 105-83E	32-40 cm b.d.	11-Aug-2010
2010.14.01	M_1 R	1	0.63	2	B-1	B-1	108N 110E	30 cm b.d.	11-Aug-2010
2010.16.01	rib fragment, L, medial portion	1	2.42	2	B-1	B-1	79-85N 93-87E	40 cm b.d.	11-Aug-2010
2010.17.01	mandible, R ascending ramus	1	12.16	2	B-1	B-1	108N 118E	33 cm b.d.	11-Aug-2010
2010.18.01	zygomatic, R	1	6.3	1	B-1	B-1	113N 107E	30 cm b.d.	11-Aug-2010
2010.18.02	probable maxilla fragments	2	1.27	3	B-1	B-1	113N 107E	30 cm b.d.	11-Aug-2010
2010.18.03	unidentifiable	3	0.32	3	B-1	B-1	113N 107E	30 cm b.d.	11-Aug-2010
2010.19.01	scapula, R, between glenoid and scapular spine (paired with 2010.09.05)	1	7.34	3	B-1	B-1	108N 103E	33 cm b.d.	11-Aug-2010
2010.19.02	mandible, right body fragment	1	4.69	3	B-1	B-1	108N 103E	33 cm b.d.	11-Aug-2010
2010.19.03	unidentifiable fragments	11	2.12	3	B-1	B-1	108N 103E	33 cm b.d.	11-Aug-2010
2010.20.01	probable humerus fragments, PE	2	1.58	3	B-1	B-1	109N 103E	31 cm b.d.	11-Aug-2010
2010.20.02	I^1 R	1	0.7	1	B-1	B-1	109N 103E	31 cm b.d.	11-Aug-2010
2010.20.03	unidentifiable fragments	2	0.91	3	B-1	B-1	109N 103E	31 cm b.d.	11-Aug-2010
2010.21.01	unidentifiable fragments	6	0.33	3	B-1	B-1	105N 100E	33 cm b.d.	11-Aug-2010
2010.22.01	scapula, axillary border	1	2.88	3	B-1	B-1	110-106N 103-91E	33-34 cm b.d.	11-Aug-2010
2010.22.02	unidentifiable fragments	9	1.72	3	B-1	B-1	110-106N 103-91E	33-34 cm b.d.	11-Aug-2010
2010.22.03	I^1 L	1	0.75	1	B-1	B-1	110-106N 103-91E	33-34 cm b.d.	11-Aug-2010
2010.23.03	unidentifiable fragments	14	2.35	3	B-1	B-1	101N 93E	34 cm b.d.	11-Aug-2010
2010.23.01	clavicle fragments, probably R	10	4.37	3	B-1	B-1	101N 93E	34 cm b.d.	11-Aug-2010
2010.24.01	rib, L, medial end	1	0.87	3	B-1	B-1	82N 93E	40 cm b.d.	11-Aug-2010
2010.24.02	rib, L	1	0.79	3	B-1	B-1	82N 93E	40 cm b.d.	11-Aug-2010
2010.24.03	probable ribs	5	0.78	3	B-1	B-1	82N 93E	40 cm b.d.	11-Aug-2010
2010.24.04	unidentifiable	15	1.84	3	B-1	B-1	82N 93E	40 cm b.d.	11-Aug-2010
2010.25.01	rib shaft	1	1.96	3	B-1	B-1	80N 100E	37 cm b.d.	11-Aug-2010
2010.25.02	unidentifiable	4	0.24	3	B-1	B-1	80N 100E	37 cm b.d.	11-Aug-2010
2010.26.01	clavicle, L	1	5.84	2	B-1	B-1	93N 106E	32 cm b.d.	11-Aug-2010

2010.26.02	probable scapula	5	3.02	3	B-1	B-1	93N 106E	32 cm b.d.	11-Aug-2010
2010.26.03	probable ribs	2	1.06	3	B-1	B-1	93N 106E	32 cm b.d.	11-Aug-2010
2010.26.04	unidentifiable	18	0.38	3	B-1	B-1	93N 106E	32 cm b.d.	11-Aug-2010
2010.27.01	rib, R medial end	1	1.25	3	B-1	B-1	92-82-86N 107-103-97E	33-37-38 b.d.	11-Aug-2010
2010.27.02	rib, L	1	1.57	3	B-1	B-1	92-82-86N 107-103-97E	33-37-38 b.d.	11-Aug-2010
2010.27.03	rib, R, medial end	1	0.92	3	B-1	B-1	92-82-86N 107-103-97E	33-37-38 b.d.	11-Aug-2010
2010.27.04	rib, L, sternal end	1	0.99	3	B-1	B-1	92-82-86N 107-103-97E	33-37-38 b.d.	11-Aug-2010
2010.27.05	rib, L, medial end	1	0.79	3	B-1	B-1	92-82-86N 107-103-97E	33-37-38 b.d.	11-Aug-2010
2010.27.06	rib, L, medial end	1	1.7	3	B-1	B-1	92-82-86N 107-103-97E	33-37-38 b.d.	11-Aug-2010
2010.27.07	rib, R	1	0.74	3	B-1	B-1	92-82-86N 107-103-97E	33-37-38 b.d.	11-Aug-2010
2010.27.08	rib, unsided	1	0.43	3	B-1	B-1	92-82-86N 107-103-97E	33-37-38 b.d.	11-Aug-2010
2010.27.09	rib, unsided	1	0.48	3	B-1	B-1	92-82-86N 107-103-97E	33-37-38 b.d.	11-Aug-2010
2010.27.10	rib, L, sternal end	1	1.38	3	B-1	B-1	92-82-86N 107-103-97E	33-37-38 b.d.	11-Aug-2010
2010.27.11	rib, R, medial	1	1.18	3	B-1	B-1	92-82-86N 107-103-97E	33-37-38 b.d.	11-Aug-2010
2010.27.12	rib, R	1	0.79	3	B-1	B-1	92-82-86N 107-103-97E	33-37-38 b.d.	11-Aug-2010
2010.27.13	rib, unsided	1	0.4	3	B-1	B-1	92-82-86N 107-103-97E	33-37-38 b.d.	11-Aug-2010
2010.27.14	rib fragments, partial	2	1.15	3	B-1	B-1	92-82-86N 107-103-97E	33-37-38 b.d.	11-Aug-2010
2010.27.15	rib head, R	1	0.62	3	B-1	B-1	92-82-86N 107-103-97E	33-37-38 b.d.	11-Aug-2010
2010.27.19	rib head, L	1	0.48	3	B-1	B-1	92-82-86N 107-103-97E	33-37-38 b.d.	11-Aug-2010
2010.27.16	vertebral body	1	0.92	3	B-1	B-1	92-82-86N 107-103-97E	33-37-38 b.d.	11-Aug-2010

2010.27.17	probable ribs	15	3.7	3	B-1	B-1	92-82-86N 107-103-97E	33-37-38 b.d.	11-Aug-2010
2010.27.18	unidentifiable	>50	10.39	3	B-1	B-1	92-82-86N 107-103-97E	33-37-38 b.d.	11-Aug-2010
2010.28.01	whole cervical vertebra (probably C3)	1	2.82	1	B-1	B-1	103-92N 108-93E	33-36 cm b.d.	11-Aug-2010
2010.28.02	whole cervical vertebra (probably C4)	1	4.05	1	B-1	B-1	103-92N 108-93E	33-36 cm b.d.	11-Aug-2010
2010.28.03	Thoracic vertebra, body (probably T1)	1	5.04	2	B-1	B-1	103-92N 108-93E	33-36 cm b.d.	11-Aug-2010
2010.28.04	cervical vertebra spinous process (probably C7)	1	28.04	1	B-1	B-1	103-92N 108-93E	33-36 cm b.d.	11-Aug-2010
2010.28.05	cervical vertebra, spinous process	1	1.69	2	B-1	B-1	103-92N 108-93E	33-36 cm b.d.	11-Aug-2010
2010.28.06	cervical vertebral spinous processes	3	2.01	2	B-1	B-1	103-92N 108-93E	33-36 cm b.d.	11-Aug-2010
2010.28.07	vertebral body fragment, probably cervical	1	1.56	3	B-1	B-1	103-92N 108-93E	33-36 cm b.d.	11-Aug-2010
2010.28.08	vertebral pedicle, R, probably cervical	1	0.88	3	B-1	B-1	103-92N 108-93E	33-36 cm b.d.	11-Aug-2010
2010.28.09	vertebral spinous process, probably cervical	1	0.23	3	B-1	B-1	103-92N 108-93E	33-36 cm b.d.	11-Aug-2010
2010.28.10	thoracic vertebra, L transverse process	1	0.38	3	B-1	B-1	103-92N 108-93E	33-36 cm b.d.	11-Aug-2010
2010.28.11	cervical vertebrae, R posterior inferior articular facets	1	0.37	3	B-1	B-1	103-92N 108-93E	33-36 cm b.d.	11-Aug-2010
2010.28.16	thoracic vertebra, R superior articular facet, probably paired with 2010.28.17	1	0.16	3	B-1	B-1	103-92N 108-93E	33-36 cm b.d.	11-Aug-2010
2010.28.17	thoracic vertebra, L superior articular facet, probably paired with 2010.28.16	1	0.39	3	B-1	B-1	103-92N 108-93E	33-36 cm b.d.	11-Aug-2010
2010.28.12	rib, R, medial end	1	1.16	3	B-1	B-1	103-92N 108-93E	33-36 cm b.d.	11-Aug-2010
2010.28.13	rib, R, medial end	1	0.49	3	B-1	B-1	103-92N 108-93E	33-36 cm b.d.	11-Aug-2010

2010.28.14	partial ribs, unsided	7	4.73	3	B-1	B-1	103-92N 108-93E	33-36 cm b.d.	11-Aug-2010
2010.28.15	unidentifiable	>50	7.79	3	B-1	B-1	103-92N 108-93E	33-36 cm b.d.	11-Aug-2010
2010.28.12	rib, R, medial end	1	1.16	3	B-1	B-1	103-92N 108-93E	33-36 cm b.d.	11-Aug-2010
2010.28.13	rib, R, medial end	1	0.49	3	B-1	B-1	103-92N 108-93E	33-36 cm b.d.	11-Aug-2010
2010.28.14	ribs, unsided, partial	7	4.73	3	B-1	B-1	103-92N 108-93E	33-36 cm b.d.	11-Aug-2010
2010.29.04	unidentifiable	25	2.1	3	B-1	B-1	86-105N 93-84E	39-37 cm b.d.	11-Aug-2010
2010.30.01	radius or ulna shaft, M 1/3	1	3.31	3	B-1	B-1	113N 80E	40 cm b.d.	13-Aug-2010
2010.31.01	probable rib	1	0.6	3	B-1	B-1	97N 109E	39 cm b.d.	13-Aug-2010
2010.31.02	unidentifiable	2	0.52	3	B-1	B-1	97N 109E	39 cm b.d.	13-Aug-2010
2010.32.01	radius or ulna shaft	2	2.44	3	B-1	B-1	102N 87.5E	42 cm b.d.	13-Aug-2010
2010.33.01	radius, proximal shaft	1	3.53	3	B-1	B-1	104N 91E	31 cm b.d.	13-Aug-2010
2010.38.01	unidentifiable tooth fragment, possibly M_1	1	0.4	3	B-1	B-1	97N 108E	36 cm b.d.	13-Aug-2010
2010.01	frontal, orbit	1	2.27	2	B-1	I-10	SW	7	10-Aug-2010
2010.02	cranial fragments	8	3.84	3	B-1	B-1	B	8	11-Aug-2010
2010.03	molar tooth roots	3	0.45	3	B-1	B-1	B	8	11-Aug-2010
2010.04	hyoid body	1	0.36	2	B-1	B-1	B	8	13-Aug-2010
2010.05	humerus, head, probably L	1	7.18	3	B-1	J-10	NW	8	9-Aug-2010
2010.06	humerus head fragment	1	1.14	3	B-1	B-1	B	8	11-Aug-2010
2010.07	femur, neck	1	0.95	3	B-1	B-1	C	8	11-Aug-2010
2010.08	probable humerus, shaft fragments	2	2.1	3	B-1	J-10	NW	8	9-Aug-2010
2010.09	long bone shaft fragments	2	2.83	3	B-1	B-1	D	8	11-Aug-2010
2010.10	rib, R, sternal end	1	0.39	3	B-1	B-1	D	8	11-Aug-2010
2010.11	rib, R	1	1.45	3	B-1	B-1	D	8	11-Aug-2010
2010.12	ribs, unsided	2	0.9	3	B-1	B-1	D	8	11-Aug-2010
2010.13	rib, sternal end fragment	1	0.59	3	B-1	B-1	D	8	11-Aug-2010
2010.14	probable rib shaft fragments	2	0.73	3	B-1	B-1	C	8	13-Aug-2010
2010.15	probable rib shaft fragments	4	1.2	3	B-1	B-1	D	8	11-Aug-2010
2010.16	probable rib shaft fragment	1	0.6	3	B-1	B-1	C	8	13-Aug-2010

2010.17	rib shaft, unsided	4	1.36	3	B-1	B-1	C	8	13-Aug-2010
2010.18	probable rib shaft fragments	3	1.58	3	B-1	B-1	C	8	11-Aug-2010
2010.19	rib head, R	1	0.22	3	B-1	B-1	B	8	11-Aug-2010
2010.20	rib head, R	1	0.32	3	B-1	B-1	C	8	11-Aug-2010
2010.21	probable rib shaft fragment	1	0.75	3	B-1	B-1	A	8	13-Aug-2010
2010.22	rib shaft, L	1	1.33	3	B-1	B-1	A,B,D	8	11-Aug-2010
2010.23	rib, L, medial shaft	1	0.79	3	B-1	B-1	A,B,D	8	11-Aug-2010
2010.24	probable rib shaft fragments	3	1.35	3	B-1	B-1	A,B,D	8	11-Aug-2010
2010.25	probable rib shaft fragments	9	2.26	3	B-1	B-1	C	8	11-Aug-2010
2010.26	manubrium, L clavicular notch	1	0.94	3	B-1	J-10	NW	8	9-Aug-2010
2010.27	sternal body, right costal notch	1	0.69	3	B-1	J-10	NW	8	9-Aug-2010
2010.28	cranial vault fragments	>50	48.69	3	B-1	I-10	SW	6	10-Aug-2010
2010.29	scaphoid, L	1	0.32	2	B-1	B-1	B	8	13-Aug-2010
2010.30	vertebra, body fragment	1	0.83	3	B-1	B-1	B	8	11-Aug-2010
2010.31	cervical vertebra, R pedicle	1	0.21	3	B-1	B-1	B	8	11-Aug-2010
2010.32	cervical vertebra, R superior articular facet	1	0.68	3	B-1	B-1	A,B,D	8	11-Aug-2010
2010.33	cranial fragment	1	1.62	3	B-3	I-09	NE	2	14-Jul-2010
2010.34	cranial fragments	2	7.62	3	B-1 or B-3	J-11	Feature 2	7	9-Aug-2010
2010.35	cranial fragment	1	1.85	3	B-3	J-09	-	8	7-Aug-2010
2010.36	temporal and occipital fragment, R	1	10.25	3	B-3	J-09/I-09	-	9	8-Aug-2010
2010.37	cranial fragments	2	6.27	3	B-1	I-10	NE	3	28-Jul-2010
2010.38	cranial fragment	1	2.32	3	B-3	I-09	SW	3	15-Jul-2010
2010.39	cranial fragment	1	3.26	3	B-3	I-09	NW	1	12-Jul-2010
2010.40	proximal manal phalanx	1	0.81	2	B-3	I-09	NW	1	12-Jul-2010
2010.41	cranial fragments	2	3.31	3	B-3	I-09	NE + SE	4	2-Aug-2010
2010.42	cranial fragment	1	2.29	3	B-3	I-09	NW	surface	11-Jul-2010
2010.43	cranial fragment	1	4.14	3	B-3	I-09	SE	3	15-Jul-2010
2010.44	rib fragments	2	1.98	3	B-3	I-09	SE	3	15-Jul-2010
2010.45	cranial fragments	4	11.75	3	B-3	I-09	NE	1	12-Jul-2010
2010.46	cranial fragment	1	2.5	3	B-3	I-09	NW	1	10-Jul-2010
2010.47	cranial fragments	3	4.87	3	B-3	I-09	NW	1	12-Jul-2010
2010.48	intermediate cuneiform, L	1	1.92	1	B-3	I-09	SW	2	15-Jul-2010

2010.49	vertebra, spinous process	1	0.22	3	B-1 or B-3	J-11	Feature 2	4	8-Aug-2010
2010.50	thoracic vertebrae, R superior articular facet	1	0.89	3	B-1	I-11	SE	5	3-Aug-2010
2010.51	intermediate pedal phalanx	1	0.18	3	B-3	I-09	NW	1	10-Jul-2010
2010.52	lunate, R	1	1.54	1	B-3	I-09	SW	1	13-Jul-2010
2010.53	proximal manal phalanx, DE	1	0.81	2	B-3	I-10	NE	1	25-Jul-2010
2010.54	intermediate manal phalanx	1	1.35	3	B-3	I-10	NE	1	25-Jul-2010
2010.55	frontal, orbit	1	5.41	3	B-3	I-09	NW	surface	11-Jul-2010
2010.56	intermediate pedal phalanx	1	0.23	1	B-1	J-11	NW	1	24-Jul-2010
2010.57	proximal manal phalanx, midshaft	1	1	2	B-3	J-09	-	7	7-Aug-2010
2010.58	intermediate manal phalanx	1	0.62	1	B-3	I-09	SE	1	12-Jul-2010
2010.59	distal manal phalanx	1	0.47	1	B-3	I-09	SE	1	12-Jul-2010
2010.60	intermediate pedal phalanx	1	0.26	1	B-3	I-09	NE	1	12-Jul-2010
2010.61	distal manal phalanx	1	0.38	1	B-3	I-09	NE	1	12-Jul-2010
2010.62	metacarpal shaft, unsided	1	0.85	3	B-3	I-09	SW	4	30-Jul-2010
2010.63	intermediate manal phalanx	1	0.51	1	B-3?	J-11	NE	4	8-Aug-2010
2010.64	proximal pedal phalanx, M1/3	1	0.16	1	?	J-11	NE	4	8-Aug-2010
2010.65	vertebra, spinous process	1	0.36	3	B-3	I-09	NE	1	12-Jul-2010
2010.66	proximal manal phalanx, DE, possible non-union fracture	1	0.19	3	B-1 or B-3	J-11	Feature 2	7	9-Aug-2010
2010.67	molar root, lower	1	0.42	2	B-1	B-1	B	8	11-Aug-2010
2010.68	rib fragment, shaft, unsided	1	1.35	3	B-3	J-09	-	7	7-Aug-2010
2010.69	rib head fragment, refit	3	0.44	3	B-1	I-11	NW	5	2-Aug-2010
2010.70	scapula, L, axillary border	1	2.53	3	B-1	J-10	NW	8	9-Aug-2010
2010.71	trapezium, R	1	1.11	1	B-3	I-09	NW	1	10-Jul-2010
2010.72	unidentifiable molar root, upper?	1	0.23	3	B-1	B-1	B	8	11-Aug-2010
2010.73	tooth root	2	0.27	3	B-1	B-1	A,B,D	8	11-Aug-2010
2010.74	molar root	2	0.52	2	B-1	B-1	B	8	11-Aug-2010
2010.75	P^4 R	1	0.27	2	B-1	B-1	B	8	11-Aug-2010
2010.76	P^3 R	1	0.59	1	B-1	B-1	B	8	11-Aug-2010
2010.77	M^2 R	1	0.38	1	B-1	B-1	B	8	11-Aug-2010
2010.78	unidentifiable	71	16.63	3	B-1	B-1	A	8	11-Aug-2010
2010.79	unidentifiable	70	17.7	3	B-1	B-1	A	8	13-Aug-2010

2010.80	unidentifiable	92	9.88	3	B-1	B-1	A, B, D	8	11-Aug-2010
2010.81	unidentifiable	52	8.43	3	B-1	B-1	B	8	11-Aug-2010
2010.82	unidentifiable	4	0.67	3	B-1	B-1	B	8	13-Aug-2010
2010.83	unidentifiable	21	1.51	3	B-1	B-1	B	8	13-Aug-2010
2010.84	unidentifiable	2	0.22	3	B-1	B-1	B	8	13-Aug-2010
2010.85	unidentifiable	5	0.97	3	B-1	B-1	B	9	16-Aug-2010
2010.86	unidentifiable	9	0.75	3	B-1	B-1	B	8	11-13-Aug-2010
2010.87	unidentifiable	24	2.21	3	B-1	B-1	C	8	11-Aug-2010
2010.88	unidentifiable	73	13.44	3	B-1	B-1	C	8	13-Aug-2010
2010.89	unidentifiable	36	5.22	3	B-1	B-1	C	9	16-Aug-2010
2010.90	unidentifiable	25	2.39	3	B-1	B-1	C	8	11-13-Aug-2010
2010.91	unidentifiable	13	1.07	3	B-1	B-1	C	9	16-Aug-2010
2010.92	unidentifiable	51	8.5	3	B-1	B-1	D	8	11-Aug-2010
2010.93	unidentifiable	37	4.41	3	B-1	B-1	D	8	13-Aug-2010
2010.94	unidentifiable	11	1.88	3	B-1	B-1	D	9	16-Aug-2010
2010.95	unidentifiable	2	0.21	3	B-1	B-1	D	9	16-Aug-2010
2010.96	unidentifiable	13	1.5	3	B-1	B-1	D	8	11-13-Aug-2010
2010.97	unidentifiable	66	13.29	3	B-1	I-10	SW	6	10-Aug-2010
2010.98	unidentifiable	2	1.66	3	B-1	I-10	SW	7	10-Aug-2010
2010.99	unidentifiable	12	1.54	3	B-1	J-10	NW	8	9-Aug-2010
2010.100	unidentifiable	17	2.84	3	B-1	I-11	SE	9	14-Aug-2010
2010.101	unidentifiable	22	2.43	3	B-1	I-11	SE Feature 2	9	14-Aug-2010