SEDIMENTOLOGY AND TAPHONOMY OF CENOZOIC VERTEBRATES FROM LANGEBAANWEG, CAPE WEST COAST, SOUTH AFRICA; WITH PALAEOECOLOGICAL INTERPRETATIONS

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DECLARATION

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ABSTRACT

The fossil locality Langebaanweg, is world renowned for its vast abundance and diversity of fauna. Langebaanweg is the only fossil site in South Africa that preserves remains fromthe Late Miocene to Early Pliocene. The Mio-Pliocene is a period of major climatic change, with global temperatures falling, and increased aridity and seasonality across the African continent. Langebaanweg, located on the coastal platform of Southern Africa, is ideally placed to investigate how these major changes in climatic conditions in the Mio-Pliocene affected ecology, environment and animals in south-western Africa. The majority of fossils from Langebaanweg were recovered from the early Pliocene Varswater Formation. Specifically, the two major fossil bearing horizons the Langeberg Quartz Sand Member (LQSM) and the overlying Muishond Fontein Pelletal Phophorite Member (MPPM). The Varswater Formation has been reconstructed as a fluvio-estuarine environment with localised tidal-flats and marshes. The relationship between the MPPM and the LQSM and their relative ages and depositional environmentsis controversial. This thesis sought to investigate the depositional environment of the MPPM and LQSM in Langebaanweg E-Quarry, with the aim of identifying the relationship and comparative ages of the two members. In order to investigate this, three test pits were excavated at Langebaanweg and the lithology, sedimentology and taphonomy of remains recovered from the test pits was studied. The test pits were located in the sivathere bonebed, the 1976/2 excavation and in a new locality positioned 200 m to the south of the 1976/2 excavation. The depositional environment of the bonebed and 1976/2 were investigated as well as their relationship to each other. The taphonomic pathways by which bones came to be interred in each test pit was identified.

Sedimentologically the MPPM and LQSM were found to be almost identical and the only major distinguishing characteristic was the lack of phosphate in the latter deposit. This indicates that the two horizons were deposited in the same setting and/or by the same depositional process. Additionally the MPPM and LQSM sediments were dominated by fine to very fine sand grains and muds and silts were virtually absent (except in the MPPM in one test pit). This, together with the texture of the sediments, lead to the conclusion that the MPPM and LQSM, in Langebaanweg E-Quarry, were had a marine origin. Langebaanweg E-Quarry is here interpreted as a barrier-island estuary formed on a wave-dominated coast. Given the consistency of sediments, taxa and taphonomic characters between the MPPM and the LQSM they are interpreted as representing a single unit or depositional event where the upper parts

(MPPM) have been secondarily phosphatised. Under this scenario, there is no unconformity or age gap between the MPPM and the LQSM. Investigations of the depositional environment of the 1976/2 excavation concur with Hendey's (1980) reconstructions for a river channel. The results of this study reject previous reconstructions of the sivathere bonebed as a lag deposit of a river channel (Roberts *et al.* 2011; Smith & Haarhoff 2006). This study shows that the bonebed was deposited in a low energy freshwater pool associated with the river. No evidence was found for an aquifer-fed spring as suggested by Brumfitt *et al.* (2013). The MPPM sediments of the test pit located to the south of 1976/2 displayed a dominance of fine muds and silts with a possible high organic content. This was interpreted as a possible marsh habitat. This is the first study to identify a marsh environment at Langebaanweg since the 1980's and all other examples of this type of environment have been destroyed by mining. The identification of this locality will provide exciting new opportunities for future research. Taphonomic analysis has shown that the influence of fire and predation on faunal remains excavated in this study was small and internment in all cases was quick. As a final note, this thesis conducted a review of previous research and excavations at Langebaanweg E-Quarry by Dr Brett Hendey and identified the location of some fossil collecting localities that had been lost. These were plotted onto aerial photographs, whichwill be beneficial to future researchers trying to identify old locals or identify new deposits.

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CHAPTER ONE

INTRODUCTION

1.1 THE MIO-PLIOCENE

The Mio-Pliocene transition is an important period both in terms of global environmental change and mammal evolution, especially in Africa. Following the Middle Miocene climatic optimum(Flower & Kennett 1994) temperatures fell, sea levels dropped and aridity and seasonal rainfall increased (Roberts *et al.* 2011); according to various sources from the marine realm (sea cores) and terrestrial strata. These climatic shifts drove changes in the floral and faunal kingdoms. On the African continent, riparian tropical and temperate forestsyielded to grasslands (Coetzee & Rogers 1982; Scott 1995). However the changeover was not complete, as relict temperate and tropical forests still exist, in a reduced form (Sayer *et al*. 1992). Animal communities from this period display a general increase from species better adapted to living intropical forests to species adapted to savannah-mosaic environments (Cerling *et al.* 1997; Sciscio *et al.* 2013). Isotopic analyses of fossil ungulatesindicate that populations of grazing taxa that predominantly consumed C_3 vegetation have shifted to populations that predominantly consumed C_4 vegetation (Cerling *et al.* 1997).

Today, along the South African west coast, the Benguella Upwelling System (BUS) mediates and controls sea surface temperature and climate (Roberts *et al.* 2011). Various authors have suggested that the BUS was already established by about 10-11 Ma (Rommerskirchen *et al.* 2011; Heinrich *et al.* 2011). The BUS has experienced numerous fluctuations in strength, with knock-on effects on sea surface temperature and marine productivity (Pether *et al.* 2000; Roberts & Brink 2002; Roberts *et al.* 2007a, b). In addition, the west coast experienced numerous changes in sea level, including a major Pliocene transgression (sea level rise) (Roberts *et al.* 2011). At least three Pliocene high sea-stands can be observed at numerous localities along the south west coast today, reaching elevation maxima at about 30 m, 50 m and 90 m amsl (Pether *et al.* 2000; Roberts & Brink 2002; Roberts *et al*. 2007a, b). Positioned on the south west coastal platform, the Mio-Pliocene deposits of Langebaanweg are ideally suited to investigate the effects of these major climatic changes on the fauna and flora of the South African west coast.

There are numerous Miocene and Pliocene fossil localities from Northern and Eastern Africa (Morales *et al*. 2005; Morales & Pickford 2008; Morales *et al.* 2000; Werdelin & Peigne 2010), however the Miocene

and Early Pliocene are poorly represented in Southern Africa (Werdelin 2010).Arrisdrift in Namibia (Morales *et al*. 1998; Pickford 2000) from the Middle Miocene is the only locality with a large and diverse faunal assemblage. The Mio-Pliocene is a period of great faunal change including the first appearance of hominins in Eastern and central Africa around 6 – 4 Ma (White *et al*. 1994; Senut *et al*. 2001; Brunet *et al*. 2002). Understanding the ecology and palaeoenvironment of southern Africa at this time period will augment our understanding of the environment across the continent and how fauna have reacted to changes to that environment. The fossil locality Langebaanweg, which is the only Mio-Pliocene aged locality in South Africa, provides an ideal opportunity to investigate the effects of post-Miocene climatic changes on southern Africa.

1.2 LANGEBAANWEG

The extraordinarily copious and diverse fossil assemblage of Langebaanweg, has been described as superlative for the study of environmental dynamics during the Mio-Pliocene transition (Ungar *et al*. 2007).Langebaanweg is located on the South African west coast, approximately 120 Km north of Cape Town (Figure 1.1) and 15 Km east of the current shoreline (Figure 1.2). The site contains sediments dating from the Middle Miocene to the Holocene (Roberts *et al.* 2011). The Early Pliocene Varswater Formation (Roberts 2006c; Roberts 2006b; Roberts *et al.* 2011) contains abundant vertebrate and invertebrate fossil remainsand is the focus of this thesis.The context in which the Varswater Formation was deposited has been reconstructed asfluvio-estuarinewith localisedtidal-flats and marshes (Hendey, 1980, 1981b; Roberts *et al.* 2011). There are two major fossil bearing horizons in the Varswater Formation, from which the majority of the Langebaanweg fossils have been collected, namely the Langeberg Quartz Sand Member (LQSM) and the overlying Muishond Fontein Pelletal Phophorite Member (MPPM). The lithology, fauna and other characteristics of these deposits are discussed in greater deal in the following chapters. The relationship between the MPPM and LQSM is controversial. Some authors believe an unconformity existed between the members (Hendey 1981b), while others indicate an erosional contact (Roberts *et al.* 2011), and still others believe the members are contemporaneous (Middleton 2000; Pether *et al.* 2000). Understanding the relationship between the MPPM and LQSM is essential to determining the context in which fossils were deposited at Langebaanweg and the length of time over which accumulation took place. Once these factors have been securely established, the animal community structure and palaeoenvironment of Langebaanweg can be explored. Exploring these characteristics at Langebaanweg can also inform our understanding of

palaeoenvironment on the south west coast during the Early Pliocene and how palaeocological conditions in this region may have responded to global climatic changes in the Mio-Pliocene.

The diversity of faunal remains discovered at Langebaanweg is striking with over 280 species identified, including mammals, anurans, avians, piscorines, reptiles and occasional invertebrates. Some organisms occur in astonishing quantities like the extinct girraffid*Sivatherium hendeyi,* of which over 500 individuals have been identified (Roberts *et al.* 2011). One of the most remarkable aspects of the Langebaanweg faunal assemblage is the large number of carnivore species found at the site (Hendey 1972, 1974; 1978a, b, 1980; Morales *et al*. 2005; Stynder 2009; Werdelin & Peigne 2010; Hartstone-Rose & Stynder 2013). Up to this point, it has been unclear whether these species coexisted at the same time, or whether the assemblage represents a time averaged deposit. This is an important consideration; the ecological factors that could allow the coexistence of so many carnivores and their effects on the rest the faunal needs to be investigated. Avian remains at Langebaanweg are numerous (Manegold *et al*. 2013); however no previous attempt has been made to identify the taphonomic pathway or accumulating mechanism for these remains. Identifying how bird bones have been modified and accumulated will supplement our understanding of the palaeoecological roles of these birds. Langebaanweg has produced vast quantities of microfauna including rodents, anurans, reptilia and even fish (Hendey 1981b). The rodentia and the anurans are the only taxonomic groups of microfauna that have been studied in any detail and they have proved to be valuable palaeoecological indicators (Matthews *et al*. 2006; Matthews *et al.* 2007; Matthews & Stynder 2011;Matthews *et al*. 2015;Matthews *et al*. 2016; Denys & Matthews 2017). The Langebaanweg fossil accumulations are characterised by vast quantities of chelonian remains. This taxonomic group, which often outnumbers mammals, is virtually unstudied, and not even the species composition is known. Various taphonomic pathways for the preservation of such vast quantities of chelonian bones are possible including carnivory or mortality from veld fires. No taphonomic information for the family has been recorded and these theories will be tested for the first time in this analysis.

1.2.1 The Bonebed

Langebaanweg is most well known for the large, high density fossil bone bed discovered in 1998. This bonebed contains remains from many taxonomic groups including mammals, reptilia, anurans, pisces and aves (Figure 1.3). These remains vary from small fauna including a vast assemblage of

micromammals and anurans to megamammals like sivathere and whales. Terrestrial, freshwater and marine species are mixed together in the bonebed. Remains in the bed are very well preserved, although numerous specimens display clear green-stick fractures indicative of trampling. Much of the bonebed excavation and fossil material has been left *in-situ* and forms the basis of the visitor experience at Langebaanweg. Despite the large faunal assemblage procured from the bonebed its taphonomy has received little attention and its origins and depositional environment are contentious. Some researchers have suggested that the bonebed was deposited as part of a river channel (Roberts *et al*. 2011). Others suggest a low energy microenvironment like a scour pool (Smith & Haarhoff 2006) or aquifer-fed waterhole (Brumfitt *et al.* 2013).

An additional excavation site (originally named 1976/2) can be found in close proximity to the bonebed. This deposit, excavated in 1976, produced vast amounts of faunal material including several bones from the African bear and partial skeletons or associated bones from several taxa. The 1976/2 excavation samples bones from the MPPM and uppermost LQSM and forms part of the important bed 3aNorth river channel deposits. Hendey (1980b, 1981) believed the bed 3a North and South deposits, respectively, formed part of a seasonal river channel system. The bed 3a North/South river channels are important fossil localities as much of the MPPM fossils were recovered from these deposits, but their precise locations (outside of the 1976/2 excavation) are lost or confused. In this thesis, I use field notes, mine records and aerial photographs to relocate these deposits. Additionally, many details of the depositional environment of bed 3a North/South and its relationship to the nearby bonebed are poorly understood.

The bonebed and 1976/2 excavationswere considered ideal locations from which to excavate fresh bone material for taphonomic analysis and for clearing new lithological profiles for sedimentary analysis. A study of the taphonomic characters of bones from the bonebed and 1976/2 excavation together with updated sedimentary analysis was utilised in this study to elucidate the depositional setting of these deposits and toamelioratepreviously palaeoenvironmental reconstructions. Detailed analysis of these sites utilising modern techniques was utilised, additionally, to augment our understanding of the Varswater Formation as a whole.

1.3 PROPOSED RESEARCH

The aim of this study was to reinvestigate the depositional environment of the MPPM and LQSM in the river channel localities of E-Quarry. Depositional environment was investigated by describing the lithology and characterising the taphonomic signature of bones from test pit excavations within the bonebed, 1976/2 excavation and in a new area (Profile One) in the southern part of the quarry. The bonebed and 1976/2 excavation are key localities in Langebaanweg E-Quarry that have produced large fossil assemblages and whose depositional contexts and palaeoenvironments are contentious. Additionally, an area external to the river channel system (Profile One) was located well away from the bonebed and 1976/2 deposit, for comparative purposes.

Identifying the lithology and taphonomy at Langebaanweg has allow me to address fourmajor research questions, namely(1) are the MPPM and LQSM contemporaneous or is there an unconformity between them?(2)Were the MPPM and LQSMdeposited by different processes or in different environments?(3) What is the depositional environment of the bonebed, the 1976/2 excavation and the new site (Profile One)?(4) What were the taphonomicpathways experienced by bones from the bonebed, the 1976/2 excavation and the new site (Profile One)?Addressing these four major questions has greatly augmentedour of understanding of Langebaanweg and of the methods by which bones have become interred in some areas of the site.

This analysis has also allowedme to address some specific taphonomic questions, namely (1) was fire the major accumulating process for chelonian remains?(2) Does Langebaanweg display high levels of carnivory and can the potential predators involved be identified?(3) Were bones sub-aerially exposed for prolonged periods?(4) Do bones display evidence for fluvial transport or high energy depositional environments?These taphonomic pathways have informed our understanding of depositional conditions of the MPPM and the LQSM and has helped clarify the origins of the bonebed and 1976/2 deposit.

The result of this investigation was a palaeoecological reconstruction of the bonebed, 1976/2 excavation and the new site that synthesises lithology, taphonomy and taxonomy of the new excavations with previous literature. These reconstructions have helped resolve the origins of these deposits. The results of this analysis have augmentedourunderstanding of depositional conditions and past environments at Langebaanwegand by extension, the South African west coast during the Mio-Pliocene transition.



Figure 1.1. South-western South Africa. Showing the border of the Western Cape Province, Cape Town and Saldanha (where the fossil park is located).



Figure 1.2. Saldanha peninsula with location of West Coast Fossil Park (blue), Langebaan lagoon and modern Berg River (arrows) shown.



Figure 1.3. Sivathere bonebed Langebaanweg. View into a portion of the bonebed with the phosphate rock just visible in the top of image. Grid squares are 1m^2.

CHAPTER TWO

THE GEOLOGICAL SETTING OF LANGEBAANWEG

2.1 INTRODUCTION

The geology of the west coast in the region around Saldanha Bay consists of deeply weathered Precambrian Malmesbury Group quartzites, limestones and shales, and Cambrian aged Cape Granite suite intrusives which are unconformably overlain by a package of Cenozoic sediments (Middleton 2003; Roberts 2006c). The Cenozoic sequence, which extends all the way to Cape Hangklip (Middleton 2003), consists of the Sandveld Group. The Sandveld Group is made up of a number of formations including the Elandsfontyn, Saldanha, Varswater, Velddrift, Langebaan, Springfontyn and Witzand Formations(Tankard 1975, 1974;Rogers 1980; Hendey 1981a; Hendey & Dingle 1983). These formations represent a variety of depositional environments ranging from marine, marginal marine, estuarine, floodplain, marsh and aeolian dunes. This study focused mainly on the Varswater Formation.

2.2 ELANDSFONTYN FORMATION

The Elandsfontyn Formation is not naturally exposed and has been defined on the basis of borehole core and quarry data. It has been dated from Early – Middle Miocene by its pollen and spore assemblage (Coetzee & Rogers 1982), however the foraminifera indicate a Middle Cretaceous age (Dale & McMillan 1999). The Elandsfontyn Formation predominantly consists of upward fining sequences of angular to fine quartzose sands without phosphate or carbonate grains (Roberts 2006a). The depositional environment is interpreted as a meandering river system (Rogers 1980, 1982).

The phosphate rich Varswater Formation overlies the Elandsfontyn Formation. The Varswater Formation is particularly well preserved in the Langebaanweg area and E-quarry is the type locality (Tankard & Rogers 1978). The vast majority of the incredibly rich fossil fauna from Langebaanweg was recovered from E-quarry (Hendey 1970b,a). At one stage, as many as three quarries were active in the Langebaanweg area, namely; Baard's-Quarry, C-Quarry and E-Quarry (Figure 2.1). Fossils were produced from all three quarries; however, the majority of remains were recovered from E-Quarry and it is this

locality that has provided the quintessential Langebaanweg fossil bones. Initially the relationships between Baard's-Quarry, C-Quarry and E-Quarry were not well understood. Indeed, today we know that Baard's-Quarry was younger than C- and E-Quarries (Hendey 1976). This problem confounded early geological interpretations which assumed that all the quarries were the same age and sampled the same deposits. Baard's- and C-Quarries were closed and backfilled by 1970, and since then, research at Langebaanweg has focussed on E-Quarry. Names and terminology of the quarries changed over time, as did the geological and palaeontological interpretations of the site. Below, quarry terminology is outlined and brief descriptions of Baard's- and C-quarries are presented before we focus on E-Quarry.

2.3 QUARRY TERMINOLOGY

In 1961, when the fossil rich phosphate quarries of Langebaanweg were announced, the mine was essentially composed of two quarries namely; *Baard's Quarry* and *Varswater Quarry*, both of which were situated on the farm "Langeberg" (Singer 1961). The farm was later subdivided, so that by 1965,Varswater Quarry was situated on the farm "Langeberg Suid" while Baard's-Quarry was situated on the farm "Remainder of Langeberg" (Boné & Singer 1965). In 1976, Hendey described Baard's-Quarry as located on the farm "Muishondfontein". By 1969, the Varswater Quarry had been separated into C-Quarry and E-Quarry, which together became known as the Varswater ore-body(Hendey 1970). The farm Langeberg Suid became known as the "*Varswater Farm*" (Hendey, 1974) and after C-Quarry and Baard's-Quarry were abandoned, the E-Quarry became known as the *New Varswater Mine* (Hendey, 1976). In this analysis, Langebaanweg is used to refer to findings from, and discussions about, E-Quarry, unless otherwise stated.

Baard's-quarry and C-quarry

Initial interpretations of the deposits at Langebaanweg, based on notes and observations by passing geologists, identified five basic layers in the deposit (Singer 1961). Among the layers observed were sands, peats, and phosphate layers, as well as, calcretes and ferricretes. By 1964, it was realised that the phosphates at the Varswater quarry differed from those of Baard's-Quarry and that the former consisted of three main layers (Boné & Singer, 1965). The first detailed descriptions of the geology and stratigraphy of Langebaanweg were presented by Hendey in 1970. Hendey (1970a) observed a bed of

deltaic sediments within C- and E-Quarries which he termed the *Varswater bed;* while at Baard's-Quarry a fluviatile horizon was termed the *Langberg bed*. C-Quarry and Baard's-Quarry were closed and backfilled after 1970.

C-Quarry was located about 500 m west of E-Quarry on the western fringes of the Varswater bed (Hendey 1970) (Figure 2.1). More details of the stratigraphy and fauna recovered from C-quarry can be found in Hendey (1970a). Baard's-Quarry was situated about 2.5 Km east of E-Quarry (Hendey 1970a). The Langeberg bed found at Baard's-Quarry contained phosphatic sandstone and river-worn quartz porphyry cobbles in a clayey sand matrix (Hendey 1978). This bed consisted of river channels containing greenish-white clayey-sands which were incised into the underlying layers of clays and clayey sands (Hendey 1978). The majority of the E-Quarry fossils were recovered from the Langeberg bed and biochronology indicates a much younger age for the Langeberg bed and underlying layers, likely early Pleistocene (Hendey 1978c). The surface sands at Baard's-Quarry contained ferricretes and other duricrusts. How the younger deposits at Baard's-Quarry correlate with the E-Quarry succession remains unclear as there are no records, or exposures, for the intervening area (Hendey, 1978c).

2.4 VARSWATER FORMATION

The Varswater Formation, which forms part of the Sandveld Group (Hendey & Dingle 1983), rests on the Neogene aged Elandsfontyn Formation or on Cambrian/Neoproterozoic bedrock (Roberts 2006c). It is overlain by a variety of Pleistocene strata, typically of aeolian origin, most commonly the Langebaan Formation (Roberts 2006c). Currently, four members are recognised in the Varswater Formation(Figure 2.2), namely the Langeenheid Clayey Sand Member (LCSM); KoningsVlei Gravel Member (KGM); Langeberg Quartz Sand Member (LQSM) and the MuishondFonteinPelletalPhosphorite Member (MPPM) (Roberts 2006c). The lithologies of these members are described below.

2.4.1 Langeenheid Clayey Sand Member

The Langeenheid Clayey Sand Member (LCSM) forms the basal member of the Varswater Formation (Roberts *et al.* 2011); it corresponds to Tankard's (1975a) Kaolinitic Clay and to the Saldanha Formation of Hendey (1981b). The LCSM consists of clayey, greyish green sands with reddish mottles. The sand is fine-grained, well-rounded, well-sorted (Roberts *et al*. 2011) and is sporadically phosphatic (Roberts

2006c). The LCSM has a thickness ranging from 1 to 11.5 m; and rests conformably on carbonaceous silts and clays of the Elandsfontyn Formation (Roberts *et al*. 2011). There is a sharp and erosive contact between the LCSM and the overlying KGM and as the latter is considered to be early Late Miocene in age, the LCSM is assumed to be notably older, in the region of the Middle Miocene (Roberts 2006c). Roberts and colleagues (2011) indicate a close resemblance between the lithology of the LCSM and estuarine deposits of the modern Berg River.

2.4.2 Konings Vlei Gravel Member

This member was named the Beach Gravel by Tankard (1975b) and represents Hendey's (Hendey 1974, 1970b) Bed 1 and Horizon 3 basal marker. Hendey (1976) changed the name to Gravel Member and Roberts (2006d) finally redesignated it as the Konings Vlei Gravel Member (KGM). The KGM gravel contains brown well-rounded and polished phosphorite clasts which are partly ferruginised (Roberts 2006c). The clasts are spherical to discoidal and up to 0.6 m in diameter. The matrix comprises slightly silty sand with pelletal phosphorite and yellowish phosphatised shell fragments. The gravel grades into coarse sandy gravel in places. In addition, there are consolidated lenses of older eroded clasts of phosphorite of up to 1 m thick (Tankard 1975b, Middleton 2003). The member attains a maximum thickness of 3 m and has a mean thickness of 1.5 m (Roberts 2006c). The complex agglomeration of material in this bed represents the reworking of multiple phases or generations of apatite cementation (Butzer 1973; Tankard 1974b) by wave action as the shoreline migrated onshore. The KGM is associated with a marine invertebrate fauna (Tankard 1975b) of Late Miocene age (Roberts *et al.* 2011), indicative of warm marine conditions (Hendey 1981b). The KGM is considered to be early Late Miocene in age (Hendey 1981b). It rests unconformably on the LCSM (the lowermost unit of the Varswater Formation). This boundary is marked by a clay-pebble conglomerate in E-Quarry (Roberts 2006c). Petrographic evidence from the KGM shows that had a more complex history of phosphatisation and reworking than the MPPM (Middleton 2003). According to Middleton (2003), the KGM displays evidence of episodic sediment reworking by wave action.

2.4.3 Langeberg Quartz Sand Member

This horizon was termed the Fluvial Sand Member by Tankard (1975b), but Hendey (1976) later changed the name to the Quartzose Sand Member (QSM). In 2006, the name of the member was updated again to the Langeberg Quartz Sand Member (LQSM) (Roberts 2006c). This member represents Hendey's (1974) Bed 2 and Hendey's (1970b) Horizon 1. The LQSM can be distinguished from the overlying member (MPPM) by its non-phosphatic character (Hendey 1981a). It consists of very fine to medium grained, moderately sorted quartzose sands (Roberts 2006c). The LQSM has a mean thickness of 1.5 m and reaches a maximum thickness of 2.5 m. Generally light grey in colour (but reddish in parts due to iron staining), the colour is distinctly paler than the overlying MPPM. Silty and peaty facies are developed in places (Tankard 1974b; Roberts *et al.* 2011), however the member predominantly reflects a fluvio-estuarine depositional environment (Roberts *et al.* 2001; Hendey 1976). Tankard (1975b) identified separate fluvial and estuarine facies in the LQSM, however these facies were not observed by Roberts (2006b) and Roberts*et al.*(2011). Roberts (2006b) and Roberts *et al.*(2011) indicate that the upper and lower boundaries of the LQSM are both sharp. However, Pether *et al.* (2000) and Middleton (2000) both suggest that the LQSM is at least partially contemporaneous with the MPPM, passing both laterally and vertically into each other. Dingle*et al.*(1979) identified the presence of a river channel (bed 3aNorth, see Chapter Three for details) in the LQSM deposit and noted a shift in this channel northwards up the section. Hendey (1976, 1981b) suggested that this member was truncated prior to deposition of the overlying member. The LQSM is one of the most highly fossiliferous deposits at Langebaanweg and is currently biochronologically placed around 5.2 Million years of age (Roberts *et al.* 2011), although there has been much debate over the years as to the date of the Langebaanweg fossils.

2.4.4 Muishond Fontein Pelletal Phosphorite Member

The uppermost part of the Varswater Formation; this unit was initially termed horizon 4 (Hendey 1970b) but later became known as bed 3a and bed 3b (Hendey 1974). Tankard (1975b) designated the unit as the Pelletal Phosphorite Member (PPM), a term used extensively in the literature up to 2006 when Roberts (2006b) renamed the unit as the Muishond Fontein Pelletal Phosphorite Member (MPPM). Roberts (2006b), additionally included the Duynefontein Member described by some authors (Olson 1985a, b; Avery & Klein 2011) in the MPPM. The MPPM displays a tabular to lenticular character, has a mean thickness of 15 m and attains a maximum thickness of 20 m (Roberts 2006b). It consists of a fine

to coarse grained, moderately sorted, light brownish grey (5YR 6/1) phosphatic and quatzose sand (Roberts 2006c). The size distribution of grains is bimodal with angular to subangular fine sand and angular to rounded, medium to coarse sand (Smith 1971). The MPPM is generally massive and structureless but fine laminations (variations in phosphate content) occur sporadically (Roberts *et al.* 2011). There are two kinds of phosphate present in the MPPM. The first are coarse-grained amber coloured shell fragments of authigenic carbonate apatite, while the remaining material is pelletal phosphorite (Roberts 2006c). Middleton (2003) notes the presence of well-rounded, sand-sized peloidal phosphorite grains in the MPPM, associated with fractured but rounded quartz grains, indicating multiple reworking and carbonate fluorapatite precipitation.

The MPPM contains unconsolidated phosphatic sands and consolidated quartzose phophorite (Middleton, 2003). The latter is generally overlain by the phosphate rich sands (Middleton 2003).The consolidated phosphorite was formed by precipitation of authigenic apatite within the pore spaces of the phosphate rich sediments (Dingle *et al.* 1979). The consolidated phosphorites and unconsolidated phosphatic sands are compositionally and texturally similar; however, the former is cemented by carbonate fluorapatite (Middleton 2003). The MPPM phosphorites are texturally different from the reworked phosphorites in the underlying KGM. Laminated sand layers support deposition and reworking in a high-energy, upper-flow environment (Middleton 2000). Clays and lignites make up less than 20% of the MPPM and form minor interbeds (Roberts 2006c).

The MPPM is generally weakly cemented by calcareous material, but local spots are hard and well cemented with phosphate. Nodular horizons of brown phosphate can be observed extending laterally for up to 300 m (Roberts 2006c). The upper boundary between the MPPM and the Langebaan Formation is strongly unconformable, marked by secondary ferruginisation, calcification and phosphatisation, resulting from subaerial exposure (and weathering) of the MPPM (Roberts 2006c). The lower boundary between the MPPM and the LQSM is sharp and slightly erosional (Roberts *et al*. 2011). Tankard (1974) believed that the phosphorites of the MPPM were derived (by erosion) from the underlying KGM. Middleton (2003) found peloids in the MPPM that were similar to peloids found in the KGM, from which he believed they were derived. The phosphate was produced authigenically as a result of periodic cold upwellingsof the Benguella Upwelling System (Roberts *et al*. 2011). The MPPM is considered to record both marine littoral and fluviatile settings (Tankard 1974a; Hendey 1981b). Middleton identified phosphatised bivalve shell fragments, echinoid spines and occasional benthic foraminifera in the MPPM sediments indicating a marine origin for the deposit. Burrows within the

consolidated phosphorite beds indicate shallow and well-oxygenated waters; however, iron-staining in the sediments indicates later subaerial exposure (Middleton 2003). The phosphorites of the Varswater Formation have been shown to be composed, mineralogically, predominantly of quartz and francolite (Middleton 2003).

The majority of the fossils recovered from the MPPM occurred as lag deposits within (two) south-westerly orientated linear channels (Roberts *et al.* 2011), known as bed 3a North (3aN) and bed 3a South (3aS), which Hendey (1976, 1981b) considered to be river channels. Beds 3aN and 3aS are directed to the south-west and their geology suggests that they were deposited as channels of fast flowing water (Hendey 1976). See Chapter Three for descriptions of bed 3aN/S and their location. Bed 3aN is, in places, at a slightly higher elevation than bed 3aS, but the former is nowhere superimposed on the latter (Hendey 1981b). Pickford and Senut (1997), proposed a Miocene age based on a revision of the East African vertebrate stratigraphy. However, Dale and McMillan (1999) and Franscerschini (2003) follow Hendey (1981b) in estimating an Early Pliocene age.Dale and McMillan (1999) utilised microfossil taxa *Uvigerina* sp. and *Discorbis* "*algoaensis"* to estimate ages at Langebaanweg; while Franceschini (2003) undertook Strontium ($^{87}Sr/^{86}Sr$) isotope ratios of phosphorite peloids from the MPPM.

2.5 ORIGINS AND CHARACTERISTICS OF THE PHOSPHORITES OF LANGEBAANWEG

Phosphorite is a term used to describe any sedimentary deposit that contains more than 18% P_2O_5, or the equivalent of 50% apatite (Bushinsky 1969). Singer (1961) and Boné and Singer (1965) believed that the phosphate rich strata of Langebaanweg were the result of replacement of shelly sands by phosphate rich solutions and that the phosphate in question was derived from guano, although the origins of the guano was left to the reader's imagination. Tankard (1975) suggested that the phosphates were formed authigenically in a shallow marine setting in three separate depositional phases. This was refuted by Birch (1979) who showed that the different phosphate deposits could have formed contemporaneously in the same environment.

Marine phosphogenesis occurs when bacterial degradation of (dead) phytoplankton, that has settled on the sea floor, releases organic phosphorous as phosphate ions. This usually happens under suboxic to oxic conditions (Trappe 1998). Phosphate ion concentrations become elevated within the interstitial spaces of the sediments, leading to eventual supersaturation of phosphate and precipitation of carbonate fluorapatite as pore-filling cement and the formation of phosphatic sandstone. This stage is

characteristically suboxic to anoxic (Trappe 1998). Precipitation of fluorapatite can also occur by replacement of precursor biogenic carbonate bioclasts, these will gradually form carbonate flourapatite-cemented phosphorite nodules and ultimately transform the sediment into a fully lithified phosphatic rock (Garrison & Kastner 1990; Middleton 2003).

Langebaanweg displays three types of phosphate, namely pure consolidated phosphatic rock, semi consolidated phosphatic sandstone, and semi consolidated pelletal phosphorite. According to Birch (1979) the finely bedded (5-30 mm) varve-like layers of pure phosphorite rock indicate that precipitation occurred directly from the overlying water column and that lithification was rapid. The well-sorted phosphatic sandstones, on the other hand, contain pelletal phosphate grains in a matrix of very fine sand-sized quartz grains. The pelletal phosphate in these sandstones could have formed through accretionary growth around suitable (organic) particles at the sediment-water interface, with the pellets growing as they rolled back and forth in shallow quiet waters (Birch 1979). Phosphorite deposition is dependent on the presence of nutrient-rich waters with high biological activity, high sea temperatures, protected waters, and a restricted supply of terruginous sediments (Tankard 1975b;Birch 1979). Such conditions can be found in an estuarine environment close to an active upwelling system (Tankard 1974a). Indeed, the presence of upwelling, nutrient-rich deep ocean water onto a continental shelf is generally considered a prerequisite for phosphogenesis (Birch 1979, 1980; Bremner 1980; Balson 1990). This would suggest that the Benguela Upwelling System was well established along the South African west coast by this period. Recent work on the origins of the Benguella Upwelling System indicate the system was well established long before this period (Rommerskirchen *et al.* 2011).

2.6 CONCLUSION

The discussion above highlights some of the important characteristics of the lithology and stratigraphy of Langebaanweg and the Varswater Formation. What is apparent, from a perusal of this literature, is that this topic has received little attention in recent years. The majority of sedimentological research at Langebaanweg was conducted in the mid-1970's. Much of the more recent research has focussed on a very limited sample of E-Quarry, such as old exposed mining trenches that are now weathered. The opening of new excavations in the quarry has provided an excellent opportunity to expand our lithological knowledge of Langebaanweg and will help elucidate issues regarding the depositional origins

of various fossil beds and by extension will provide new insights into the palaeoenvironment of the west coast of southern African in the Early Pliocene.

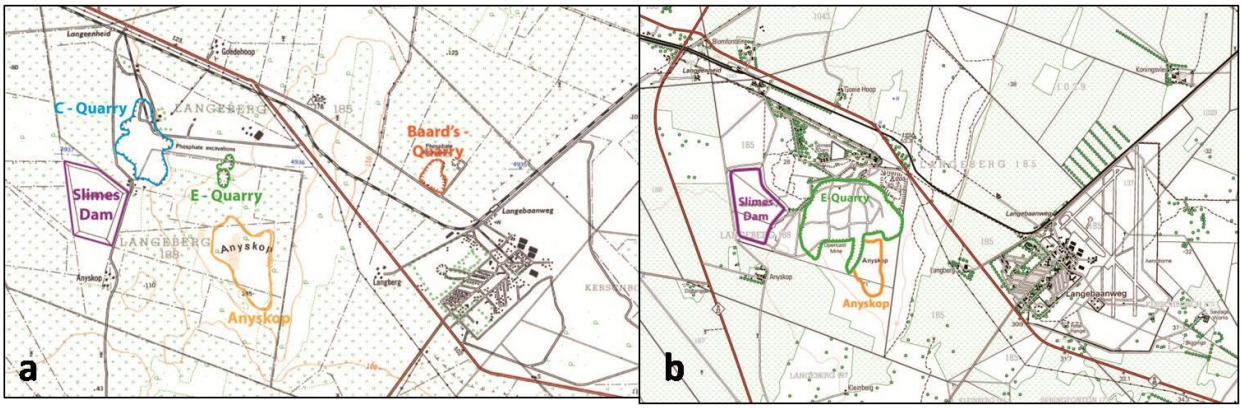


Figure 2.1. Topographic map of Langebaanweg from a) 1974 and b) 2008 showing the relative positions of C-Quarry, E-Quarry, Baard's-Quarry and Anyskop hill.

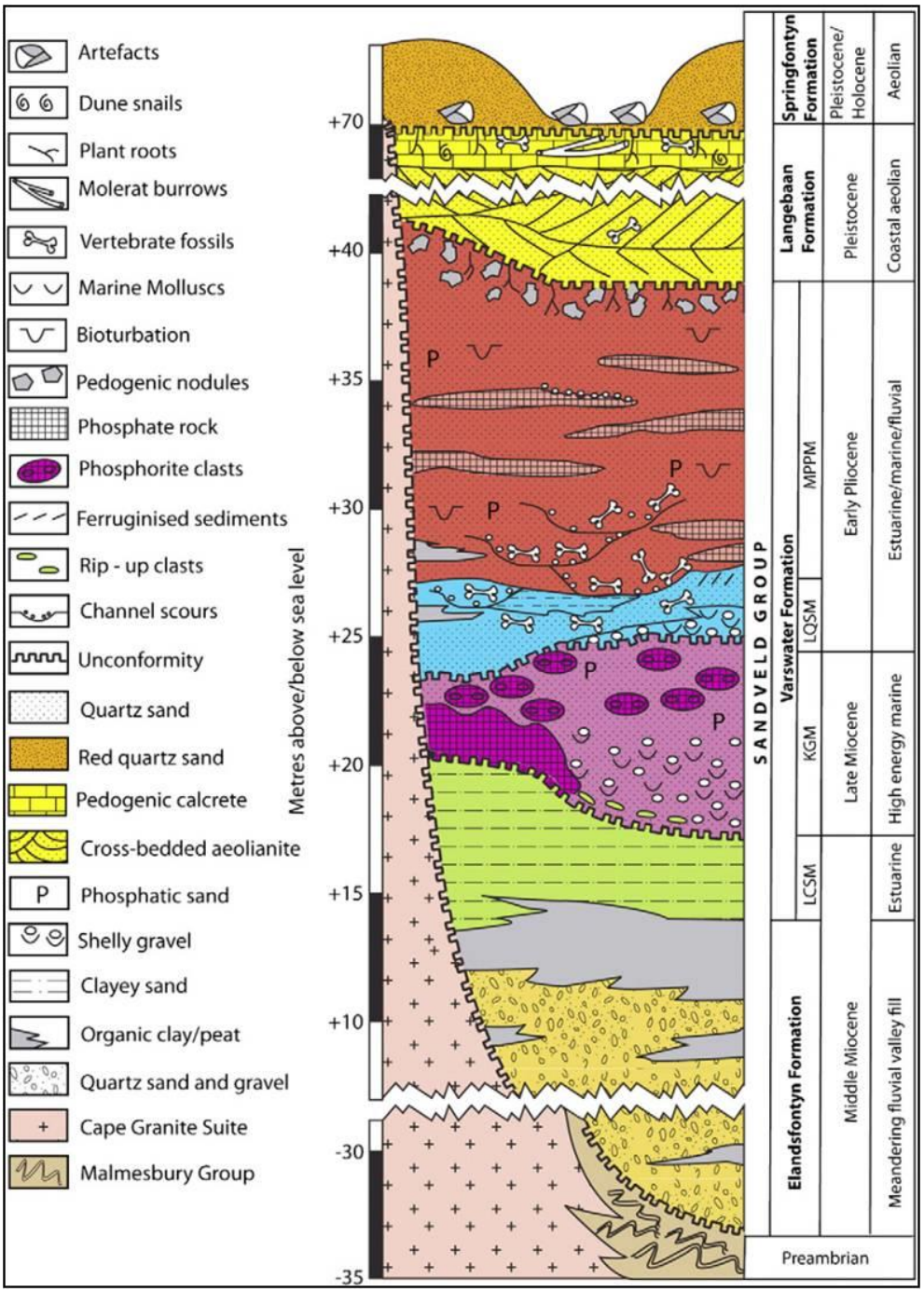


Figure 2.2. Summary Stratigraphic column for Langebaanweg. Reprinted from Roberts *et al*. 2011, Earth-Science Reviews, 106, pp. 195.

CHAPTER THREE

A HISTORICAL REVIEW OF LANGEBAANWEG

3.1 INTRODUCTION

Scientists first discovered fossils at Langebaanweg in the late 1950's. These discoveries initiated six decades of fossil collecting, occasional excavations, research and publications on the Langebaanweg fossil remains. The bulk of the fossils from Langebaanweg, of which there are over one million curated in the Department of Cenozoic Studies, Iziko Museum South Africa, were collected by Dr Brett Hendey under the auspices of the museum. Dr Hendey published widely on his work (Hendey 1970b,a, 1976, 1980, 1981, 1982), but perusal of the literature can be confusing as stratigraphic interpretations were updated over time and the original locations of fossils or areas of interest became muddled.

Mining operations at Langebaanweg were halted in 1993. At this time, the mining company Samancor assisted with the preservation of the site and the establishment of the West Coast Fossil Park which acts as a hub for education, research and palaeo-tourism. The West Coast Fossil Park was opened in 1998. In 2014, the site of Langebaanweg finally received National Heritage Site status. Today, the West Coast Fossil Park is the only site in South Africa where *in-situ* viewing of a fossil bonebed is possible, and is one of only a few such sites in the world (other examples include Riversleigh, Australia; Ashfall Fossil Beds, Nebraska; La Brea Tarpits, Los Angeles; and the Dinosaur National Monument, Utah). In addition, the West Coast Fossil Park is an example of international best practice in responsible mine rehabilitation. After closure of the mine, pioneering methods were utilised to restore the natural vegetation and the West Coast Fossil Park is now maintained as a nature reserve. It has become a refuge for wildlife in a region facing expansive urban and industrial development. The Fossil Park mandate is to act as an outreach and education centre with a focus on fossils, evolution and environmental change. The Fossil Park caters for school groups and students and provides a palaeotourism experience unrivalled in the Western Cape. In addition, to preserving the fossils, the Park also acts as a nucleus for multidisciplinary research. Today there are an average of 14 000 visitors to the Park a year and the inauguration of the multi-million rand new visitors centre (in late 2017) will massively expand the capabilities of the Park, turning it into a major tourism and education hub on the west coast.

The West Coast Fossil Park houses various notes, photographs and records from the early period of excavations at Langebaanweg while the site was still an active mine. Dr Pippa Haarhoff, manager of the West Coast Fossil Park, has kindly allowed me to access some of this material including copies of various notes and diagrams kept by Dr Hendey during his research. This chapter presents a chronological history of research at Langebaanweg and its purpose is to summarise and contextualise the various excavations and field trips conducted over the years. The purpose of this chapter is to identify how the quarry changed over time and to locate areas which have previously been highly productive. This represents a first step towards testing many long-held theories regarding the depositional history and palaeoecology of Langebaanweg. Theories that have their roots in Hendey's original thinking. This is the first time any attempt has been made to summarise and contextualise previous excavations at Langebaanweg. This chapter covers research at Langebaanweg up to about 1998. Results of more recent excavations (1999 – 2013) are still being published and are not covered here.

3.2. LANGEBAANWEG: 1940 - 1965

The African Metals Corporation (AMCOR) commenced mining at Langebaanweg in 1942. The Second World War had resulted in shortages of imported phosphate rock, which was utilised in the production of phosphoric pig iron (Krumm *et al.* 1974). These shortages, additionally, resulted in shortages of fertiliser.Thus, the corporation began using low-grade ore from the Langebaanweg mine to produce phosphate fertiliser. The mine at this time consisted of C-Quarry and Baard's Quarry (Figure 2.1). The demand for phosphate fertiliser grew until it became necessary to open a second mine. This mine, Varswater or E-quarry as it later became known, was positioned approximately five kilometres due west of the original workings (C-Quarry) and appears, based on aerial photographs, to have been opened by 1960 (Figure3.1). In time, the ore reserves became depleted and attention was directed to the extensive low-grade phosphatic sands found adjacent to the Varswater works. Initially ignored, these poor sands could be upgraded by fatty-acid flotation to a more economically viable ore. By 1965, a flotation plant had been constructed on the site (at a cost of R4 million). By 1974, the Langebaanweg plant was producing 250 000 metric tons of fertiliser per year, mostly sold under the name Langfos Premium.

3.2.1 Mining Operations

Overburden (Pleistocene and Holocene deposits, see Roberts (2006); Roberts *et al*. (2011) for descriptions) was removed by the mine with push-loaded bulldozers (Krumm *et al.* 1974). These dozers were also used to pre-loosen and break up large rocks in the underlying deposits by ripping. The overburden material was utilised to construct the walls of the slimes dam (Figure3.2). The dam, which was utilised to retain the plant tailings and slimes, had walls 20 m high, with a top width of 20 m and a base width of 130 m. Slimes or mine tailings refers to the uneconomic fraction of the ore, the materials left over after separating the valuable minerals, in this case phosphate (Nagaraj *et al.*1994). At Langebaanweg, the ores were finely crushed to allow for chemical extraction methods. Some authors estimate as much as 80% of the fossil material from Langebaanweg was destroyed in the mine mill (Hendey 1976). The mill would have produced a tailings slurry, that is a mixture of fine mineral particles and water. The slurry was pumped into an impoundment (dam) for storage and water extraction. In most mines, once dewatered, the tailings can be used in other parts of the mine for construction or can be resurfaced and re-vegetated.

The phosphate ore at Langebaanweg was mined in two cuts due to the high-water table (Krumm *et al.* 1974). The mine cuts had 7 m faces (vertically) and a common bench upon which the two excavators stood. The top cut (T.C.) was mined with a face shovel. A face shovel or front shovel is a hydraulic excavator used to dig above track level. It operates with an upward motion, crowding material away from itself into a bucket, which is then dumped into trucks for removal. Parallel vertical scrape marks from this excavator can still be observed in the high wall at Langebaanweg (Figure 3.3). The front shovel has a high breaking force, capable of extracting heavily compacted dirt and rock. The bottom cut (B.C.) was mined with a dragline excavator. A dragline is a combined cyclic excavator and material carrier. It consists of a large bucket suspended from a boom with wire ropes and chains. The bucket is dropped from the front of the boom and then dragged horizontally along the ground back towards the machine. The bucket is lifted and the machine can pivot in place and the contents of the bucket discarded onto an adjacent dump or into a truck. The dragline will typically sit above the ore or overburden on the highwall side and excavate the material in front of itself. The excavators utilised at Langebaanweg were equipped with 1.9 m^3 buckets.

3.2.2 Excavations and Fossil Collecting

Fossils were first discovered in the Langebaanweg region in 1958 from surface material recovered at Baard's-Quarry (Singer & Hooijer 1958). Miners had observed and collected 'pretty bones' from the mine excavations prior to this, but it was not until the late 1950's that scientists had success at accessing and finding fossils from the quarry (Singer & Hooijer, 1958). Prior to 1966 fossils were collected from Baard's-Quarry and C-Quarry (Varswater) from boreholes, the surface, and pits dug for commercial reasons (Singer 1961; Bone & Singer 1965). Excavations were conducted at Baard's-Quarry in 1965 (Bone & Singer 1965) and after 1966 all excavations refer to E-Quarry. Excavations and research during this period, up until 1968, were conducted under the auspices of Ronald Singer of the University of Chicago. The first excavations carried out at E-quarry were conducted in 1964. The trench area is shown by Hendey (1976) in a photograph dated from July 1974 (Figure 3.4). During 1968, a research program was formulated by the South African (now Iziko) Museum aimed at the recovery and investigation of fossils from Langebaanweg, then still an active mine (Hendey 1973). Thereafter a number (at least four) of short field seasons were carried out during the winter months at the site, with surface collecting and excavation of fossils from areas that were to be backfilled. These field seasons appear to have focussed on the East Stream area. The highly fossiliferous East Stream was a *modern* drainage observable in the floor of the mine to the south-east of the current Langebaanweg excavation and is discussed in more detail below.

In order to assist with contextualising photos and sketches from Hendey's field notes and publications, I acquired a series of aerial photographs from the National Geo-Spatial Information unit of the Department of Rural Development and Land Reform. The aerial photos were taken in 1960, 1971, 1977, 1979 and 2003. Unfortunately, the period between 1979 and 2003 is not covered, either because there were no photos available of Langebaanweg, or the photos that are available are of such a poor resolution as to be unsuitable for any meaningful interpretations. The aerial photos are shown in Figure 3.1, Figure 3.2, Figure 3.5, Figure 3.6, Figure 3.7 and Figure 3.8. Each aerial photo is shown along with an annotated version indicating visible features of the mine. Later in this thesis, these photos will be utilised to contextualise Hendey's excavations and locate his fossil collecting areas.

3.3 GRAPHICAL SUMMARIES OF LANGEBAANWEG

Included within Hendey's notes are a series of mine Progress Plans. These plans, produced at monthly intervals, consist of outline drawings of the bottom cut, top cut and over burden, with new excavation areas for each month noted in red (Appendix H). Hendey's notes contain Progress Plans from several months in the years 1970, 1971, 1972, 1973, 1974, 1975, 1976, and 1977 (Table 3.1); these are presumably periods when Hendey was actively working in the quarry at Langebaanweg. Hendey undertook most of his research work at Langebaanweg during the winter months, at least up until 1974. Most, or the entire year of 1975 and 1976 are covered; this is the period when the BCWW (see section 3.6) excavations were being conducted and highly fossiliferous material was being recovered. I have combined the Progress Plans for each year into a yearly figure, tracking changes across, and expansion of, the quarry over time; these can be observed in Figure3.9 – Figure 3.16. In addition, the locations of interesting finds or beds (like East Stream) are shown on these Quarry Maps (as they will hereafter be known).

All the mine Progress Plans and even some sketches of the quarry (Figure 3.17) made by Hendey (1970b) are drawn onto a grid system. This grid appears to have been utilised by the mine in their excavations, although to the best of my knowledge, nothing of the grid now remains in the quarry. Grid intervals were 500 feet (approximately 150 m) apart (Hendey 1970b). This grid allows us to compare and combine different Progress Plans, Quarry Maps and photographs of the quarry more accurately. I have copied the grid onto all my images including the aerial photos.

The Quarry Maps were later overlain onto the aerial photographs in order to contextualise both changes in the quarry and fossil localities. Matching the Quarry Maps to aerial photographs was somewhat interpretative and there is certainly room for improvement with higher resolution images. The best results were obtained where Quarry Maps from the same year as the aerial photos were available (namely in 1971 and 1977). Excavation areas observable on the aerial photos were matched by shape to the Quarry Maps. Exact matches were not possible, there was always some slight difference in the shape of the quarry, and perspective was sometimes problematic as aerial photos are not always taken from directly above; however the resulting images are overall highly informative. Once close matches had been made between images from the same year, consistent characteristics of the quarry (for example the northern part of bottom cut remains unchanged throughout the period) were used to align the other Quarry Maps. Quarry Maps for 1970, 1971, 1972, 1973, 1975 and 1976 are plotted on the aerial photograph from 1971 (Figure 3.18 – Figure 3.23). Similarly Quarry Maps from 1971, 1972, 1973, 1975,

and 1976 have been overlain onto the aerial photo from 1977 (Figure3.24 – Figure 3.28). These images allow one to locate excavation areas and fossils in the quarry while the mine was active, and it is helpful for identifying mine activities (like excavations or backfilling) that may have affected fossil locals. It would also be beneficial to place these areas onto a map of the modern quarry which has undergone many changes since the late 1970's. Thus the Quarry Maps for 1971 and 1977 have been placed on an aerial photograph from 2003 (Figure 3.29, Figure3.30).

Detailed, high-resolution photographs of parts of E-Quarry are provide in a number of publications from the times (Hendey 1976,Dingle *et al*. 1970); they were annotatedwith fossil and sampling localities. I have compared these photos to the aerial images and the relative position of Hendey's photos in the quarry are shown in Figure 3.31and Figure 3.32. The figures from this chapter provide a graphical summary of previous research and excavations conducted at Langebaanweg. These images should allow future researchers to locate or contextualise fossil specimens already excavated without having to return to the site. It will be particularly beneficial for specimens derived from areas that have been mined out or backfilled and cannot be returned to.

3.4 EXCAVATIONS DURING1964 - 1969

3.4.1 1964 Excavations

The first controlled excavations carried out at E-Quarry were conducted in 1964 in a large trench, measuring approximately 240 m X 120 m with a depth between 2 m to 30 m (Hendey 1976). The trench area is shown by Hendey (1976) in a photograph dated from July 1974 (Figure 3.4). This trench was likely excavated by the mine, possibly while prospecting the area, but it produced highly fossiliferous material. The 1964 excavation area is shown on the 1971 aerial photo in Figure3.31. When the relative position of the 1964 excavation (Figure3.31) is compared with the Quarry Map from Figure 3.19, the position of the 1964 excavation is slightly east of the West Wall in grid squares R1 and R2. The position of the 1964 excavation in the modern quarry is shown in Figure 3.29; The 1964 excavation area has been covered by mine overburden and is no longer accessible.

3.4.2 1966 Excavations

1966/1

After 1960, all fossil excavations, or at least those for which I have field notes, focussed on E-Quarry and thus the term "quarry" from this point forward refers to E-Quarry. In May 1966, a joint investigation was made by the University of Chicago (J.J. Wymer) and the South African Museum (now the Iziko Museum) at Langebaanweg. This excavation, called 1966/1, consisted of a large cutting (approximately 75 m long, 3 m wide and 17 m deep) made in E-quarry. Both 1966/2 and 1969/1 were located along the bottom cut West Wall. This wall of the quarry remained unmodified until 1975. In describing the origins of Dump four (see section 3.7), Hendey indicates that excavations 1966/2 and 1969/1 were located on the original wall of cut one (see section 3.6; Figure 3.35). The 1966/2 excavation was located further to the south than 1969/1 (Appendix C: 8). It is possible, given these descriptions, that the 1966/1 and 1966/2 excavations were related to or part of the Bed 3a deposits.

1966/2

Later that same year (August & October),the excavation was expanded and additional fossil material collected. Thus excavation 1966/2 has the same location as 1966/1. Stratigraphic information was collected at this point and three distinct horizons were observed. The Upper Layer had uniform brown sands approximately 2.7 m deep with few fossils. Bones from this layer indicate quick burial with little weathering, gnawing or lateral movement. Fossils were generally rare in this layer, although microfauna were observed. The Middle Layer consists of a yellow band about 0.9 m thick and 3.6 m below the surface, that displays contortions and river bedding. The Middle Layer has abundant, if poorly preserved fossil remains, including microfauna, birds and marine and terrestrial taxa. Micromammals and amphibians were abundant with the former predominant. Seals were commonly recovered. Hendey described considerable decomposition of less durable elements from parts of this layer where dentition was preserved, but the remainder of the skull lost. Similar preservation was seen in some of the excavations in the current analysis (see Chapter Seven). The sediments of the Bottom Layer ranged from blue-grey to white-grey to white, depending on depth. The horizon attained a maximum depth of 4.8 m and was 1.2 m thick. The Bottom Layer contained some large fossils, and Chelonia carapace fragments were common. Fossils displayed increasing mineralisation with depth and proximity to the water table. Although, below a certain depth, the quantity of fossils declined sharply. Microfauna were abundant in

this layer. These stratigraphic layers were consistently observed in later excavations at the quarry and were termed Horizon A (upper brown sands), Horizon B (the middle, yellow layer) and Horizon C (bottom blue-grey layer). These horizons were later changed to Horizon 1 to 3. Hendey's notes contain many more descriptions and sketches of sedimentary units, all apparently variations on the one given above. As these units are discussed in many of his publications, they are not repeated here. The reader is however encouraged to refer to the appendix for more detailed descriptions.

3.4.3 1969 Excavations

1969/1

Excavations and fossil collecting at Langebaanweg was from this point forward (until 1986) conducted by Dr Brett Hendey of the South African (Iziko) Museum. The 1969 excavations are poorly recorded. The excavation 1969/1 was undertaken around July 1969. The excavation consisted of a trench 7 m X 4 m long consisting of seven 1 m X 4 m sections. The exact location of the trench is unclear. Hendey describes the north wall of the trench as occurring 1 m south of the "9 line of grid A", however any diagrams indicating the position of grid A have been lost. Certainly, grid A is not related to the main quarry grid. From field sketches of the quarry (Appendix C:4, 6 - 8), we can estimate the position of the trench as occurring along the lower (bottom cut) West Wall, between 20 m and 30 m east of the road (on the top of west wall). It is presumed that the 9 line of the grid occurred towards the southern end of the west wall, but a more exact location is not possible to assess at this time. A diagram of the mine, dated from August 1969 (Hendey 1970b), indicates the position of the lower west wall of the mine at this time located in grid square S4 (Figure 3.17). In addition two concentrated pockets of microfauna (No. 1/1968 and No. 12/1968) described by Hendey (1981: 81), are shown occurring in the white sands of Horizon C in the southern part of the quarry near the West Wall. The relative location of the lower West Wall at this time period can be observed in the 1970 and 1971 Quarry Maps (Figure 3.9, Figure 3.10), and in the aerial photo from 1971 (Figure 3.18). The position of these deposits is shown on a recent aerial photograph in Figure 3.29.

Hendey's notes of excavation 1969/1 include sketches of the key section (section 3) which indicates the presence of Horizon A occurring up to a depth (from the surface) of 1.8 m. Underlying Horizon A were iron stained sands (Horizon B) and grey sands of Horizon C with the contact occurring 1.9 m to 2 m below the surface. Hendey excavated by using arbitrary spit depths (varying between 25 cm to 45 cm)

and material was sieved in a 10 mm and a 5 mm mesh. The region of the quarry where the 1964, 1966 and 1969/1 excavations were located, has been described as displaying MPPM, LQSM and KGM deposits (Roberts *et al.* 2011), which would compare favourably with Hendey's findings of a number of horizons in this area.

1969/2

A selection of Hendey's field notes dated from November and December 1969 indicate that he was working along or near the east face of the bottom cut, in what came to be known as the East Stream area (Figure3.10 and Figure 3.11). Hendey does not number these excavations, and I have merely termed them 1969/2 here for convenience. Indeed no excavations or trenches are described for this period and it seems likely that much of the fossils collected at this time were recovered from the surface. This period saw the establishment of Datum B, 102 m west of the east face and the discovery of an elephant fossil L12723(Figure3.10). Numerous hyeanid, viverrid and *Trogocerus* remains were recovered from this area in December 1969. Hendey observed differences in the faunal remains between the East Face and the remains recovered from the West Wall.

The 1969 excavations resulted in the stratigraphic model presented in Hendey (1970b). This revised section shows Horizons A – C replaced by Horizons 1 – 4. By this stage, at least 60 distinct mammalian types from 11 different orders had been identified at Langebaanweg (Hendey 1970b), as well as birds, reptiles, amphibians and cartilaginous and bony fish. By the end of 1969, mining in C-quarry and Baard's-Quarry had ceased (Hendey 1970b). Indeed later aerial photographs show no changes at C-quarry, other than vegetation regrowth (Figure 3.2). Hendey believed that there was a close relationship between C-Quarry and E-Quarry and that their fossil assemblages were for the most part contemporaneous (Hendey 1970b).

3.5 EXCAVATIONS DURING1970 - 1974

3.5.1 1970 Excavations

1970/1

Hendey's notes mention a number of quick site visits in the early part (January, February, and May) of 1970 with surface collecting of remains. Little of note was found until June, when a number of fossils were recovered from the bottom cut of the mine excavated in May (Figure3.9). During this period, Hendey observed the presence of a thin fossiliferous horizon immediately above the Gravel Member (KGM) in the southwest corner of the quarry. He noted how the high water table made recovery of fossils (and even excavations by the mine) difficult. He observed fossiliferous material from Horizon 1 (LQSM) underlying the entire region between Beacon B and the May bottom cut of the mine. This area produced a number of interesting finds including; elephant, ostrich, seal, giraffe (*Libatherium*), a large Hyeanid, frog, rhino, *Tragocerus* (Bovidae)and giant extinct pig (*Nyanzachoerus)*. The exact location and nature of the 1970/1 excavation is not recorded in the notes available for this analysis, but the Quarry Map for 1970 indicates that the mine was excavating extensively along the south wall of the bottom cut and in all likelihood, the 1970/1 excavation was located somewhere is this area. From the location of the bottom cut south wall, as observed on the 1977 aerial photo (Figure 3.24),we can see that much of the surrounding area is underwater. This makes sense, given Hendey's description of the wet conditions. It could also explain why the East Stream developed. Notes from a later period (Appendix F: 19) indicate that 1970/1 was part of the Bed 3aS channel (See section 3.6). This might be possible if 1970/1 was located towards the eastern end of the south wall.

The East Stream (Figure3.33) and surrounds produced a great deal of fossil material. There has been some confusion in the literature regarding the origin and meaning of this 'deposit'. East Stream does not refer to a sedimentary unit or fossil bed, but was a *modern* drainage channel in the floor of the quarry. Hendey sketched its location, as well as other nearby fossils and beacons and it is shown on the Quarry Maps (Figure 3.10, Figure 3.11). East Stream extended over a distance of at least 100 m, running from the north-east to the south-west; located between grid lines R and Q and across grid line two. Many fossil remains were recovered in this region of the quarry, including numerous partial skeletons, a few of which are shown in Hendey's sketch of the deposit. Bones from the East Stream were recovered (predominantly) from LQSM sediments and the drainage channel indubitably exposed remains and

helped with fossil recovery. Remains from East Stream (shown in Figure 3.33) include as many as four *Nyanzachoerus* (partial) skeletons, a boselaphine, hyena and chelonian remains.

The location of East Stream on the aerial photograph of Langebaanweg from 1971 is shown in Figure 3.19. There is a clear shadow visible in the aerial photographs in this location and which no doubt represent East Stream itself. When the 1971 Quarry Map with East Stream is overlain onto the 1977 aerial photo (Figure 3.24) it become clear that East Stream and its surrounds are under mine overburden. These deposits were backfilled probably in the mid-1970's. The East Stream area is located some distance from the modern dig site. The overburden is less clear in the modern aerial maps, but what should be clear is that East Stream in no longer present. From its position East Stream would have been well outside the river channels (Bed 3aN/S) described by Hendey (1980, 1981). Given that East Stream was a modern channel it is likely that Main Stream was likewise also a modern feature of the quarry. The location of Main Stream is shown in Figure 3.11.

1970/2

Sketches made by Hendey of the 1970/2 excavation show white sands capped by sandstone and lenses of phosphate rock. In August 1970, an associated partial skeleton of *Tragocerus* was recovered from the northern end (head) of East Stream. The specimen is not shown in the sketches of East Stream (which were in any event created a year later), but Hendey describes its location as the head of the East Stream. Large numbers of articulated tortoise shell fragments from multiple individuals were observed in close association with the skeleton, as was a Hipparion mandible. Hendey sketched the association of the *Tragocerus* bones of in great detail. The skeleton was spread out and generally sloped to the west with distances of 1.5 m to 2 m between individual bones not being unusual. A possible nearby datum (Beacon C) is indicated in some of the drawings. Hendey utilised sections from this area of E-Quarry as well as sections from C-Quarry and Baard's-Quarry in order to trace evidence of marine, estuarine and fluviatile deposition. This resulted in the stratigraphic section described in Hendey (1970b: 79) and indicated the action of a marine transgression at Langebaanweg.

3.5.2 1971 – 1974 Excavations

The second *Nyanzachoerus* skeleton, shown in the East Stream sketch (Figure 3.33), was excavated in August 1972.Some 25 individual bones (or bone pieces) from the skeleton were recovered from an area of 20 m^2. During this period,the mine excavated a pair of trenches (Bull dozer trenches or BDT's). These trenches provided a cross-section through the deposits in the East Stream area and displayed gravels from the Gravel Member (KGM) overlain by fine-grained quartzose sands, some of which displayed horizontal bedding and capping by silcrete and/or phosphatic nodules. Extensive test-pitting and fossil collecting, was undertaken in 1974 around the elephant site (Appendix G: 5).Terms like Quartzose Sand Member start to appear in Hendey's notes from this point onwards, although they first appear in the literature only in 1975 (Tankard 1975b). We know from Hendey (1973, 1976), and infer from the presence of progress plans for this period, that substantial excavations or at least fossil collecting were conducted at Langebaanweg during this period. A number of areas of interest (for example peat areas) were recorded on the Progress Plans for this period, and they are shown in the Quarry Maps (Figure3.9 – Figure3.14). Unfortunately, the field notes and records that were thus far available to me, do not provide any additional information regarding this important period of research at Langebaanweg.

3.6 BOTTOM CUT WEST WALL (1975– 1976)

During 1975 and 1976, mine excavations were focussed on the northern end of the West Wall Bottom Cut (Figure3.15, Figure 3.16) which was extended in a westward direction. It is apparent from the extensiveness of Hendey's notes that fossils were abundant in this area. Hendey tracks the mining through a series of eight or nine successive westerly cuts into the West Wall. A simplified schematic of these excavations which he refers to as the Bottom Cut West Wall (BCWW) is shows in Figure 3.34. Figure 3.35 displays a close-up view of the BCWW excavations inferred from the Progress Plans, and the cuts (as described by Hendey and shown in Figure 3.16) are numbered. Some cuts appear shorter than others, as they are sketched from the mine progress plans, but it is apparent that they all eventually covered the full length of the west wall. The bottom cut was pushed back still further by the end of 1976, but Hendey's notes only cover up to cut nine. The BCWW excavations are important as this is the location of (or at least the main outcrop of) the Bed 3aN and 3aS river channels. The 1976/1 and 1976/2 excavations were both located within the BCWW digs and the 1975/1 excavation is associated with BCWW. The approximate location of BCWW on the 1971 aerial excavation is shown in Figure 3.22; while

Figure3.27 displays the location of BCWW on the 1977 aerial photograph. Part of the BCWW (the 1976/2 trenches) is also observable on the 1979 aerial photo (Figure 3.36). The modern Langebaanweg excavation is located in the remaining parts of BCWW and is shown in Figure 3.30 for reference. These various excavations are discussed in more detail below.

3.6.1 Bed 3aS

The first cut was excavated around October 1975. The cuts were excavated consecutively westward and the final cut (of this series, cut nine) was made around September 1976 (Figure 3.34). Cuts were approximately 5 m in width (although this varies a lot) and the entire series was approximately 120 m wide. Two datums (D1 and D2) were located on the west wall at the start of cut one. Hendey made cross sectional sketches of the sediments through many of the cuts (Appendix F) but cut one is particularly interesting (Appendix F: 5-9). He noted the colour and character of all sedimentary units encountered, as well as interesting fossils. In this area, as many as seven sedimentary units were observed overlying the LQSM (QSM). This would suggest high variability in the MPPM sediments, a finding which this study corroborates (see Chapter Seven). Later cuts were not recorded in such detail. What is of particular interest is the channel shape displayed by the sediments in cut one. This may have given rise to Hendey's interpretation of these deposits as a river channel. However, if this is the case, then the perspective of the sketch is confused. A cross section of cut one would face west, indeed the northern corner of the quarry is shown in the cross section, and in this case the river channel would be orientated east to west. However the river channels are shown by Hendey (1980) to be orientated northeast to southwest (Figure 3.37). Some caution must then be utilised in making inferences from this sketch.

The dates noted in Figure3.34 for cut two and cut three (and all subsequent cuts) likely represent days where Hendey sampled the deposit and made sketches of cross sections and similar. A number of dumps (Dump five – Dump seven) are marked on the schematic. The dumps consist of material mechanically excavated by the mine on behalf of Hendey and set aside for later sieving and analysis (see section 3.7). The schematic shows the origins of the dump material. The edges of a large phosphate rock were intercepted during cut four around March 1976. This phosphate rock is also shown in Figure 3.37. An excavation (1976/1) was located on top of the phosphate rock and another datum (T2) was established.

Cut one produced remains from suid, equid, boselaphine, proboscidean, pinniped and microfauna. The majority of the fossils appear to have been derived from the light orange sand and the light grey sand. There were presumably many more remains which are not recorded in Hendey's sketches. Other interesting fossils which were retrieved from BCWW include giraffe (cut two), *Mellivora* (cut seven), wolverine (cut seven) and more microfauna from cut six.

There is a great deal of confusion around the bed 3aN and 3aS deposits. Hendey first described the bed 3a deposits in 1973 (Hendey 1973) as occurring on the west wall of the quarry and containing numerous vertebrate bones. In 1976, Hendey describes two exposures of bed 3a, namely bed 3aNorth and 3aSouth. Bed 3aN is initially described as occurring along the top cut west wall (Hendey 1976). However I can find no evidence for this. The Progress Plans, maps, sketches, even the aerial photos all suggest that bed 3aN and 3aS were found in the bottom cut area (BCWW). It is possible that the upper limits of 3aN were first transacted during excavations of the top cut in this area, which would have been during 1975 (Figure 3.15). Bed 3aS differs from the north deposit in that the base of the deposit was not bounded by phosphate rock. Hendey initially believed that 3aS was deposited in the path of a river (discharging into the ocean) and that the river shifted northwards with the sea transgression to bed 3aN (Hendey 1976). Early sketches of the possible course of bed 3aN/S show the river running from north-east to south-west (Figure 3.38). This orientation of the river would provide the channel cross-section described and sketched by Hendey in the first cut. By 1980, however the two river channels are shown as coming in from the northeast and turning towards the south (Figure 3.37). Hendey (1980) has interpreted the two river channels as dry season and wet season channels. Bed 3aS becomes the dry season channel where water, under low flow conditions, is deflected by the phosphate rock southwards. This position of bed 3aS indicates that material from this deposit was recovered during mining of cuts one to four. Bed 3aS is, in addition, indicated as occurring in the 1970/1 excavation, some 88 m southeast of TCWW Prom (Appendix F: 19).

3.6.2 Bed 3aN

The phosphate rock first encountered in cut four, extended to cut seven. Hendey (1980) noted that bones were concentrated on the lee side of the phosphate rock and believed that the rock obstructed flow causing bones to accumulate beside it. The excavation 1976/2 was located in sediments to the west of the phosphate rock in cut eight. The 1976/2 excavation can be observed in the aerial photo from

Hendey (1980) (Figure 3.37) as a series of east-west orientated trenches. The 1976/2 excavation is still visible in the quarry today. It was excavated briefly by Dr D.D. Stynder in 2008 and 2009 and is now covered by the smaller of the two horticultural tunnels. 1976/2 is described in Hendey's notes as Indentation West Rock Platform (IWRP). 1976/2 was between 15 m and 5 m from the (western) edge of the phosphate rock and Hendey indicates that a datum point for these excavations was set up just beside the phosphate rock.

The base of the bed 3aN deposit was marked by a phosphatic sandstone (Hendey 1976). The rock surface was, in places, highly irregular with crevasses and potholes filled with coarse sand and gravel. Fossils were abundant where the rock surface was irregular and were often found concentrated in the crevasses and potholes. This would suggest fast-flowing water. Indeed, Hendey (1976) described bones from bed 3aN, where protruding parts had been abraded or broken off. The 1976/1 and 1976/2 excavations both sampled bones from bed 3aN (Hendey 1980). Most of the fossiliferous horizon of 1976/1 was mined out and bones were recovered immediately above the rock surface or from depressions within the surface. The 1976/2 excavation was laid down in the lee (westside) of the phosphate rock on an unconsolidated substratum of LQSM material. Hendey (1976) suggested that some bones from this deposit might have been eroded from the underlying bed, although testing this might prove quite challenging. To the south of 1976/2, an extensive carbonaceous area of peat-like material was observed (Hendey 1980). Hendey (1980), believed that during dry periods, slow flowing waters would be deflected by the phosphate rock into bed 3aS, hence this bed is labelled as the dry bed in his diagram (Figure 3.37). While, in the rainy season, flood waters would wash over the phosphate rock (1976/1) and around it (1976/2) depositing large amounts of bone remains, including possibly whole carcasses. Beyond the phosphate rock (and 1976/2) to the south and west, fossils were observed occurring in a lag deposit. The lag thinned towards the west until it came up against another phosphate rock (Figure 3.37). The lag deposit thickened towards the south and spread out laterally, particularly towards the southwest, becoming increasingly carbonaceous as it did so. Fossil bones decreased southwards. This would suggest a widening of the channel and slowing of flow with deposition of lightweight organic (plant) material (Hendey 1980). It should be noted that no controlled excavations were conducted in the carbonaceous deposits which were revealed by mining. These deposits, if still available in the quarry and not mined out later or weathered away, may provide an ideal location to sample for palynological or phytolith analysis. There is some confusion in Hendey's (1980) description of bed 3aN/S and 1976/1. Initially he indicated that 1976/1 is part of bed 3aN but his description of the perceived mechanism of flow indicates that the wet channel is bed 3aS. I have presented here what I

believe to be the most accurate analysis of his notes but there is room for improvement should additional information come to light. Bed 3aN/S appears for the most part to sample MPPM deposits, particularly the lower levels of the member, but there may be LQSM material mixed in as well. Final mention should be made of an excavation conducted in (August) 1975 to the north of the phosphate rock, and the existing road. It is shown in Hendey (1980) as 1975/1 and is recorded in Hendey's notes as Top Cut West Wall Promontory (TCWW Prom). A disarticulated partial hyena skeleton is recorded from this excavation, preserved in greyish clay. TCWW Prom is recorded as part of Bed 3aN in Hendey's notes.

The modern excavation, housed beneath the larger of the horticultural tents and containing a substantial and incredibly dense bonebed, is located on top of and on the leeward side of the phosphate rock between excavations 1976/1 and 1976/2. Given its position, it likely samples material from bed 3aN. It is unclear at this stage, why the material in this excavation is denser than other parts of the bed 3aN deposit. Various research into the bonebed deposit have found little indication for a fast flowing annual or temporary river. Remains from the bonebed indicate perennial water and low energy environments with resident anurans, birds and many mammal species (Smith & Haarhoff 2006; Brumfitt *et al.* 2013). Hendey describes bed 3aN as producing large amounts of marine mammals in the form of seals. The bonebed does contain marine elements, some from large individuals, like whales. Smith and Haarhoff (2006) explain the differences in the bonebed deposit compared to Hendey's findings as a scour pool fed by a stream or river. Brumfitt and colleagues (2013) feel that the bonebed is indicative of a freshwater aquifer but don't provide an explanation as to the surrounding deposits. Further research will be needed in order to understand the bonebed and how it relates to the fossiliferous deposits around it. This study seeks to begin to understand this issue by sampling sediments and taphonomy from both 1976/2 and the bonebed and comparing them in order to find differences in their composition that might inform our understanding of their depositional settings. This will allow us to build a greater picture of the environment of Langebaanweg at the time of deposition.

3.7 MINE DUMPS

At Dr Hendey's instigation, fossiliferous material was excavated by the mine with mechanical excavators from areas under threat and moved to safe locations (Table 3.2). This material was then sieved and sorted by hand to recover fossils. At least ten of these dumps were created and are outlined in Hendey's notes (Appendix G). The origins of the dumps and the sedimentary units they sample are indicated in

Table 3.2. Dumps one, two and three were recovered from the East Stream area in October 1974. Dumps one and two sample the same material and were both derived from LQSM sediments just south of the elephant site (Figure 3.10) (Appendix G: 3). During excavation of this material, a *Percrocuta* (*Chasmaporthetes australis*) skeleton was recovered and thus an extra load of sediment was excavated and made into Dump two. Material from Dumps one and two were sieved and sorted during 1975. Dump three was collected from around the elephant site. The vast majority of remains in this dump were derived from the LQSM, however phosphate concretions associated with dense fossils were also observed, suggesting some of this material may be derived from basal MPPM. Dump three material was sieved and sorted during 1976 and 1977. Dump four was excavated from cut one of the BCWW in November 1975. It represents one tip-truck's worth of deposit, and was derived from bed3aS of the MPPM. It appears that most of the dumps represent about a tip-truck's worth of material. It is not recorded whether this material (Dump four) was ever sieved or sorted or where it has been stored. Dumps five, six and seven (the origins thereof) are shown in Figure 3.34. Dump five was collected from the lower part of cut three of BCWW. It contains MPPM sediments of bed 3aS. Sorting of this material was commenced in 1976. Dump six material was recovered from cut four in February 1976. Early sorting recovered few fossils, which were derived from bed 3aS of the MPPM. Further to the south of Dump six (cut four) additional material was excavated to create Dump seven. This material, also collected in February 1976, was partially sorted in the same year.

In April 1977, a large amount of material (approximately 100 tons) was collected from just south of the 1976/2 excavation (Dump eight). Dump eight is shown in Figure3.37 occurring between 1976/2 and the carbonaceous deposits. Whether it samples any of the latter material is unclear. Dump eight is the first dump material from bed 3aN. It was sorted in 1977 and 1978. Dumps eight, nine and ten all contain at least some material from the LQSM. Dump nine was collected in August 1977 to the west of 1976/2, between it and the phosphate rock (Figure 3.37). This material (from bed 3aN) was sieved in 1977. A large amount of material (hundreds of tons) was collected from north of 1976/2. This deposit contained both MPPM and large amounts of LQSM. It contained overwhelmingly giraffid remains, although the teeth were much better preserved. Hendey suggests this area was part of a lag deposit abutting the rock platform. It is clear that Hendey endeavoured to collect as much material from around the 1976/2 deposit was possible, which is a pity as it makes going back to this area and possibly extending the excavations troublesome. It is particularly irksome that MPPM and LQSM material became mixed in this area. But it will be shown in this analysis that these deposits are in all likelihood contemporaneous and simply reflect differences in depositional conditions.

3.8 CONCLUSION

Langebaanweg has a long history of excavations and palaeontological research. Over one million specimens have been collected from the site and numerous publications regarding its fauna, geology, and palaeoecology have been produced. A perusal of this literature can be very confusing as sedimentary interpretations evolved and terminology was changed without detailed explanation. This chapter utilised a wide variety of sources, including aerial photographs, photographs of the quarry, field notes, sketches, maps and various publications in order to clarify how and where excavations were conducted. This is the first attempt to make use of Hendey's field notes to understand how research was conducted at the quarry. It links various pieces of information and provides a simplified explanation of the origin and meaning of various fossil deposits. Probably most important of all, this chapter utilises quarry maps to identify the location of important fossil deposits and superimposes these maps onto aerial photographs of the quarry from the past and of the quarry as it stands today. This will allow researchers to find or re-visit areas they might find interesting.

Indeed, this chapter has proved helpful in deciding where to excavate for the current study. Three areas were eventually chosen. One, in the 1976/2 excavation area, one in the bonebed deposit and one well away from this area, in the south of the quarry. The locations of these excavation sites has allowed me to investigate how the 1976/2 and the bonebed differ, in terms of their sedimentology and taphonomy. Those differences have further allowed me in infer differences in the depositional setting of these deposits. The test pit in the south of the quarry has provided a view from outside of the river channel deposits, that further illuminated depositional characters of the quarry.

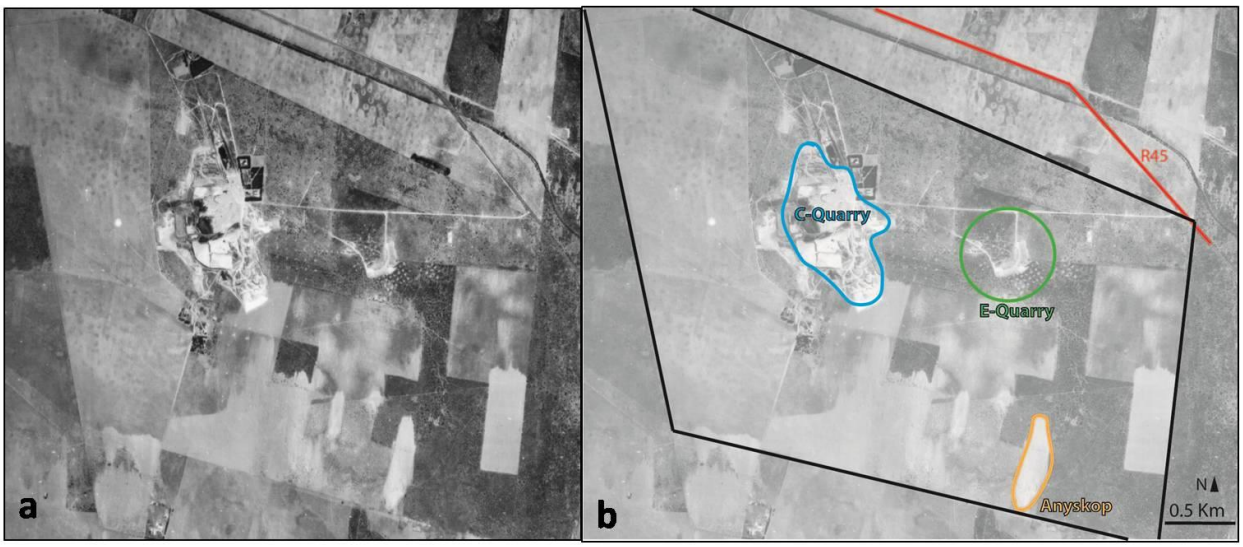


Figure 3.1. Aerial photograph of Langebaanweg from 1960; a) original aerial photo; b) photo from left showing location of C-Quarry, the main road (R45) and Anyskop. Anyskop in these photos is not the outline of the hill itself but of the blowout area. The incipient E-Quarry deposit is shown.



Figure 3.2. Aerial photograph of Langebaanweg from 1971; a) original photo; b) annotated version showing C-Quarry, E-Quarry and the slimes dam.



Figure 3.3. View of High Wall (Top Cut West Wall) at Langebaanweg today. Note the vertical scrape marks still visible in the wall.

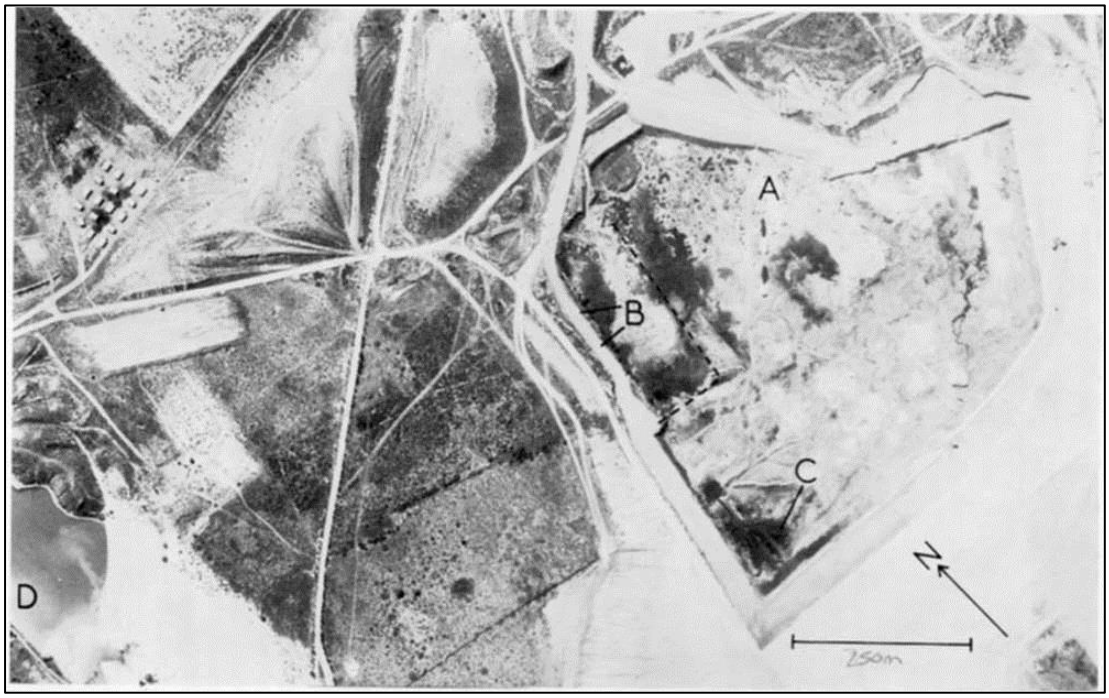


Figure 3.4. Aerial photograph of E-Quarry dated from July 1974. A, East Stream; B, bed 3aS (excavations 1966/2 and 1969/1); C, Peat bed. Dotted lines indicate approximate extent of 1964 excavation. Reprinted from Hendey (1976), Annals of the South African Museum, 69(9), pp. 217.

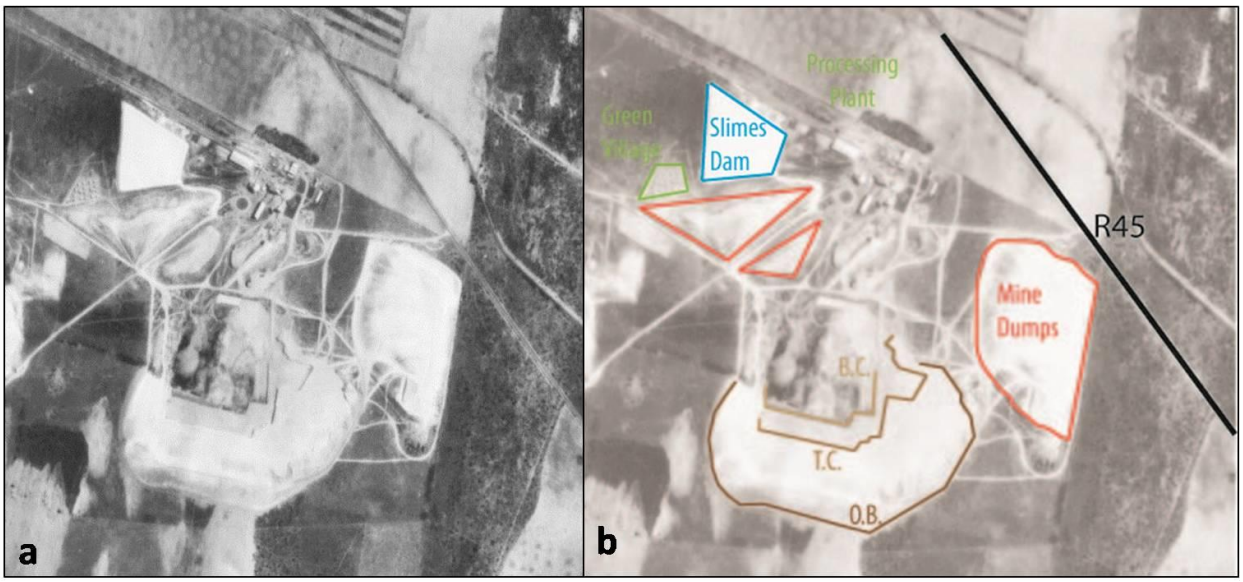


Figure 3.5. Closeup of 1971 aerial photograph of E-Quarry and associated parts; a) original; b) annotated version with excavation area, slimes dam, and mine dumps shown. The green village is the old workers accommodations. Abbreviations: B.C., Bottom Cut; T.C., Top Cut; O.B., Over Burden.

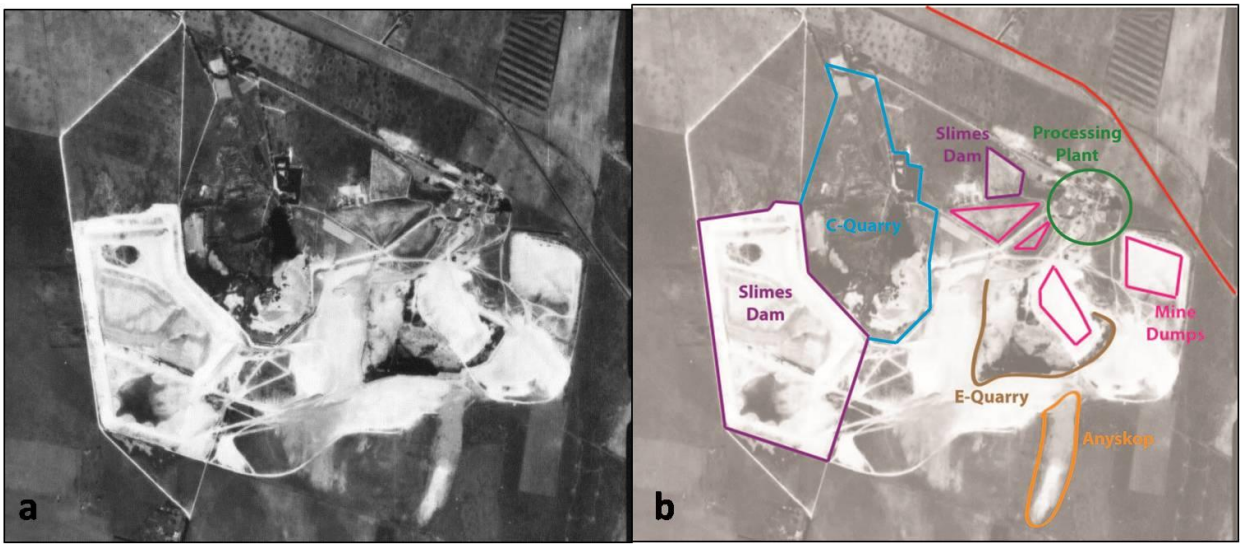


Figure3.6. Aerial photograph of Langebaanweg from 1977; a) original; b) annotated version showing slimes dam, E-Quarry, mine dumps and processing plant. Note the increased size of the excavation area and slimes dam.

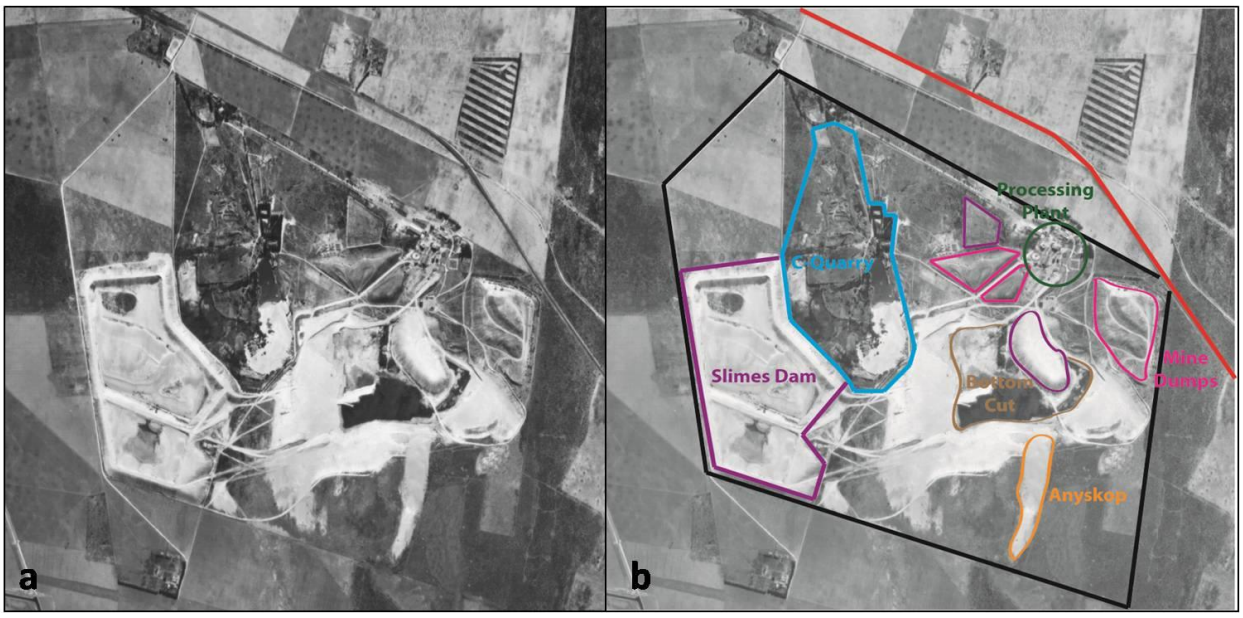


Figure 3.7. Aerial photograph of Langebaanweg from 1979; a) original; b) annotated version showing slimes dam, E-Quarry, mine dumps and processing plant.Note the increased size of the excavation area and slimes dam.

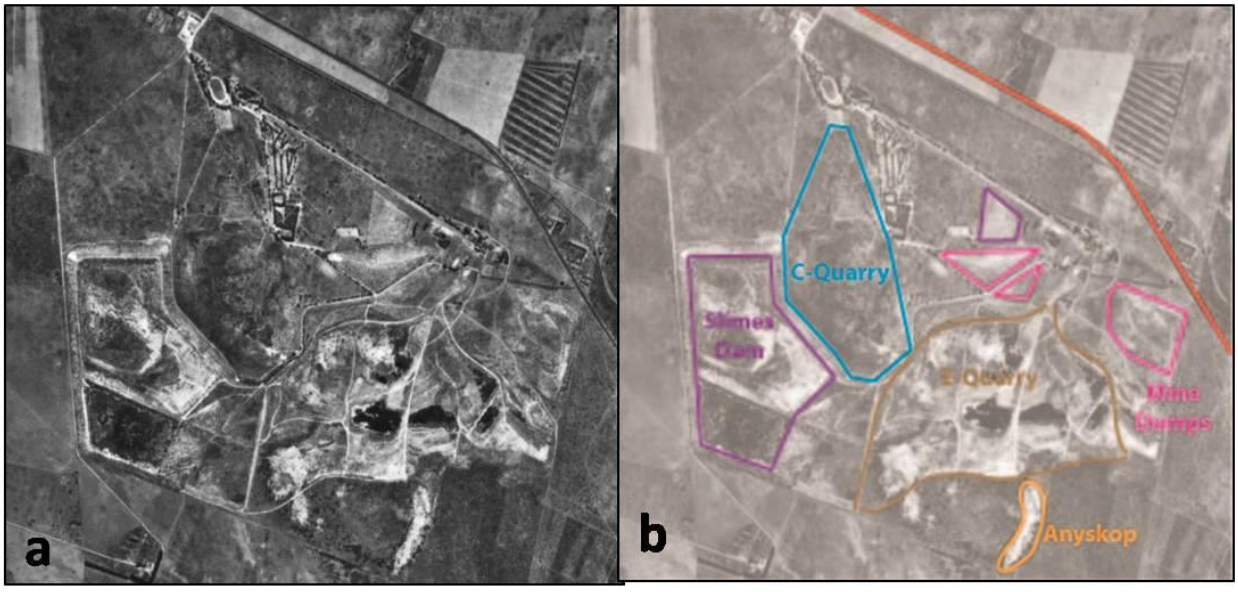


Figure3.8. Aerial photograph of Langebaanweg from 2003; a) original; b) annotated version showing quarry characteristics. Note the change in quarry shape relative to mine dumps and slimes dam.

Table 3.1. Dates covered by Mine Progress Plans

Year	Month
1970	May – September
1971	May – July
1972	July – August
1973	August – September
1974	March – August
	November – December
1975	January – March
	July – October
	December
1976	January - December

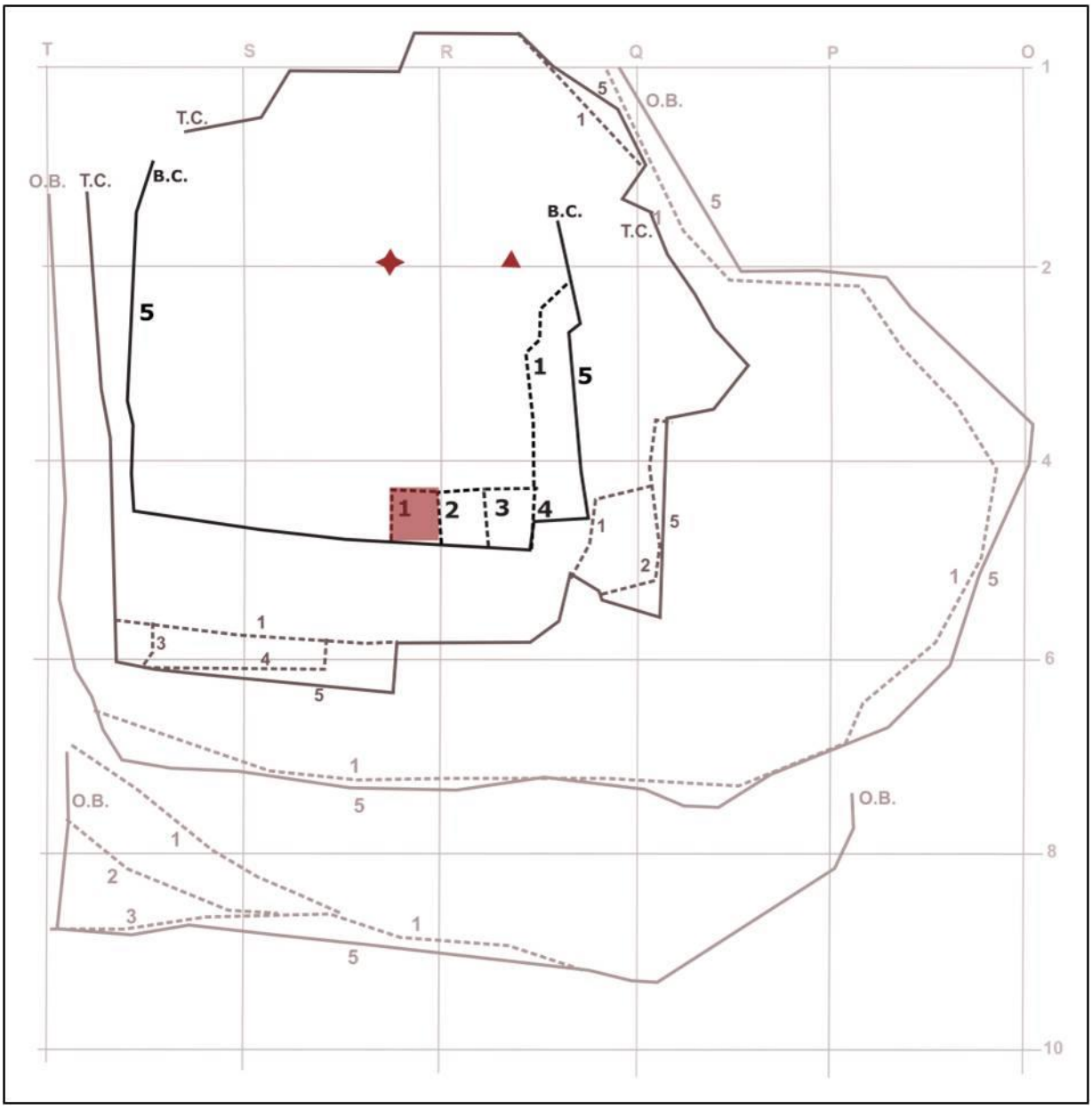


Figure 3.9. Quarry Map from 1970. Compiled from mine Progress Plans. Solid line indicates quarry dimensions at end of period, dotted lines are previous cuts. 1) May 1970; 2) June; 3) July; 4) August; 5) September. Symbols: Red square indicates the May 1970 excavation area; Red star is labelled as area or Beacon B; Red diamond indicates the Elephant (L12723) Site. Abbreviations: B.C., Bottom Cut; T.C., Top Cut; O.B., Over Burden.

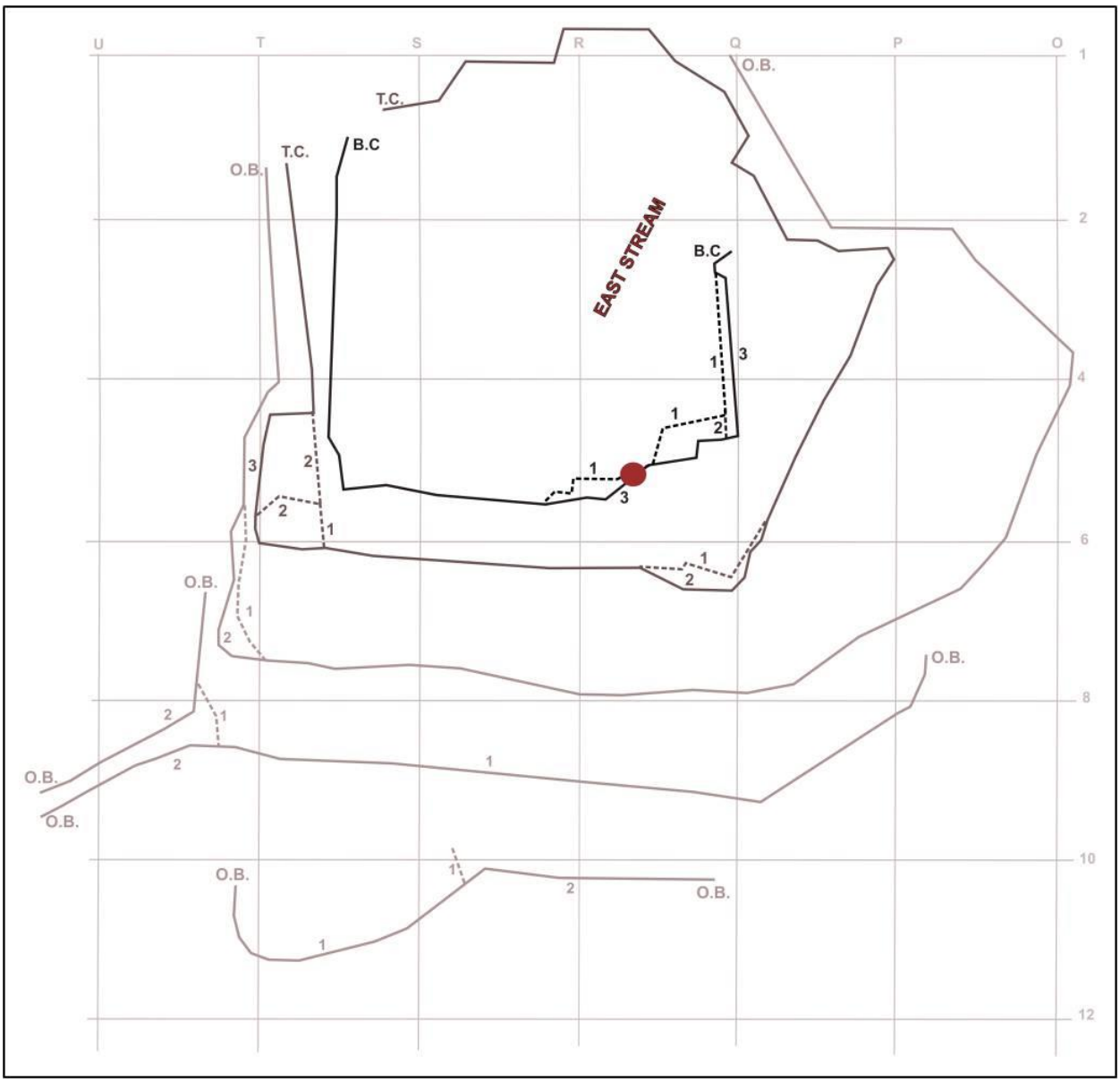


Figure 3.10. Quarry Map from 1971. Compiled from mine Progress Plans. Solid line indicates quarry dimensions at end of period, dotted lines are previous cuts. 1) May 1971; 2) June; 3) July.Red circle indicates the location of pig (*Nyanzachoerus*) seven, collected in June 1971. Abbreviations: B.C., Bottom Cut; T.C., Top Cut; O.B., Over Burden.



Figure 3.11. Quarry Map from 1972. Compiled from mine Progress Plans. Solid line indicates quarry dimensions at end of period, dotted lines are previous cuts. 1) July 1972; 2) August. Abbreviations: B.C., Bottom Cut; T.C., Top Cut; O.B., Over Burden.

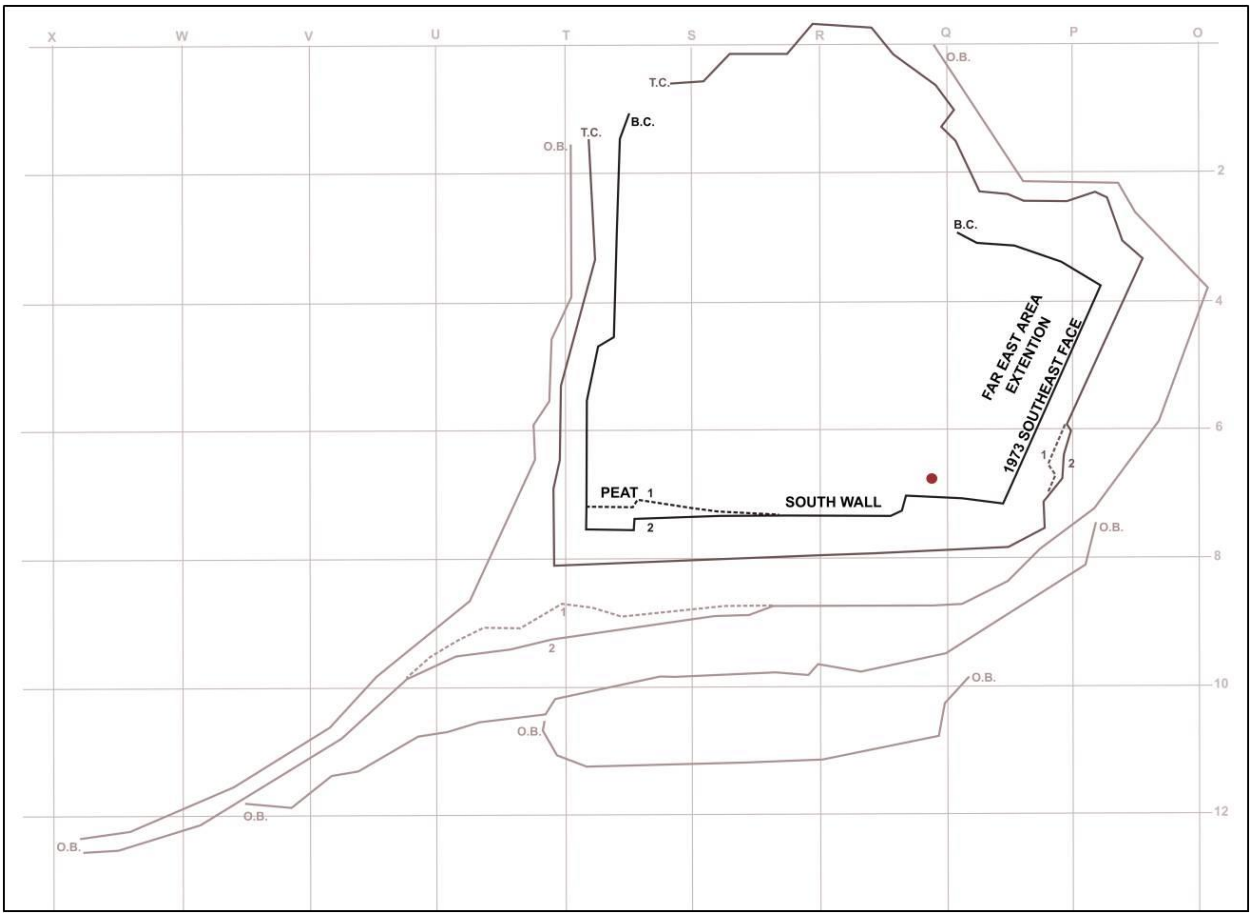


Figure 3.12. Quarry Map from 1973. Compiled from mine Progress Plans. Solid line indicates quarry dimensions at end of period, dotted lines are previous cuts. 1) August 1973; 2) September. Red circle indicates pig seven from 1971. Abbreviations: B.C., Bottom Cut; T.C., Top Cut; O.B., Over Burden.



Figure 3.13. Quarry Map from 1974. Compiled from mine Progress Plans. Solid line indicates quarry dimensions at end of period, dotted lines are previous cuts. 1) March 1974; 2) April; 3) May; 4) June; 5) July; 6) August; 7) November; 8) December. Abbreviations: B.C., Bottom Cut; T.C., Top Cut; O.B., Over Burden.

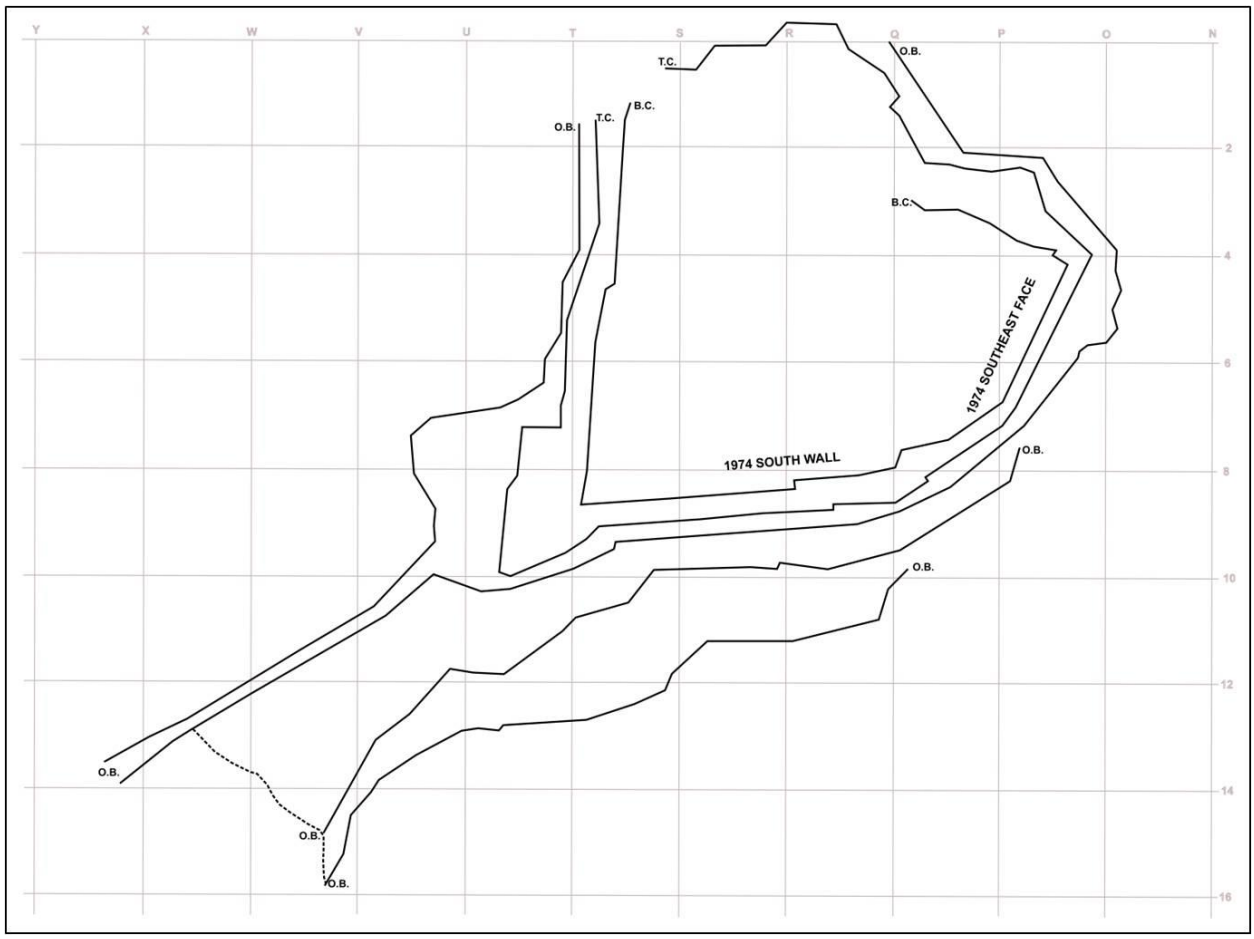


Figure 3.14. Quarry Map from 1974 showing final outline and excavation areas. Abbreviations: B.C., Bottom Cut; T.C., Top Cut; O.B., Over Burden.



Figure 3.15. Quarry Map from 1975. Compiled from mine Progress Plans. Solid line indicates quarry dimensions at end of period, dotted lines are previous cuts. 1) January 1975; 2) February; 3) March; 4) July; 5) August; 6) September; 7) October; 8) December. Abbreviations: B.C., Bottom Cut; T.C., Top Cut; O.B., Over Burden. The December excavation on bottom cut represents cut one of BCWW.



Figure 3.16. Quarry Map from 1976. Compiled from mine Progress Plans. Solid line indicates quarry dimensions at end of period, dotted lines are previous cuts. 1) January 1976; 2) February; 3) March; 4) April; 5) May; 6) June; 7) July; 8) August; 9) September; 10) October; 11) November; 12) December. Abbreviations: B.C., Bottom Cut; T.C., Top Cut; O.B., Over Burden. January represents cuts two and three of BCWW, February was cut four, March was cut five, April was cut 6, May was cut seven and eight, June was a continuation of cut eight, and July was cut nine.

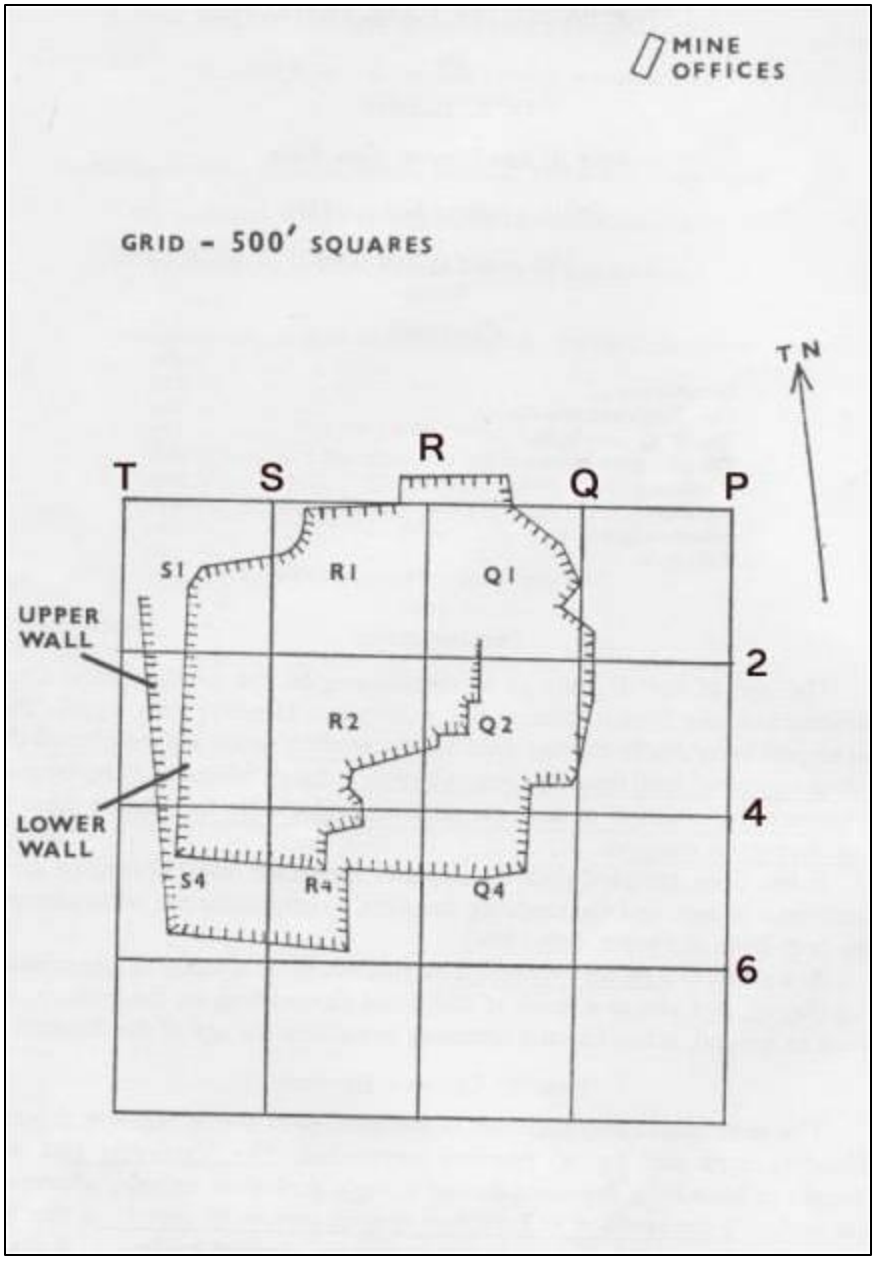


Figure 3.17. Quarry Map from August 1969 showing outline of bottom cut and top cut and the quarry grid. Reprinted from Hendey (1970b), Annals of the South African Museum, 56(3), pp. 120.

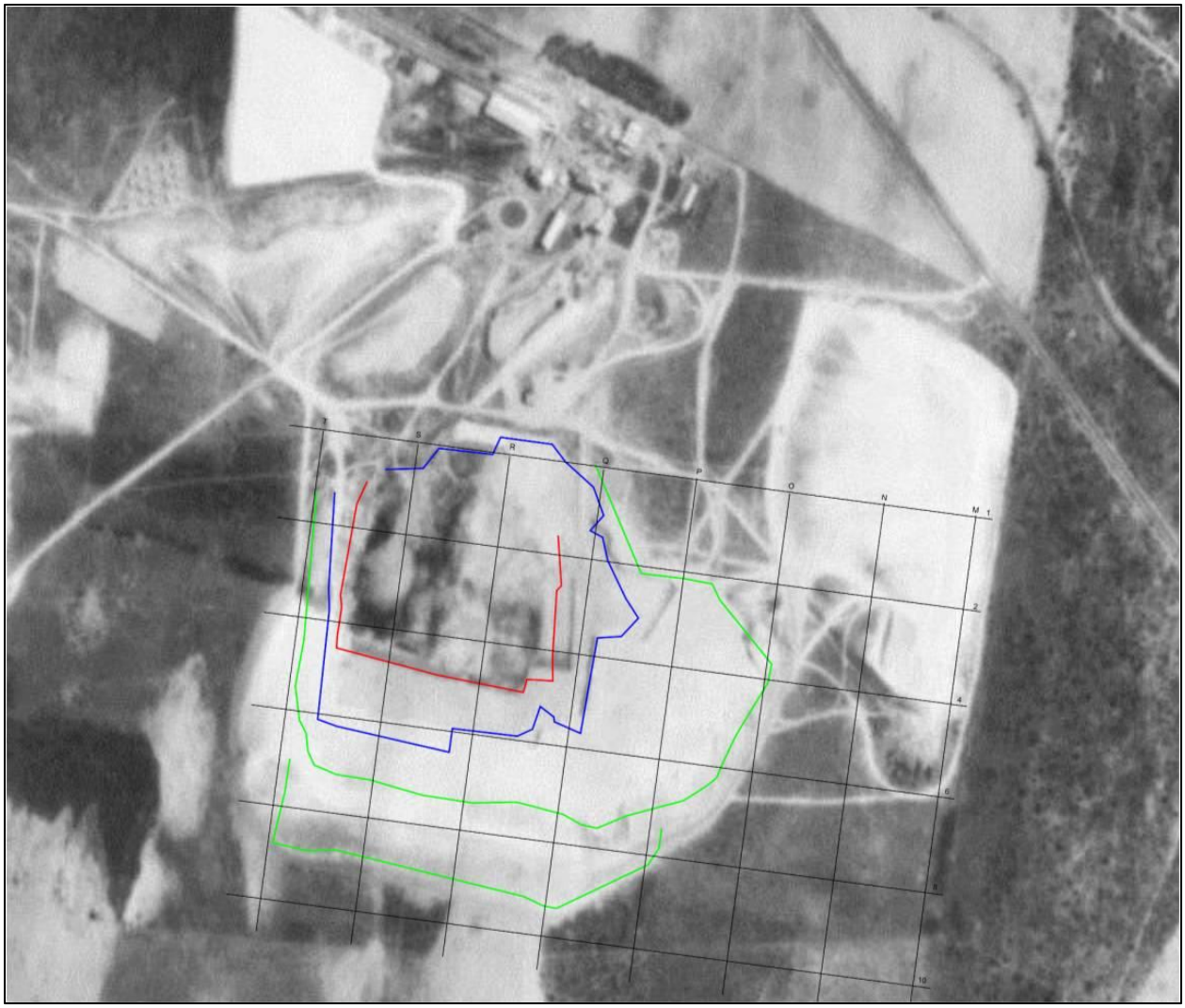


Figure 3.18. Quarry Map from 1970 superimposed on an aerial photograph of E-quarry from 1971. Red lines are Bottom Cut, blue lines are Top Cut and green lines are the Over Burden. Quarry Maps are aligned with as much accuracy as possible but there are always some areas that do not match accurately, particularly in the over burden. The bottom cut and top cut are the most important for understanding mining and fossil excavations at Langebaanweg.

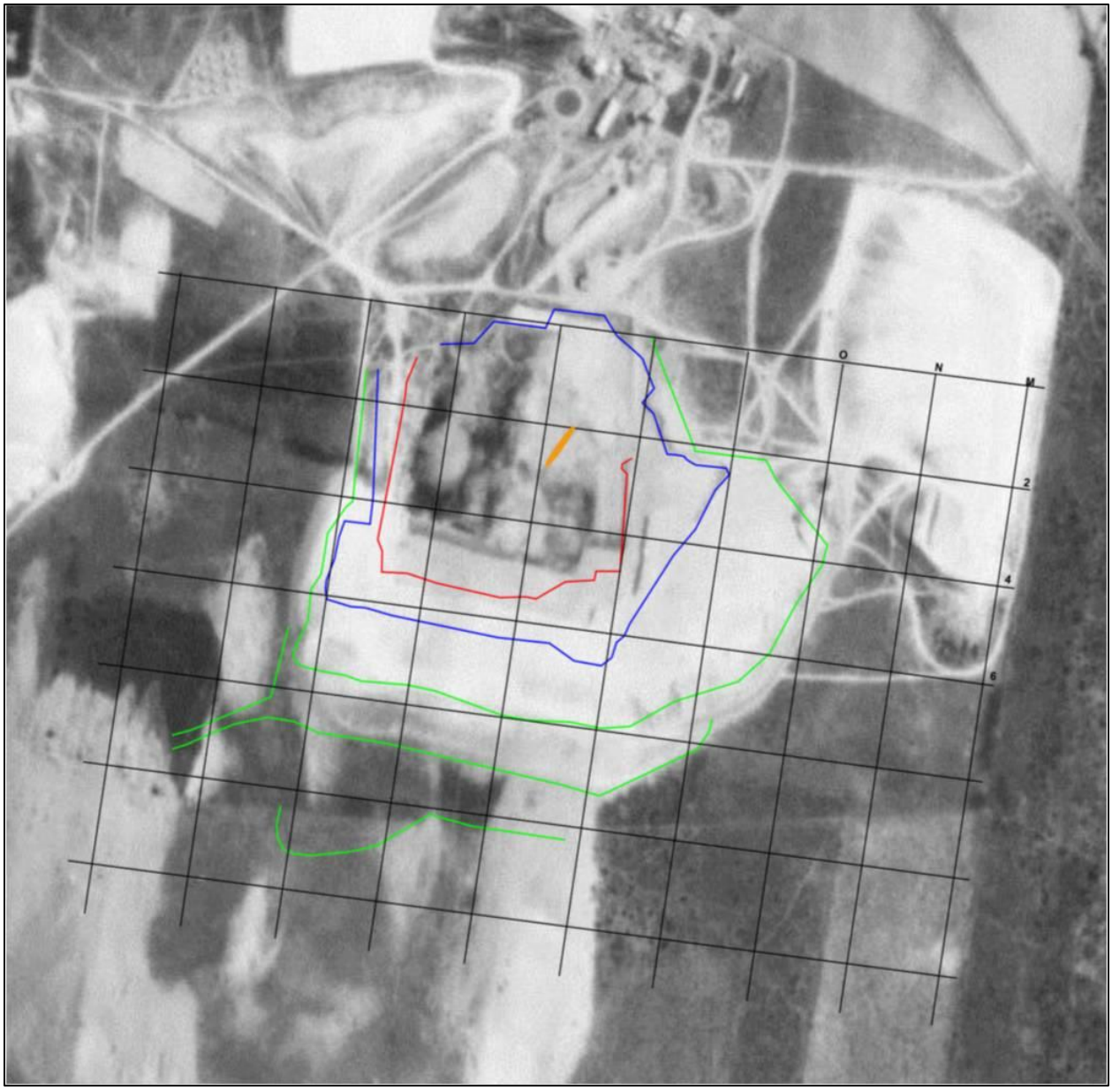


Figure 3.19. Quarry Map from 1971 superimposed on an aerial photograph of E-quarry from 1971. Red lines are Bottom Cut (B.C.), blue lines are Top Cut (T.C.) and green lines are the Over Burden (O.B.). Location of East Stream is shown as an orange line.

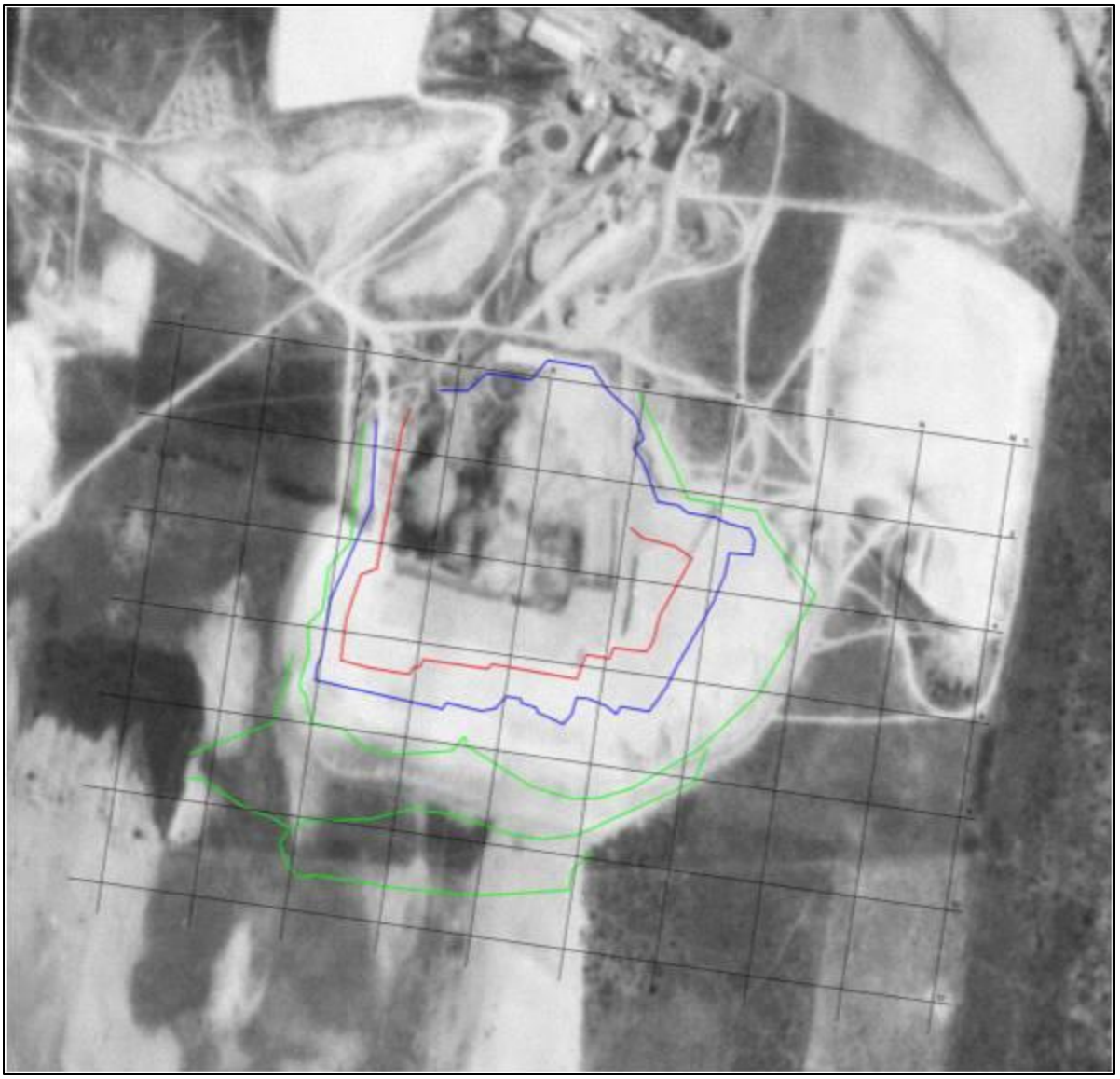


Figure 3.20. Quarry Map from 1972 superimposed on an aerial photograph of E-quarry from 1971. Red lines are Bottom Cut (B.C.), blue lines are Top Cut (T.C.) and green lines are the Over Burden (O.B.).



Figure 3.21. Quarry Map from 1973 superimposed on an aerial photograph of E-quarry from 1971. Red lines are Bottom Cut (B.C.), blue lines are Top Cut (T.C.) and green lines are the Over Burden (O.B.).



Figure 3.22. Quarry Map from 1975 superimposed on an aerial photograph of E-quarry from 1971. Red lines are Bottom Cut (B.C.), blue lines are Top Cut (T.C.) and green lines are the Over Burden (O.B.). Arrows indicate location of BCWW

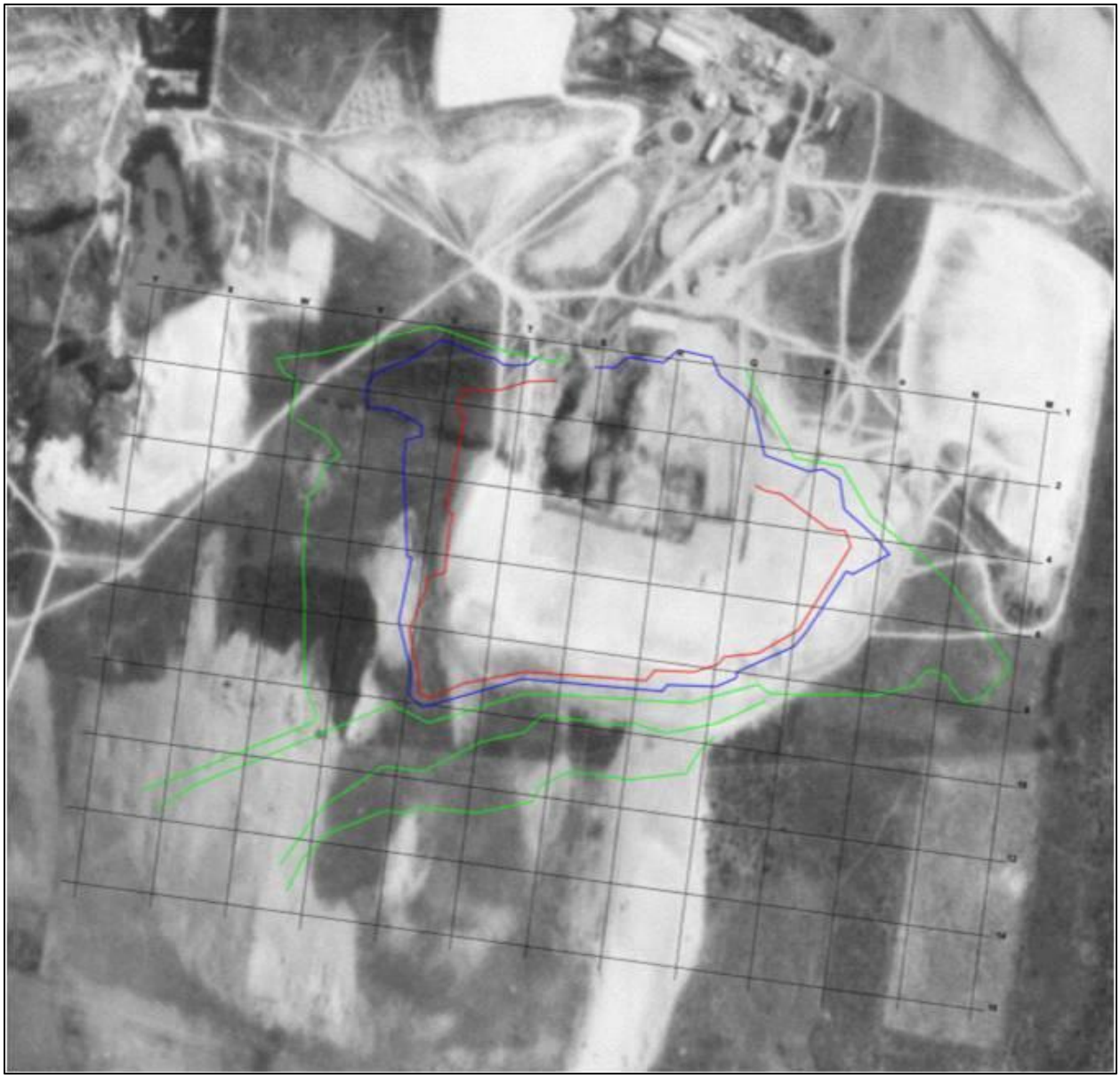


Figure 3.23. Quarry Map from 1976 superimposed on an aerial photograph of E-quarry from 1971. Red lines are Bottom Cut (B.C.), blue lines are Top Cut (T.C.) and green lines are the Over Burden (O.B.).

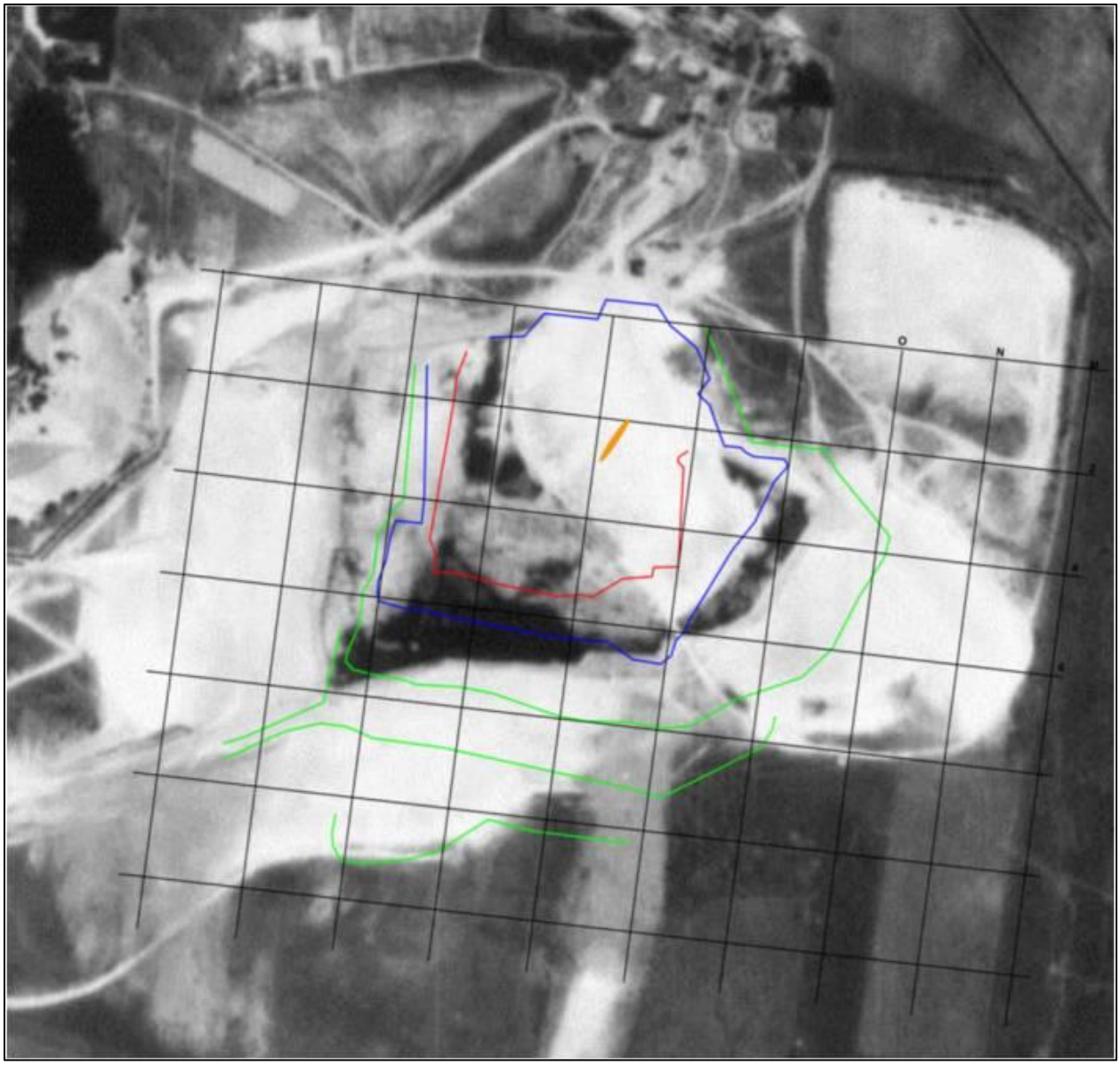


Figure 3.24. Quarry Map from 1971 superimposed on an aerial photograph of E-quarry from 1977. Red lines are Bottom Cut (B.C.), blue lines are Top Cut (T.C.) and green lines are the Over Burden (O.B.). Orange line indicates location of East Stream, not the white mounds of over burden covering the East Stream area.

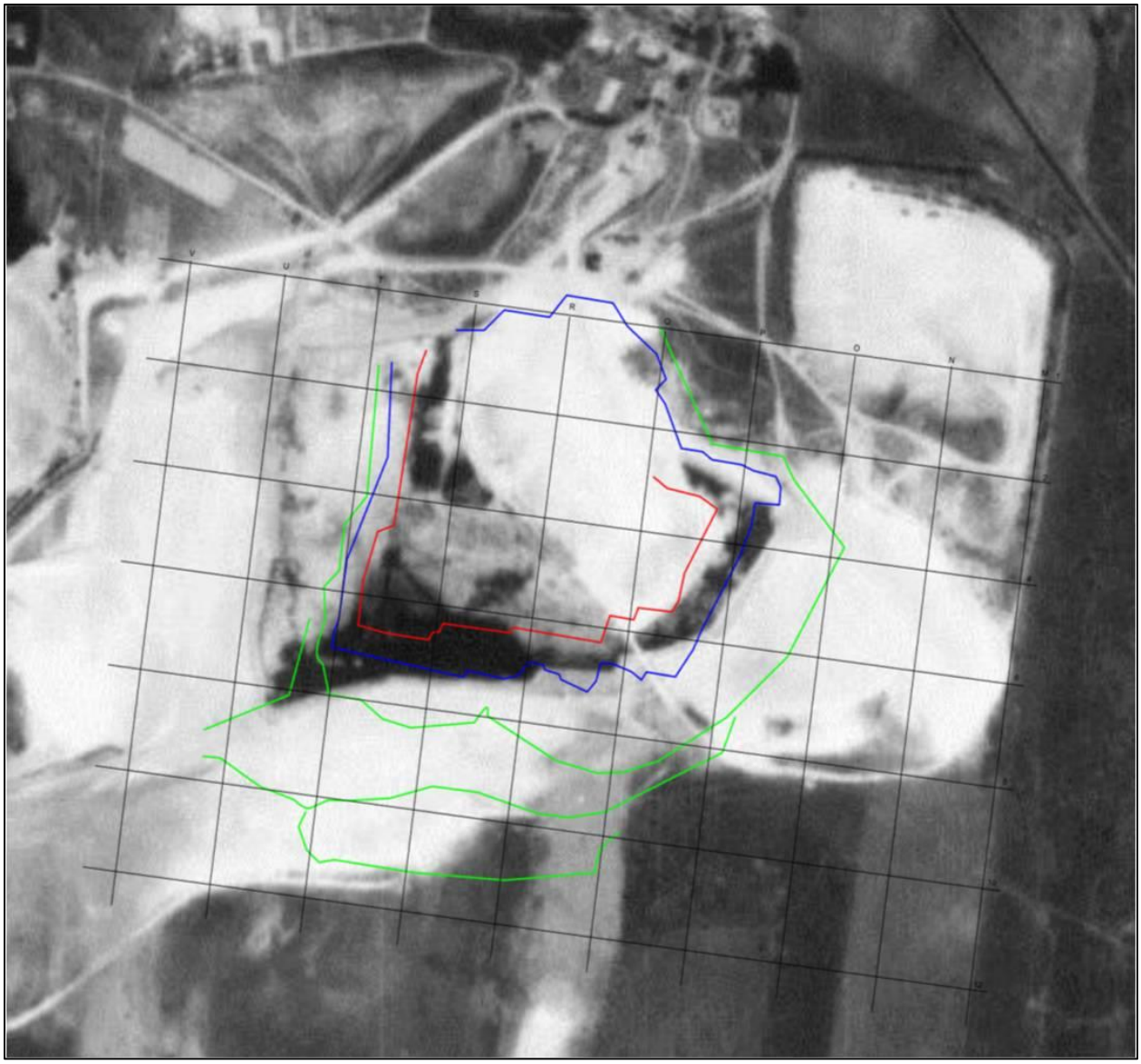


Figure 3.25. Quarry Map from 1972 superimposed on an aerial photograph of E-quarry from 1977. Red lines are Bottom Cut (B.C.), blue lines are Top Cut (T.C.) and green lines are the Over Burden (O.B.).



Figure 3.26. Quarry Map from 1973 superimposed on an aerial photograph of E-quarry from 1977. Red lines are Bottom Cut (B.C.), blue lines are Top Cut (T.C.) and green lines are the Over Burden (O.B.).



Figure 3.27. Quarry Map from 1975 superimposed on an aerial photograph of E-quarry from 1977. Red lines are Bottom Cut (B.C.), blue lines are Top Cut (T.C.) and green lines are the Over Burden (O.B.). Arrows indicate position of BCWW.

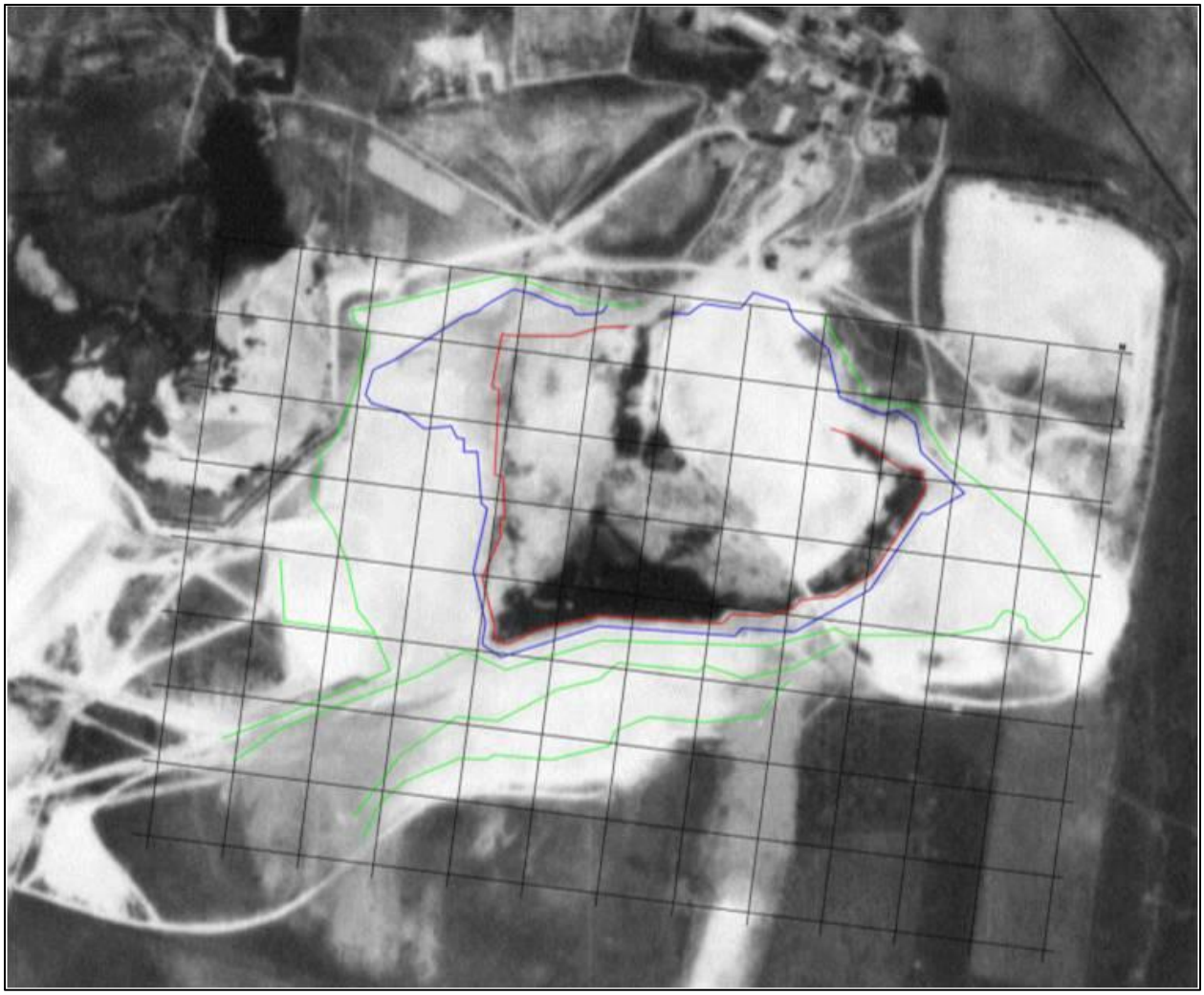


Figure 3.28. Quarry Map from 1977 superimposed on an aerial photograph of E-quarry from 1977. Red lines are Bottom Cut (B.C.), blue lines are Top Cut (T.C.) and green lines are the Over Burden (O.B.).



Figure 3.29. Quarry Map from 1971 superimposed on an aerial photograph of E-quarry from 2003. Red lines are Bottom Cut (B.C.), blue lines are Top Cut (T.C.) and green lines are the Over Burden (O.B.). Arrow indicates the position of the current excavations in E-Quarry; orange line indicates the postion of East Stream; rectangle is the approximate location of the 1964 excavations; and the circles indicate the approximate position of the 1966/2 and 1969/1 excavations.

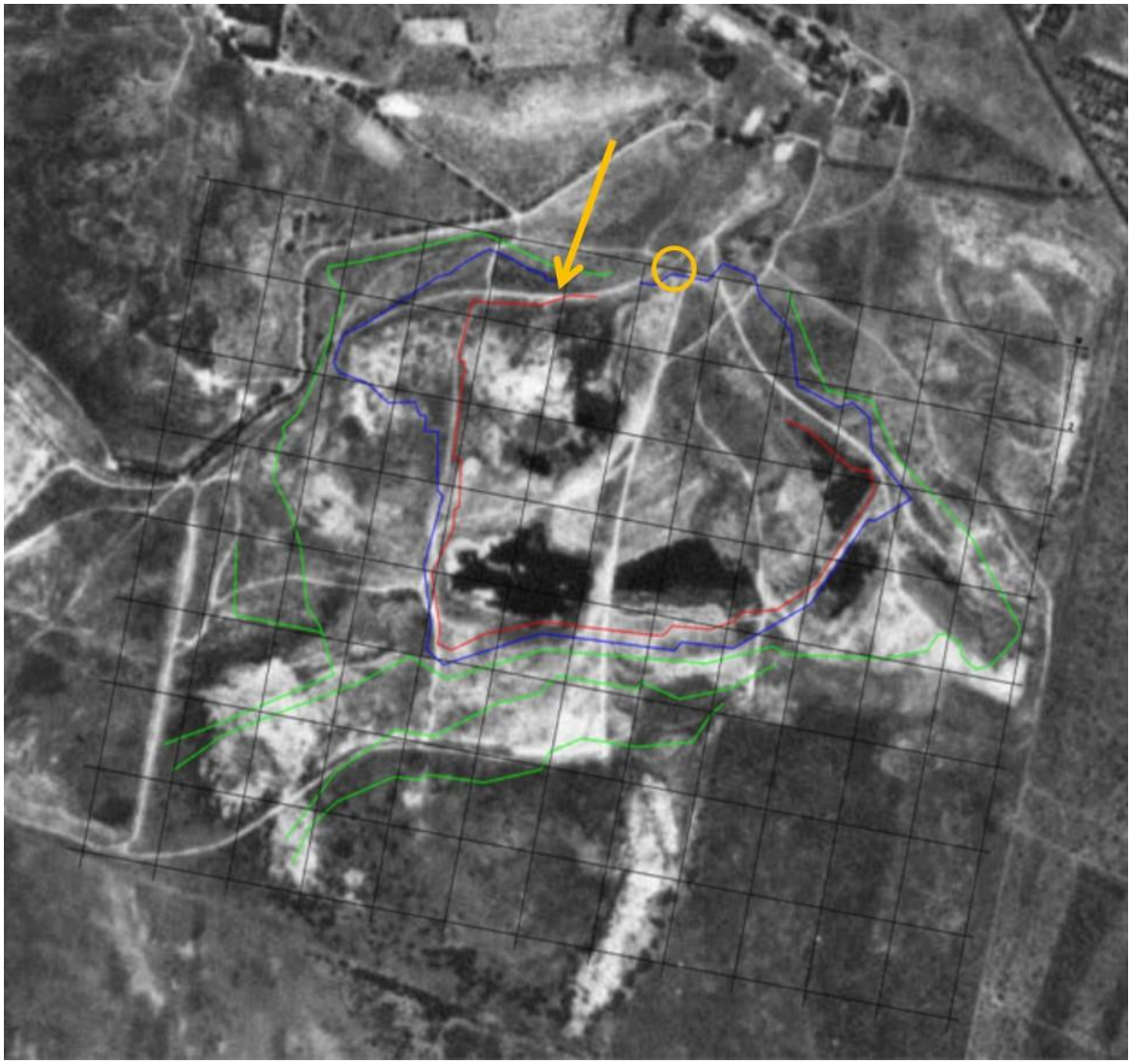


Figure 3.30. Quarry Map from 1977 superimposed on an aerial photograph of E-quarry from 2003. Red lines are Bottom Cut (B.C.), blue lines are Top Cut (T.C.) and green lines are the Over Burden (O.B.). Arrow indicates the location of the current excavation, this is also the northern end of the bed 3a deposits. The circle denotes the location of the new visitors centre.

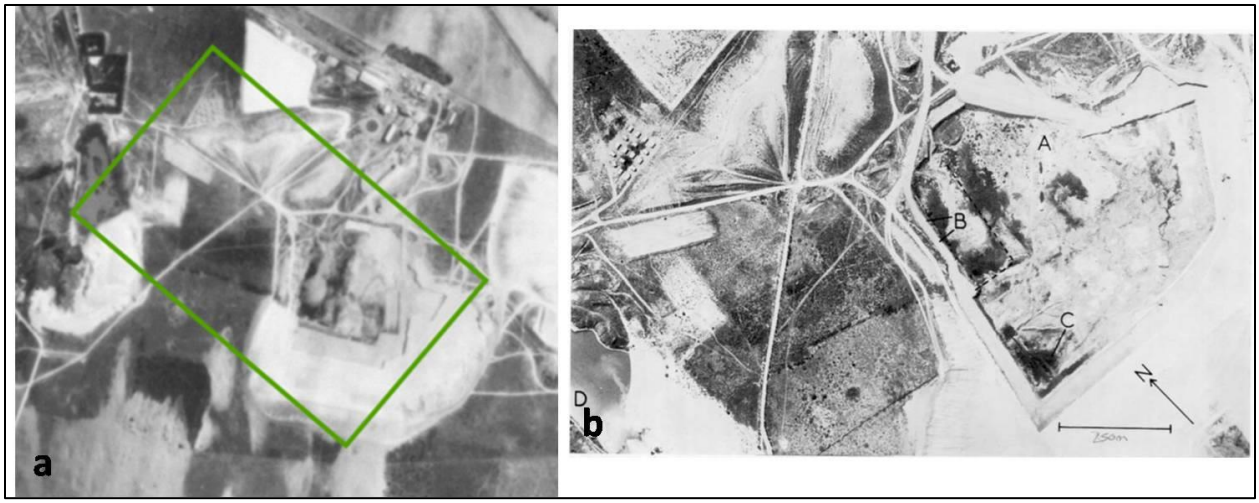


Figure 3.31. Location of quarry photo from 1974. a) Aerial photograph from 1971 showing relative position of quarry photograph from 1974. b) Photograph of E-Quarry dated July 1974. See Figure 3.4 for description of photo.

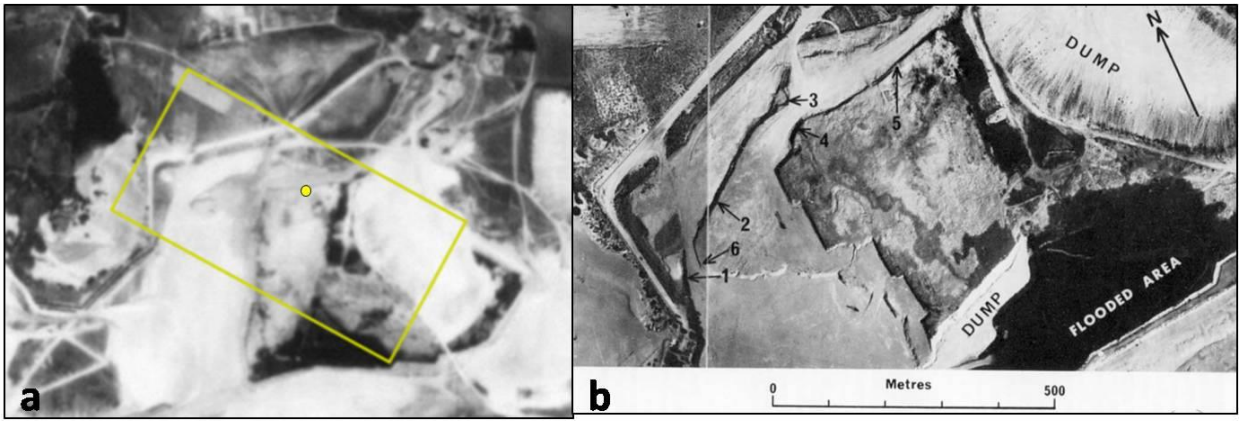


Figure 3.32. Location of quarry photo from 1979. a) Aerial photograph from 1977 showing relative position of quarry photograph from 1979; circle indicates location of current excavation. b) Photograph of E-Quarry dated 1979. Numbers in figure refer to sedimentary samples, see Dingle*et al.* (1979) for an explanation. The number 5 marks the location of the 1976/2 excavation.See Figure 3.36 for description.

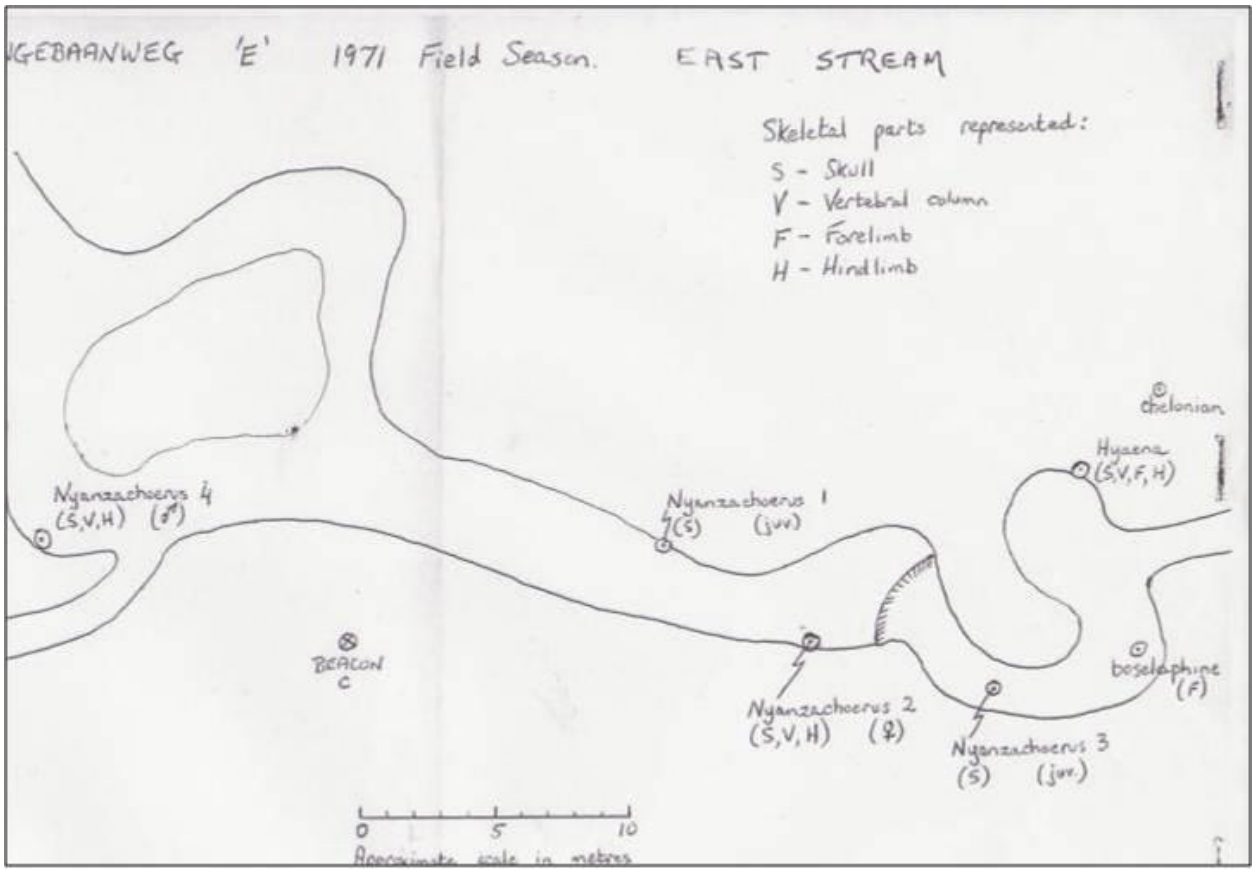


Figure 3.33. Sketch of East Stream showing location of some important fossil finds. Reprinted from Hendey' s field notes (1971).

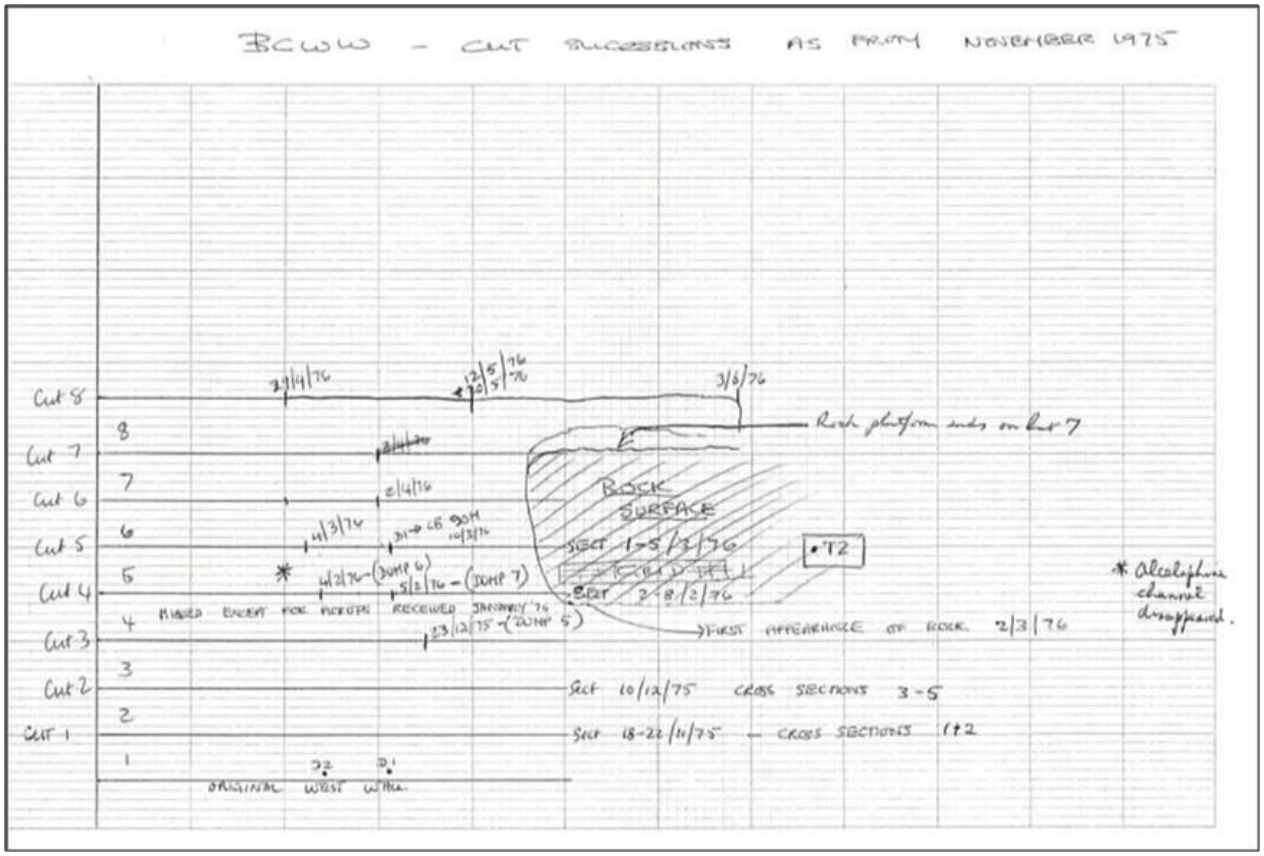


Figure 3.34. A schematic representation of the BCWW showing mine cuts, fossil excavation, dumps, datums and more. Reprinted from Hendey' s field notes (1975).

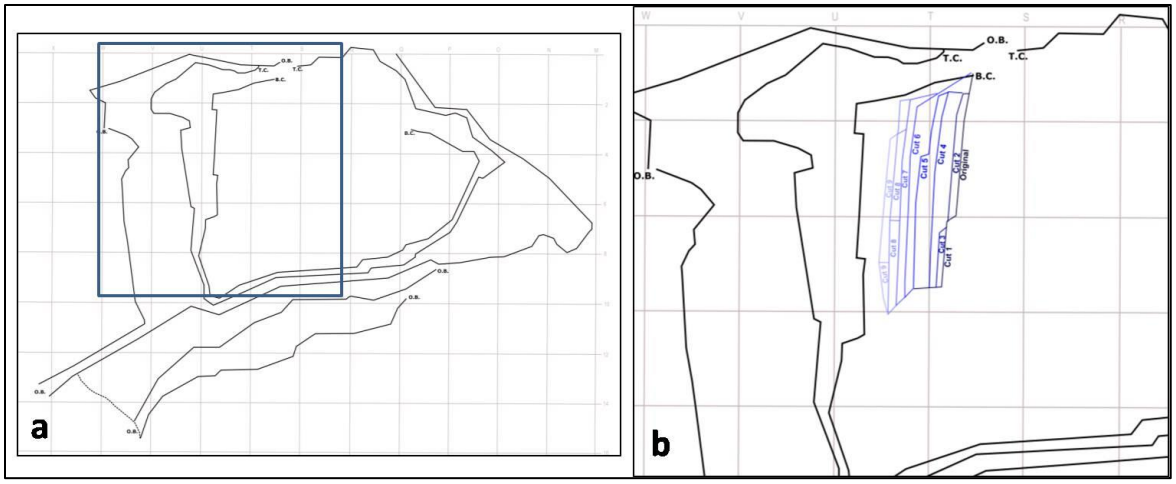


Figure 3.35. Quarry Map showing BCWW 1976. a) Quarry Map 1976 with inset. b) BCWW cuts shown chronologically by colour gradient. January represents cuts two and three of BCWW, February was cut four, March was cut five, April was cut 6, May was cut seven and eight, June was a continuation of cut eight, and July was cut nine.

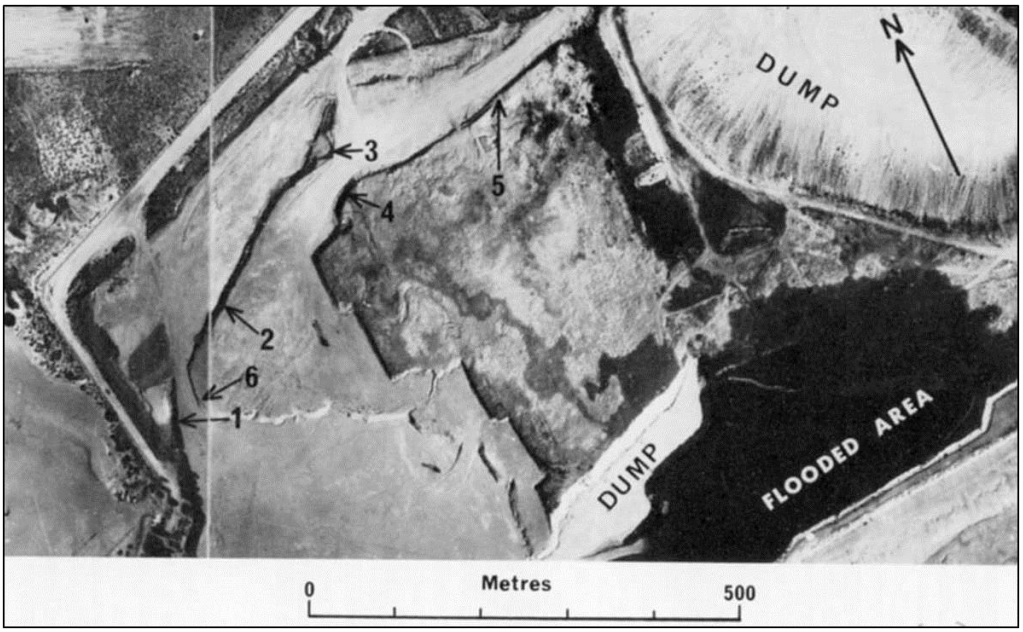


Figure 3.36. Aerial photograph of E-Quarry dated 1979. Numbers in figure refer to sedimentary samples, see Dingle & Lord (1979) for an explanation. The number 5 marks the location of the 1976/2 excavation.Reprinted from Dingle, Lord& Hendey (1979), Annals of the South African Museum, 78(1), pp. 84.



Figure 3.37. Aerial photograph of E-Quarry from 1980 focussing on bed 3aN/S. This image shows the river channels 3aN (W) and 3aS (D). The phosphate rock is marked by R. The trenches of the 1976/2 excavation can be observed and is marked by 4. Other areas of interest: 1) 1975/1 excavation (3aN); 2) 1976/1 excavation, on northeast corner of phosphate rock (3aS); 3) Dump ten; 4) 1976/2 excavation; 5) Dump nine; 6) Dump eight; 7) Carbonaceous deposits to the south of the river channels. Reprinted from Hendey (1980), Annals of the South African Museum, 81(1), pp. 58.

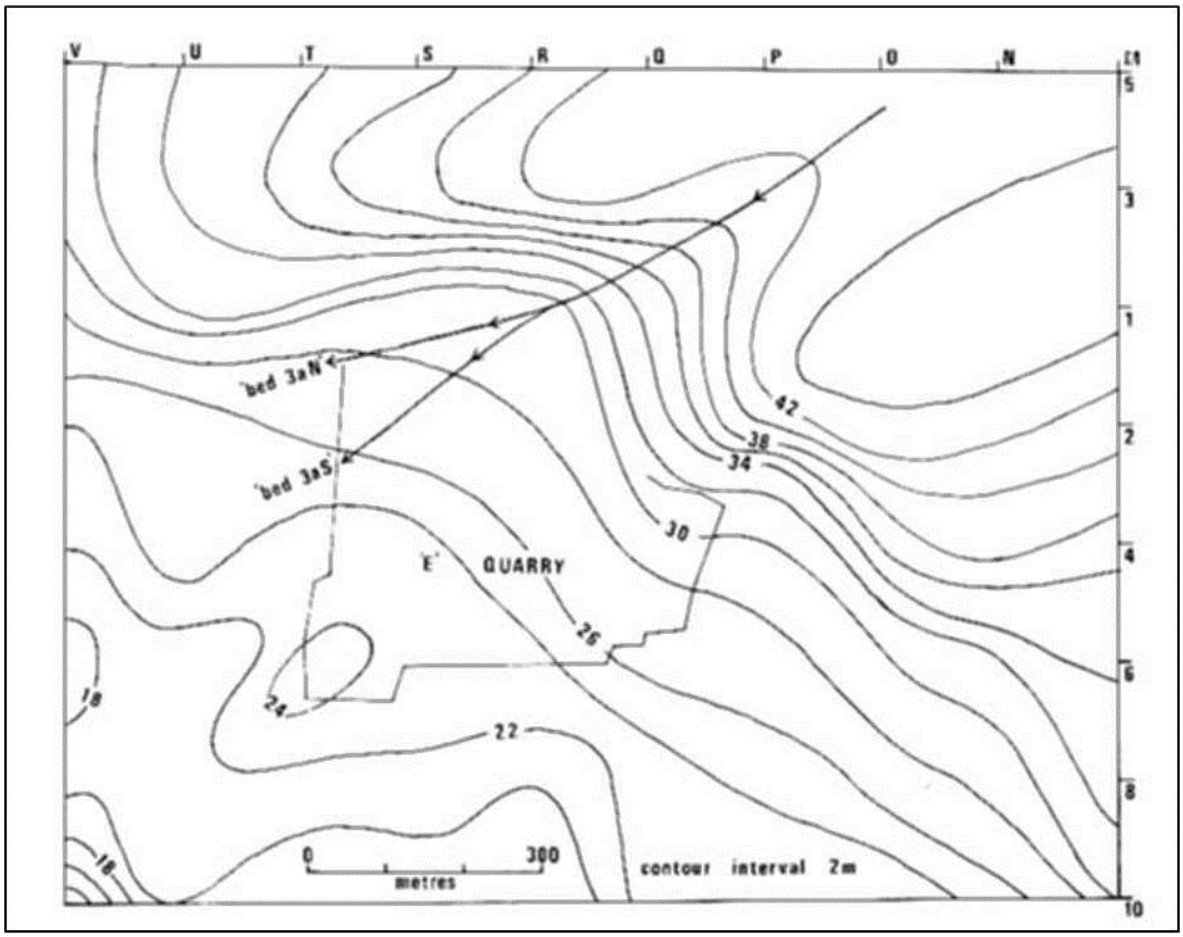


Figure 3.38. Early interpretations of river courses of bed 3a from 1976. Contour lines represent the base of the MPPM deposit (see Tankard (1975) for details). Note the orientation of river courses compared to later interpretations in Figure 3.37. Reprinted from Hendey (1976), Annals of the South African Museum, 69(9). Pp. 229.

Table 3.2. Dump origins and sedimentary units.

Dump	**Origin**
Dump one	East Stream, LQSM
Dump two	East Stream, LQSM
Dump three	East Stream, LQSM/ MPPM?
Dump four	Cut one, BCWW, bed 3aS
Dump five	Cut three BCWW, grey sands, bed 3aS
Dump six	Cut four BCWW, bed 3aS
Dump seven	Cut four, northern end, bed 3aS
Dump eight	South of 1976/2, Bed 3aN
Dump nine	West of 1976/2, bed 3aN
Dump ten	North of 1976/2, bed 3aN

CHAPTER FOUR

FAUNAL REMAINS AT LANGEBAANWEG

Langebaanweg is internationally known for its very abundant and diverse faunal assemblage. The taxonomic composition at the site includes mammals, reptiles, birds, fish and amphibians. Taxa vary from tiny animals like lizards and frogs to megamammals like the Sivathere and bears. These animals occupied an array of different environments including marine, fresh water and terrestrial habitats. Various authors have used the fauna of Langebaanweg to draw conclusions regarding the palaeoenvironment both locally and regionally and to reconstruct the palaeoclimate. The following chapter highlights some important taxonomic groups and their implications regarding depositional processes and palaeoenvironment. This section of the thesis, indicateswhat little taphonomic work has been undertaken at Langebaanweg.

4.1 FAUNA

4.1.1 Mammals

The array of mammal groups recovered from Langebaanweg and the diversity of species is astounding. The Mio-Pliocene transition was a period when many modern mammal genera or families were emerging and thus Langebaanweg, as the only fossil locality of this age on the west coast of South Africa, is well placed to investigate the evolution and dispersion of these mammals. Table 4.1 displays an updated species list, showing the source (MPPM / LQSM) of the material, environmental preferences where known or inferred and references to identifications. Included among the Langebaanweg mammals are insectivores, rodents, leporids and assorted families of small mammals, proboscideans, aardvarks and pangolins, primates and an unusually large carnivore assemblage. There are suids, equids and rhinoceros, whales and hippopotamus, giraffidae and even bovids. I will address these groups in greater detail below.

Rodentia

Micromammal families occurring in the Langebaanweg faunal assemblage include Chrysochloridae, Soricidae, Macroscelididae, Bathyergidae, Hystricidae and Muridae; as well as a number of subfamilies (Table 4.1). Almost 20 genera of micromammal have been identified at Langebaanweg to date (Hendey 1981b; Matthews *et al.* 2007). Muridae and Bathyergidae have received extensive interest lately; however the soricid and macroscelid populations require more work. Below is a discussion of the taphonomy and palaeoecological interpretations of some of the more interesting and well studied micromammal taxonomic groups.

Muridae

The Mio-Pliocene is a time when many modern murid genera emerged (Denys 1996, 1999), and Langebaanweg represents the first appearance in South Africa of a number of murid and bathyergid species (Pocock 1976, 1987; Denys 1990a, 1991, 1994a, b, 1998; Matthews 2004). Langebaanweg preserves the oldest *Aethomys* species recovered in Africa (Matthews *et al.* 2007). Genera like *Zelotomys, Rhabdomys* and *Aethomys* appear to have originated in southern Africa and spread northwards across the continent (Denys 1999). Matthews (2007) records many modern genera at Langebaanweg which are found together with extinct species. She infers from this that environmental conditions at Langebaanweg have shifted over time, necessitating some adaptation in these animals (at the specific but not generic level). Another notable genera at Langebaanweg was the tree rat (*Thallomys*), usually associated with acacia trees.

Muridae bones from Langebaanweg generally display a low frequency of water rounding and a low degree of breakage, suggesting transport over short distances in a medium-low or low-energy environment (Matthews 2004). Preservation was generally better in the LQSM than the MPPM, and bones appear to have been buried quicker in the former than the latter. Incisor digestion was observed on 53% of murid remains from the MPPM and 65% from the LQSM (Matthews 2006). Digestive etching was of a predominantly light intensity (Matthews 2006), consistent with owls and similar predators (Andrews 1990). Digestive modifications were similar in the MPPM and LQSM, suggesting micromammal bones in both assemblages could have been accumulated by the same type of predator. Murid remains display little weathering damage indicating quick internment. Matthews *et al.* (2007) were unable to accurately assess differences in species diversity between the MPPM and the LQSM due to a lack of control in the recovery methods utilised. Certain modern micromammal species display co-dependency

with fynbos plant species; for example some Iridaceae appear to have co-evolved with mole-rats (Lovegrove & Jarvis 1986). Certain ground proteas are dependent on the murid *Myomyscus verreauxi* (which is endemic to the southwestern Cape) for pollination, while this animal is dependent on the protea for food (David 1978). These patterns suggest a long-standing relationship between micromammals and the Cape Macchia vegetation, and by extension indicates the presence of fynbos vegetation at Langebaanweg in the Early Pliocene (Denys 1990, 1999; Matthews 2004, 2006).

Bathyergidae

Bathyergidae are represented by two species at Langebaanweg; *Bathyergus hendeyi*, the most commonly occurring of the two, and *Cryptomys broomi*, which was relatively rare (Denys 1998; Matthews *et al.* 2006). Mole-rats occur at very high frequencies in Langebaanweg (Denys 1998), although murids always dominate the assemblage (Matthews 2006). There has been some debate over possible reasons for the high frequency of Batherygidae. Hendey (1981b) proposed that these fossorial animals were drowned in their burrows, resulting in the high numbers of these remains. However, Matthews (2006) finds no evidence for this, since there is little water damage or evidence for transportation or weathering. In addition, juvenile remains would be expected in this scenario and there are almost no juveniles preserved at Langebaanweg. Matthews (2006) draws on several lines of evidence, including molecular trees, to suggest that the high numbers of mole-rats at Langebaanweg was an indication for eusocial behaviour. In this situation, eusociality would be the basal condition for mole-rats, and *Bathyergus* would have undergone a radical change in behaviour over the last 5 million years. Matthews (2006) attributed the lack of juvenile mole-rats to predation bias; juveniles would have remained in the den and would have been protected from predation. Predation alone however, cannot account for the high frequency of mole-rats or other fossorial rodents like Chrysochloridae. Matthews (2006) suggests that the high frequency of burrowing rodents is likely a taphonomic artefact of some kind, or the results of animal behaviour; for example, Langebaanweg (and the area around it) may have presented ideal habitat conditions for these animals. For example, modern mole-rats frequently inhabit back beach dunes along the south west coast. All extant mole-rats eat geophytes and their presence at Langebaanweg indicates the likely existence of these plants on the west coast at this time, particularly given that mole-rats occur at Langebaanweg in unusually large quantities (Matthews *et al.* 2007; 2006). Indeed, it suggests that geophytes, which today are an important component of west coast vegetation, were already well established during the early Pliocene.

Gerbilinae

A single member of the family Gerbillinae, *Desmodillus magnus*, is known from Langebaanweg (Denys & Matthews 2017). *Desmodillus magnus* is the oldest representative of its genus in Africa. Denys and Matthews (2017) indicate that remains from *D. magnus* were most likely accumulated by a predator. Today, Gerbillinae are frequent prey for some owl species and these nocturnal predators are known from Langebaanweg (Manegold 2013; Pavia *et al.* 2015). The presence of *D. magnus* is suggested to indicate the presence of open, dry areas at Langebaanweg (Denys & Matthews 2017), a finding collaborated by many bird remains (Manegold *et al.* 2013). The ratio of Murinae to Gerbillinae has been used by a number of authors as an index for aridity (Denys 1996, 1999; Fernandez-Jalvo *et al*. 1998). In general, the number of Gerbillinae increases with increased aridity while the number of Murinae decreases. The ratio of Gerbillinae/Murinae at Langebaanweg is 1 species to at least four. Denys & Matthews (2017) have used this ratio and the linear relationship between diversity and rainfall to estimate between 500 and 1600 mm of precipitation at Langebaanweg; that is less aridity 5 Ma ago than observed today at the site. These findings are corroborated by the large anuran assemblage (Matthews *et al.* 2015).

Tubulidentata

Tubulidentata material in the African fossil record is generally scarce. However, Langebaanweg has produced over 40 aardvark specimens (Lehmann 2006). This material was referred to the modern aardvark *Orycteropus afer* by Pickford (2005), based on dental remains and phalanges. These elements are not the most diagnostic for aardvarks and Lehmann (2006) in reassessing the material states that it should be cautiously referred to *Orycteropus*cf.*afer*, until such time as more diagnostic material is recovered. It must also be noted that there is a probable second species of aardvark represented in the Baard's-Quarry deposits. This will not be considered here, as the Baard's-Quarry material is younger than E-Quarry (see Chapter Two). The Langebaanweg aardvark is the earliest known representative of this species in South Africa (Lehmann 2006). Lehmann (2006) suggests that *O. afer* may have evolved in South Africa and spread northwards, probably replacing older tubulidentates. Modern aardvarks have a wide habitat tolerance, although they have been found to prefer open areas where food is abundant (Skinner and Chimimba 2005). They often make use of sandy ground, but are also capable of utilising heavy soils associated with woodlands (Skinner and Chimimba 2005).

Proboscidea

The first ever taxon to be described from Langebaanweg was a proboscidean, a Stegolophodon molar, recovered from Baard's Quarry in the 1950's (Singer & Hooijer 1958). Since then a large amount of proboscidean material, including over 50 dental remains and at least one partial skeleton have been recovered from E-Quarry (Maglio & Hendey 1970;Sanders 2007). This material has been studied by a number of researchers and undergone numerous re-identifications. Today, Proboscidean material from Langebaanweg is derived from the elephantids *Mammuthus subplanifrons* (Singer & Hooijer 1958; Aguire 1969; Maglio & Hendey 1970)and *Loxodonta cookei* (Sanders 2007)and the gomphothere *Anancus capensis* (Hendey 1970a, 1976; Sanders 2007). Langebaanweg represents the earliest occurrence of the species *M. subplanifrons* (Mol 2006) and of the genus *Mammuthus*(Sanders 2007). The best represented proboscidean at Langebaanweg is *L. cookei* (Sanders 2007). Sanders (2007) suggested that *L. cookei* may have been ancestral to the *L. exoptata-L. africana* lineage, which contains the modern African elephant. *Loxodonta cookei* thus, helps bridge a phylogenetic gap between the first appearance of loxodont elephants in the Miocene of east and central Africa, and the modern species (Sanders 2007). *Mammuthus subplanifrons* represents the most basal stage of mammoths and therefore provides important evidence for an African origin for *Mammuthus* (Sanders 2007). The gomphothere, *A. capensis*, is known from both the MPPM and the LQSM. *Mammuthus subplanifrons*, on the other hand, is only found in the LQSM; while *L. cookei* is only known from the MPPM.

Sanders (2007) utilised proboscidean biochronology to estimate ages for the MPPM and LQSM, and found that there was little difference in age (5 – 4 Ma) between the deposits. The Langebaanweg proboscideans do not display particularly hypsodont dentition, or any other dental adaptations derived for grazing. However, stable carbon isotope studies of all other early elephant fossils (mostly in East Africa) have shown patterns consistent with C_4-grazing ecologies (Sanders 2007 and references therein). Sanders, none-the-less, concluded that substantial amounts of grass grew in the Langebaanweg palaeoenvironment, enough to support three species of proboscidean as well as other large grazing forms. A preliminary study of carbon and oxygen isotopes in the Langebaanweg proboscideans indicated that these species were predominantly mixed feeders with *A. capensis* being closest to the browsing end of the spectrum (Groenewald 2016).

Pholidota

Another unusual occurrence, of a mammal that is not typically found in fossil assemblages, is the pangolin. A number of pangolin remains, including a partial skeleton have been recovered from Langebaanweg (Hendey 1976). This material has been attributed to the giant pangolin *Manis gigantea* originally found in western and central Africa (Botha & Gaudin 2007). *Manis gigantea* was probably ground dwelling with a quadrupedal gait (Botha & Gaudin 2007). The Langebaanweg specimen is the first positively identified pangolin from South Africa and is the oldest fossil occurrence of the species.*Manis gigantea* has only been recovered from the LQSM. The modern *M. gigantea* is known to occur in forests and savannas where termites are abundant and water is available (Kingdom 1971).

Perissodactyla

Equidae

Hendey (1981) lists three equid species at Langebaanweg, *Hipparion* cf. *primigenium*, *Hipparion* cf. *namaquense* and *Hipparion* cf. *baardi*. The latter species has been reassessed on numerous occasions. Originally classified as *Hipparion* cf. *baardi* (Bone & Singer 1965; Hooijer 1976), it has been linked to both the Eurygnathohippus clade (Franz-Odendaal *et al.* 2003) and the Hipparion clade (Hendey 1978; Eisenmann 1983). Finally in 2006, Bernor and colleagues re-classified and identified this material to the new species *Eurygnathohippus hooijeri*. The remaining equid material from Langebaanweg is likely in need of re-investigation. *Hipparion* cf. *primigenium* has not been definitively shown to occur in Africa; while *Hipparion* cf. *namaquense* is most likely better placed in the genus *Eurygnathohippus* (Bernor & Armour-Chelu 1999; Franz-Odendaal *et al.* 2003). It should be noted that *H. primigenium* was only observed in the KGM, and is thus not listed in Table 4.1. One of the reasons for the confusion over the *E. hooijeri* classification was that the animal displayed derived, highly hypsodont dentition (Hooijer 1976). Mesowear analysis on *E. hooijeri* indicates that MPPM and LQSM populations were both grazers; however isotopic analysis indicated a diet high in C_3 vegetation (Franz-Odendaal *et al.* 2003). The dietary regimes between the MPPM and LQSM populations differed slightly (Franz-Odendaal *et al.* 2003). *Eurygnathiohippus hooijeri* appears to have gone from feeding in a wetter habitat (like floodplain environment) in the LQSM to a more extreme, drier habitat in the MPPM (Franz-Odendaal *et al*. 2003). In addition, the postcranial skeleton of *E. hooijeri,* when compared to east African material, indicates a functional shift that facilitated cursorial locomotion (Bernor & Kaiser 2006).

Rhinocerotidae

The presence of rhinoceros bones at Langebaanweg was noted early on (Hendey 1970a), when these remains were classed as (relatives of) the black rhino,*Diceros* aff. *bicornis*. Hooijer (1972) later identified this material as an early white rhino *Ceratotherium praecox*, similar to material recovered in East African localities. Rhino remains are highly abundant at Langebaanweg and include partial skulls, associated partial skeletons and numerous isolated remains from adults, subadults and juveniles (Hooijer 1972). The presence of this animal at Langebaanweg is notable for its hyposodont dentition and the grazing ecology of its modern relatives. It has previously been taken as an indicator for grassland environments at Langebaanweg. However, isotopic analysis of these remains suggests that their diet was rich in C_3 plants (Franz-Odendaal *et al.* 2002). This signal could have come from C_3 grasses, which are a characteristic of winter rainfall macchia vegetation, but this requires further investigation. The abundance of this material would suggest that this habitat was prevalent, but large, robust bones like those of the rhino are likely to have high preservation potential. Thus it is unwise to draw any inferences from the abundance of rhino remains until the taphonomy of this species and that of the site as a whole is better understood.

Artiodactyla

Suidae

Langebaanweg has produced numerous remains from the family Suidae. It has also produced remains from the family Tayassuidae (peccaries) (Hendey 1976). Peccaries, are now confined to the new world and for a long time were assumed to have always been restricted to the Americas. The peccary from Langebaanweg representsed the first time that a member of this group was identified on the African continent (Hendey 1976). Hendey first identified the Langebaanweg peccary as ?*Pecarichoerus africanus*. Pickford (1988) later determined that this material did not belong to a peccary at all, but to a true pig and created a new genus *Cainochoerus* for this species, which became (and is still known as) *Cainochoerus africanus*. The recovery of additional material from Lothagam, Kenya has confirmed that this species is a true pig (Harris &Leakey 2003). *Cainochoerus africanus* is an extremely small, cursorial suid with very simple peccary-like dentition (Cooke & Wilkinson 1978; Bishop 2010). *Cainochoerus africanus* was recovered from the MPPM.

The remaining suid material from Langebaanweg all belonged to the genus *Nyanzachoerus*, which was observed in both the MPPM and LQSM (Hendey 1981). *Nyanzachoerus* bones were rare in the MPPM, with only two specimens occurring, compared to over 100 *Nyanzachoerus* bones from the LQSM (Cooke & Hendey 1992). Cooke and Hendey (1992), in re-assessing the suid material from Langebaanweg, assigned the *Nyanzachoerus* material from the LQSM to a new subspecies namely *Nyanzachoerus kanamensis australis*. The *Nyanzachoerus* from the MPPM differed from this material. One specimen was assigned to the "normal" *Nyanzachoerus kanamensis* (not the subspecies discussed), while the other was found to have features more reminiscent of *Nyanzachoerus jaegeri*. This specimen, was thus identified as *Nyanzachoerus* cf. *jaegeri*. Cooke and Hendey (1992) believed that the differences in suid population between the MPPM and LQSM, was an indication for changing environmental conditions between the deposits, which they considered to differ in age.This is, generally, no longer considered the case. *Cainochoerus* specimens display a long presence in the fossil record; however this group has always been rare (Bishop 2010). Due to the wide habitat tolerances and preferences of modern suids, it is problematic to try to utilise fossils suids for palaecological reconstructions. However, some genera, such as *Nyanzachoerus* are useful biochronological markers.

Hippopotamidae

Hippopotamidae at Langebaanweg represent the earliest and sole known occurrence of the family in southern Africa (Boisserie 2006). The family is known from Langebaanweg from many isolated teeth, some dental rows and isolated postcrania. Boisserie & Merceron (2011) characterised this material as a large, early form of the subfamily Hippopotaminae, but were unable to assign the Langebaanweg hippo to any particular genus due to the lack of diagnostic material. The Langebaanweg hippo remains for now Hippopotaminae sp. Almost all the hippo material analysed by Boisserie & Merceron (2011) was derived from the MPPM, particularly from bed 3aN.

Boisserie (2006) noted how hippos are a particularly rare component of the fossil record until the Late Miocene (8.5 – 7 Ma), thereafter they abruptly and without transition become an ecologically predominant group. This sudden irruption in abundance (which he terms the "Hippopotamine Event") was almost certainly driven by major environmental change. This sudden increase in hippo populations appears to be temporally correlated with the major expansion of C_4 grasslands (Cerling *et al.* 1997; Cerling *et al.* 2003;Jacobs 2004) at the end of the Miocene (Boiserrie 2006). Stable isotope analyses of

many of the hippopotamines from this period indicate diets high in C_4 plants (Boisserie *et al.* 2005). The diet of the modern African hippo (*Hippopotamus amphibious*) is likewise characterised by C_4 plants. However stable isotope analyses of the Langebaanweg hippos indicate diets high in C_3 plants (Franz-Odendaal *et al*. 2002).Franz-Odendaal and colleagues (2002) noted the incongruity of these results compared with isotope signatures in other parts of Africa (Cerling *et al*. 1997) for this time period. They correlate their findings with the development of a C_3 dominated Mediterranean climate. Mesowear analysis in the Langebaanweg hippos indicates a strong grazing signal (Boisserie & Merceron 2011). Modern hippos can be considered opportunistic feeders incorporating C_3 and C_4 plants in their diets and they are not precise feeders (Boisserie *et al.* 2005). Boisserie and Merceron, thus concluded that the Langebaanweg hippos were feeding on grasses or herbaceous material in an environment lacking C_4 vegetation. Overall hippopotamine evolution in Africa is linked to expansion of C_4 grasslands(Boisserie *et al.* 2005). The sudden rapid evolution of these grazers lead to dispersal into C_3 dominated areas, like Langebaanweg. It must also be noted that the presence of a hippopotamine in the MPPM of Langebaanweg is indicative of perennial water deep enough for full emersion (Boisserie & Merceron 2011).

Giraffidae

Giraffids are a common component of the Langebaanweg fauna. Three species have been identified, namely *Sivatherium hendeyi*, *Palaeotragus* cf. *germaini* and a *Giraffa* sp. (Harris 1976; Hendey, 1970b, 1974, 1976, 1980). The most common of these is the Sivathere, of which over 500 individuals have been counted in the assemblage (Roberts *et al.* 2011). Sivatheres had a wide distribution in Africa during the Pliocene and Pleistocene, although Langebaanweg was the only deposit in which they form a substantial part of the palaeocommunity (Harris *et al.* 2010). The African post-Miocene history of palaeotragines is poorly known and the modern relative of the group (*Okapia johnstoni*) is today only found in forested regions of central Africa. The brachydont dentition of *Palaeotragus germaini* suggests a broadly browsing diet (Harris *et al.* 2010). The Langebaanweg palaeotragine suggests a previously broader distribution across the continent for the group and the possible presence of forested or woodland areas in the Langebaanweg region. *Sivatherium hendeyi* displayed brachydont dentition; however dental mesowear, microwear and stable isotope analysis all indicate mixed feeding (Franz-Odendaal & Solounias 2004). In addition, Franz-Odendaal and colleagues (2003) found dental pathologies (linear enamel hypoplasia) indicative of episodic stressful periods in many Sivathere remains. Indeed, these

pathologies were observed in almost all herbivores species recovered from Langebaanweg and appear to be the result of increased seasonality from increased aridity (Franz-Odendaal *et al.* 2003).

Bovidae

Perusal of the complete species list from Langebaanweg shows that there is relatively low species diversity in Bovidae in an otherwise large and diverse assemblage, particularly when compared to many other African fossil localities. A total of only 10 species have been identified (Gentry 1970; Gentry 1980) and it remains unclear why bovids make up such a small component of the collection, although competition with the other large herbivores might have played a role. All ten species are represented in the MPPM deposit, while 7 of the 10 have also been recovered from the LQSM; The three species present in the MPPM but not the LQSM are *Kobus subdolus*, *Kobus* sp. B and *Damalacra neanica* (Stynder 2011). Gentry (1980) found that the bovids did not provide any meaningful ecological information, as there was no bias in representation of any particular group or species, nor were differences in species between members consequential. However later isotopic analyses together with microwear and mesowear studies have shown the Langebaanweg bovids were predominantly mixed feeders, in a closed woodland environment with scarce grass, feeding on predominantly C_3 plants (Franz-Odendaal et al. 2002; Merceron & Ungar 2005; Ungar et al. 2007; Stynder 2011).

Marine Artiodactyla

Cetacea

Cetacean remains from Langebaanweg have received little attention, in part owing to the fragmentary nature of the remains, with few diagnostic parts being preserved (Govender *et al.* 2016). Cetacean remains appear to include balaenopterids and odontocetes and only the former group has been analysed in any detail. Govender and colleagues (2016), in an analysis of the balaenopterids note the presence of a *Plesiobalaenoptera*-like species, but are unable to make a definitive diagnosis on the Langebaanweg material. In a brief taphonomic overview of the cetaceans they note stage three to five weathering, green-stick fractures from trampling, and terrestrial and aquatic carnivore modifications (Govender & Chinsamy 2013). In addition, many of the remains were derived from juveniles. The Langebaanweg area is believed to have experienced a marine transgression (Hendey 1981; Hendey

&Dingle 1989; Erasmus 2005; Roberts *et al*. 2011), creating a lagoon or estuarine setting around Langebaanweg with sand bars and beaches. Govender and colleagues (2016) suggest the cetaceans might have been stranded along these beaches or misdirected into shallow waters. The carcasses and bones were exposed on the surface allowing scavenging and weathering. Scavengers might also have been responsible for transporting cetacean bones into terrestrial or fluvial settings.

Pinnipeds

There is a large sample of phocid (true seal) remains from Langebaanweg, originally identified as *Prionodelphis capensis* (Hendey& Repenning 1972), but later moved to the genus *Homiphoca* (De Muizon & Hendey 1980). Recent morphometric analysis of the material indicates the presence of at least two seal (Phocidae) morphotypes at Langebaanweg possibly representing two separate species (Govender *et al.* 2012; Govender 2015). The majority of this material was recovered from the MPPM, although some isolated remains have also been recovered from the LQSM and even the KGM (Hendey 1974). The Phocidae remains include neonates, juveniles and adults indicating that the seal population was local and resident, a breeding population rather than vagrants (Hendey 1981b). Phocidae remains have been recovered in the roughly contemporaneous deposits at Koeberg, as have remains of an Otariidae (fur seals) seal of the genus *Arctocephalus* (Avery & Klein 2011). Avery and Klein (2011) have suggested that the absence of *Arctocephalus* at Langebaanweg might have been the result of some form of niche partitioning in these early seals, but the stratigraphy and chronology of the Koeberg deposits requires resolution prior to drawing any firm conclusions. Hendey (1982) noted the presence of pathologies in many of the Langebaanweg seal remains. A recent analysis of pathologies on seal remains found that of the over 3000 seal remains recovered from Langebbanweg, less than 1% of remains displayed pathologies (Govender *et al*. 2011). Govender and colleagues concluded that ontogenetic maturity (arthritis), as well as intra-population interactions were the likely causes for the pathological damage observed. A total of four members of the family are still found off the southern African coast today (Skinner & Chimimba 2005).

Carnivora

The carnivores are the most diverse mammalian order at Langebaanweg (Hendey 1980) with over 19 species. No other African fossil locality can boast such a diverse array of species (Werdelin 2006). Carnivores from Langebaanweg include the families Ursidae, Canidae, Hyaenidae, Felidae, Mustelidae, Viverridae and Herpestidae, as well as marine pinnipeds. Each family will be discussed in more detail below. The Langebaanweg carnivorans have not proved very useful as palaeoecological indicators in themselves. The very high abundance and diversity of carnivores at Langebaanweg is noteworthy and has not been adequately explained, although some ecological factor must have allowed for the co-existence of this many carnivores and/or some taphonomic factor must have resulted in the concentration of carnivore remains in the deposit. Perhaps even some combination of the two. Hendey (1982) noted that carnivoran remains appear to display a greater prevalence for pathologies than herbivores, although requires testing.

Ursidae

The Langebaanweg bear *Agriotherium africanum* (Hendey, 1972; Wolff *et al.* 1973) was the first pre-Pleistocene ursid to be identified in Africa (Stynder & Kupczik 2012), as well as the first Agriotheriinae in Africa and remains the only bear recovered in sub-Saharan Africa. *Agriotherium africanum* was a large bear, similar in size (up to 750 Kg) to the living Kodiac bear (Hendey 1982), with a stocky body plan (Wolff *et al.* 1973). *Agriotherium africanum* appears to be absent from LQSM deposits. Remains were collected from the bed 3aN and S deposits (MPPM), with the majority of the material originating in the bed 3aN deposit (Hendey 1980). Carnivore and rodent gnawing is visible in some *A. africanum* remains, and various elements from a partial skeleton display burning (Hendey 1980).

Morphological similarities were quickly noticed between *A. africanum* and the north American short-faced bear (*Arctodus simus*) (Hendey 1980). This lead Hendey to postulate a similar ecological niche for *A. africanum* as a predominantly carnivorous bear preying on large herbivores, which while not truly cursorial may have been capable of bursts of speed. This hypothesis has been challenged by various authors. Oldfield *et al.* (2012) found, in investigating cranial mechanics, that *A. africanum* could deliver and sustain extremely powerful bites. The dentition in *A. africanum* is consistent with a diet that included both meat and plant material as well as adaptations for grinding food (Sorkin, 2006). Sorkin (2006) in an analysis of craniodental and postcranial morphology of ursids, big cats and wolves found

that *A. africanum* lacked adaptations for capturing and killing large prey. The short rostrum, characteristics of this species, could provide a better adaptation for crushing bones, leading Sorkin (2006) to suggest brown and stripped hyenas as better living models for the ecomorphology of *A. africanum*. These species supplement their diet of scavenged meat with plant material like fruit (Sorkin, 2006). However,Stynder & Kupczik (2012) found that tooth-root morphologies in *A. africanum* was inconsistent with habitual hard feeders like hyenas. These authors sugest that hard skeletal elements might have formed a secondary food source, and that *A. africanum* might have been more likely to focus on tough tissues scavenged from carcasses. The large body size and long legs in *A. africanum* would have allowed it to cover large areas while searching for food and would have made it easier to scare other scavengers off carcasses (Stynder & Kupczik 2012).

Canidae

Canid remains at Langebaanweg are fairly poorly represented and their affiliations are uncertain (Hartstone-Rose *et al.* 2016). Canid material from the site has been attributed to a number of species or groups such *Canis brevirostris* (Hendey 1980). This material was later revised and attributed to the genus *Eucyon* (Rook 1993, cited by Spassov & Rook 2006). It is unclear whether a second species of canid is present at Langebaanweg. Werdelin (2006) and Werdelin and Peigné (2010) record only *Eucyon*; while Hartstone-Rose *et al.*(2016) follow Hendey (1981) in also recording a fox-like *Vulpes* sp. *Eucyon* was only observed in the MPPM (Hendey 1981; Werdelin 2006). The presence of a canid at Langebaanweg illustrates the rapid dispersal of the family across Africa during the Miocene (Werdelin 2006).

Felidae

At least five species of felid are known from Langebaanweg including *Amphimachairodus* sp. A, *Amphimachairodus* sp. B, *Dinofelis* sp., *Metailurus obscurus*, and Felidae sp. A (Werdelin 2006, Werdelin and Peigné 2010). Both *Amphimachairodus* species, as well as the *Dinofelis* sp. and the Felidae sp. A were only recovered from the LQSM (Werdelin 2006). *Metailurus obscures*, on the other hand, was only observed in the MPPM. The large machairodont felids of the genus *Amphimachairodus* are relatively rare elements of the Langebaanweg felid sample. Langebaanweg contains one of the youngest representations of this group in its fossil record (Werdelin 2006). Additional medium to large

Machairodontinae material at Langebaanweg was represented by the genus *Dinofelis*, a very early record for this species. *Dinofelis* is a very wide-spread genus in the African Neogene (Werdelin and Peigné 2010). *Metailurus obscurus* was first described by Hendey in 1974 under a different genus. This species has been assigned to numerous genera over the years, but is now considered *Metailurus* (Werdelin 2006). Langebaanweg is the youngest definitive record of this genus worldwide. Finally a small felid of unknown affinity is also preserved. Many felids are highly specific to environments and a revised understanding of the taxonomy, systematic and functional ecology of this family could vastly improve our understanding of the palaeoenvironment at Langebaanweg (Hartstone-Rose *et al.* 2016).

Hyaenidae

Hyaenas are the most commonly recovered terrestrial carnivore at Langebaanweg and four species have been described from the site, namely *Hyaenictitherium namaquensis*, *Hyaenictis hendeyi*, *Chasmaporthetes australis* and *Ikelohyaena abronia* (Werdelin *et al.* 1994; Werdelin 2006; Werdelin & Peigné 2010). Some authors (Hendey 1980; Harstone-Rose *et al.* 2016) suggest there might be a fifth as yet undiagnosed species (Hyaenidae sp.) of hyaena at Langebaanweg, but this requires further investigation. The genus *Hyaenictitherium* is a late surviving genus from the Miocene and Langebaanweg may be the last representation of the group before extinction (Werdelin 2006). *Hyaenictitherium namaquensis* is a medium to large hyaena, which displays robust dentition and a well built skull and jaw conductive to consuming obdurate foods (Hartstone-Rose *et al.* 2016).*Hyaenictitherium namaquensis* has been recovered from the MPPM, exclusively (Werdelin 2006). *Hyaenictis hendeyi* was a gracile, long-limbed hyena (Werdelin *et al.* 1994) known from a number of African localities, although Langebaanweg has provided by far the best sample of the species (Werdelin & Peigné 2010). All this (*H. hendeyi*) material was derived from the LQSM. Dentition in *H. hendeyi* is not consistent with an obdurate bone crusher and the species was considered to have been cursorial and actively predaceous (Hendey 1978; Werdelin *et al.* 1994). Some authors have even suggested that *H. hendeyi* might have occupied the ecological niche now occupied by the extant cheetah (*Acinonyx jubatus*). *Chasmaporthetes australis,* which has often been termed the 'hunting hyena', is the largest and most gracile of the hyenas of Langebaanweg (Hartstone-Rose *et al.* 2016). The Langebaanweg material derived from both the MPPM and the LQSM, is among the oldest representations of this species in Africa (Werdelin 2006). Dental analyses of Langebaanweg *C. australis* indicates a level of hypercarnivory consistent with those of modern felids, suggesting a similar diet (Hartstone-Rose & Stynder 2013). The smallest hyena recovered

from Langebaanweg was *Ikelohyaena abronia*. This species is well represented at the site and includes a mostly complete skeleton. Dental analyses of this species indicate that *I. abronia* was the most durophagus of all the Langebaanweg hyenas (Hartstone-Rose & Stynder 2013). *Ikelohyaena abronia* was collected in the MPPM and the LQSM.

Mustelidae

The Mustelidae at Langebaanweg are known from three large species,namely *Mellivora benfieldi*, aff. *Plesiogulo monspessulans* and *Sivaonyx hendeyi* (Hendey 1978; Morales & Pickford 2005; Morales *et al.* 2005; Werdelin 2006). *Mellivora benfieldi* and *S. hendeyi* were recovered from the MPPM, while *P. monspessulans* was recovered from the LQSM (Werdelin 2006). Mustelids were widespread throughout Africa during the late Tersiary, but are poorly represented compared to some other families at Langebaanweg (Hartstone-Rose *et al.* 2016). The honey badger, *Mellivora capensis*, is known throughout Africa today. However, Langebaanweg is the oldest published record of the genus in Africa (Werdelin & Peigné 2010). *Mellivora benfieldi* is smaller than the modern honey badger, with less specialised dentition (Hendey 1978). It is known at Langebaanweg from as many as six individuals (Hartstone-Rose *et al.* 2016). The affinity of *M. benfieldi* is unclear, as Petter (1987) suggests it may be conspecific with *M. capensis*, the ancestral starting point of the modern honey badger. *Plesiogulo monspessulans* is a large ancestral species to the extant wolverine (*Gulo gulo*) (Kurtén 1970). Langebaanweg was the first African locality to produce remains from a wolverine and remains the southern-most known record for the group (Hendey 1978). Dental characteristics of *P. monspessulans* suggests powerful durophagous abilities, even greater than that of the modern wolverine (Hartstone-Rose *et al.* 2016). The *Sivaonyx hendeyi* material was originally attributed to *Enhydriodon africanus* (Hendey 1974) and it was not until 2005 that the attribution was updated. The genus *Sivaonyx* is known from a number of African Mio-Pliocene localities. The absence of small mustelids, like weasels, is interesting as small species are known from other African fossil localities during this period (Werdelin & Peigné 2010). Small mustelids have additionally, been observed in later fossil locals in South Africa (O'Regan *et al.* 2013). The small carnivores of Langebaanweg have not been well studied (see Herpestidae and Vivarridae sections) and it is possible that small mustelid material may still come to light.

Viverridae

Two species of Viverridae have been identified at Langebaanweg namely, the extremely large civet *Viverra leakeyi* and *Genetta* sp. (Hendey 1974). *Viverra leakeyi* had a pan-African distribution during the Mio-Pliocene and is known from a number of fossil localities on the continent. Attribution of this species is controversial with some authors arguing for inclusion in other genera like *Megaviverra* or *Sahelictis* (Morales *et al.* 2005; Werdelin & Peigné 2010; Werdelin *et al.* 2014). The *Genetta* sp. from Langebaanweg is small, approximately one third the size of extant genets (Hendey 1974). Langebaanweg is the only African fossil locality to produce definitive *Genetta* material (Werdelin & Peigné 2010). Hartstone-Rose *et al*. (2016) suggest that more small Viverridae specimens which have not been classified beyond the family level are present in the Langebaanweg collection. Viverrid material from *V. leakeyi* was recovered in the MPPM and the LQSM. The *Genetta* material was only recorded in the LQSM.

Herpestidae

Thus far only two unidentified and undescribed herpestids, *Herpestes* sp. A and *Herpestes* sp. B have been recorded from Langebaanweg (Hendey 1974; Werdelin & Peigné 2010). As there are now scores, if not hundreds of small carnivore (herpestid) specimens recovered from Langebaanweg, a detailed analysis is likely to identify additional taxa. *Herpestes* sp. A has been recorded in the MPPM, by contrast *Herpestes* sp. B is from the LQSM. I hasten to note however, that both the Herpestidae and the Viverridae are greatly in need of additional study and that representation of these families in the two members is likely to change significantly.

Other mammal groups

There are a number of mammalian families, mostly small in size, on which no work has been done since the 1980's. There include Chysochloridae, Macoscelididae, Hystricidae, Leporidae, Hyracoidea and Chiroptera. Golden moles are represented by a single species from the genus *Chrysochloris*; while the elephant shrews were represented by the genus *Elephantulus* (Pocock 1976). Leporidae are represented by *Pronolagus* sp. (Pocock 1976) and hyraxes by *Procavia* cf. *antiqua* (Hendey 1976).The hystricidae remain unstudied, although Hendey (1981) indicates the presence of two unidentified genera and

species. Modern *Pronolagus* and *Procavia* are associated with rocky outcrops surrounded by open grassland, which provide protection from predators (Skinner & Chimimba 2005). Small granite outcrops occur on the west coast and in the areas surrounding Langebaanweg today, but it is unclear whether these outcrops would have been exposed during the Pliocene marine transgression. Primates are of particular interest at Langebaanweg for their near absence. Only a single taxon, unidentified below the family level has been recorded from the site from two (now lost) teeth (Grine &Hendey 1981). Primates are generally considered indicative of wooded environments. The poor representation of primates is an interesting characteristic of the fossil sites which has been inadequately explained.

4.1.2 Aves

Langebaanweg contains one of the largest pre-Pleistocene fossil bird assemblages in the world (Rich 1980), with vast numbers of well preserved and disarticulated bird bones (Table 4.2). At least 90 bird species have been observed in the site, although most of the material has yet to be described (Manegold *et al.* 2013). Manegold and colleagues (2013) recently conducted a review of all the avian species recovered from Langebaanweg, which they then utilised for a palaeoecological analysis of the site. Bird remains from Langebaanweg indicate a mosaic environment with diversified habitats ranging from arid regions and open grasslands to woodlands and wet, marshy areas. I will provide a brief synopsis of Langebaanweg bird palaeoecology, as well as other bird species or characters of interest.

Marine Avifauna

Langebaanweg preserves a diverse assemblage of marine avifauna (Manegold *et al.* 2013). These include penguins (Spheniscidae), Albatross (Diomedeidae), storm-petral (Oceanitinae), tubenoses (Procellariidae), pelecans (Pelecanoididae) and Booby (Sulidae)(Olson 1983; Olson 1985a, c). In addition, cormorants (Phalacrocoracidae) and gulls (Laridae) which are associated with but not limited to marine environments, are also known at the site. The most commonly occurring of these groups (by NISP) are storm-petrals and tubenoses. Many of these pelagic birds (albatross, storm-petral, pelican and booby) are represented by a single taxon, usually only identified to the generic level. Manegold and colleagues note that most the marine material has been inadequately described. However the penguins, tubenoses

and cormorants are diverse groups. Only the penguins have been studied in any detail (Simpson 1971, 1973, 1979a, c; Olson 1983, 1985; Ksepka & Thomas 2012).

Penguins were the first fossil birds to be described from Langebaanweg, and represent the oldest identification of penguins on the African continent (Olson 1985a; Thomas & Ksepka 2013). Four penguin species have been recovered from Langebaanweg namely; *Inguza predemersus, Dege hendeyi, Nucleornis insolitus,*and *Palaeospheniscus huxleyorum* (Simpson 1971, 1973, 1979a, c; Olson 1985). The most abundant penguin at Langebaanweg is *D. hendeyi*. All four species have been recovered in the MPPM deposits, however only *I. predemersus* and *D. hendeyi* were identified in the LQSM (Simpson 1975; Simpson 1979b; Ksepka & Thomas 2012). A cladistic analysis of the Langebaanweg penguins found no relationship between any of the species; indicating that the four penguin lineages must have colonised South Africa independently, by the late Miocene (Ksepka & Clarke 2010; Ksepka & Thomas 2012; Thomas & Ksepka 2013). Additionally, no relationship was found between the Langebaanweg penguins and the extant species (*Spheniscus demersus*), indicating that the ancestor to this species independently colonised South Africa at a later time, probably in the Plio-Pleistocene (Ksepka & Clarke 2010; Ksepka & Thomas 2012; Thomas & Ksepka 2013). Langebaanweg represented the first appearance of many pelagic birds in the fossil record (Olson 1985a). Most of the Procellariiform individuals were recovered from the LQSM deposit, indicating that this unit probably had a somewhat stronger marine signal than the MPPM (Olson 1985c).

The diversity of marine avifauna at Langebaanweg is striking and comparable diversity(of modern marine avifauna) is only observed on certain Subantarctic islands (Olson 1983). This assemblage also indicates that there has been a near complete turnover and restructuring of the marine avifauna of the Cape region since the early Pliocene (Olson 1983). It has previously been assumed that this diversity was evidence for the establishment of the Benguela Upwelling System off the west coast of southern Africa (Olson 1985a); an upwelling system that was colder and more nutrient rich than today. Studies have indicated that the Benguella system had initiated by 11 Million years ago, with an increase in ocean productivity (dinoflaggelate populations) (Heinrich *et al*. 2011). However recent sea surface and sub-surface temperature estimates suggest that around the time that the fossils were deposited, between 6.5 and 5 Ma, the Benguella Current was much warmer than today (Rommerskirchen *et al.* 2011). Rommerskirchen and colleagues do indicate that marine productivity remained high despite the elevated temperatures. Juvenile remains were recovered from a number of seabird species at Langebaanweg, including penguin, albatross, storm-petrel and multiple prion species. These birds, none

of which breed on the South African coast today, were likely breeding close to the fossil site in the early Pliocene (Olson 1983). The raised (by about 50 m) sea levels of the marine transgression of the late Miocene - early Pliocene would have turned the West Coast Peninsula, Table Mountain and other peaks into large islands. Islands which would have provided ample suitable breeding habitats for marine birds(Ksepka & Thomas 2012). Thus the combination of increased marine productivity and suitable nesting localities appears to have been the main limiters of seabird diversity.

Inland water birds

As much as 10-15% of bird remains from Langebaanweg were derived from freshwater habitats (Manegold *et al.* 2013). Freshwater or inland water birds at Langebaanweg include Anatidae (ducks, geese, swans), grebes (Podicipedidae), ibises (Threskiornithidae), hamerkop (Scopidae), Rallidae (rails & moorhens), cranes (Gruidae), stilts (Recurvirostridae), sandpiper (Scolopacidae), snipes (Rostratulidae), and waders and gulls (Charadriidae) (Rich 1980; Olson 1985b; Olson & Eller 1989; Olson 1994). The most common and diverse freshwater birds were the Anatidae and Charadriidae. The majority of Anatidae are undescribed; however, the identification of the swan genus *Afrocygnus* sp. is particularly interesting as swans are not found in sub-Saharan African today, and fossil swans have previously only been observed in northern Africa (Louchart *et al.* 2005). Fossil swans in other parts of Africa (Chad, Libya) have been considered indicative of the presence of large, calm water bodies and humid conditions (Louchart *et al.* 2005). Extant swans are generally sedentary, and are not observed in southern Africa, except as rare vagrant or wintering birds (Louchart *et al.* 2005). It is thus possible that the swan from Langebaanweg, which is represented by a single specimen, was a temporary migrant rather than a consistent part of the South African avifauna.

The Podicipedidae were represented by two species; a dabchick (*Tachybaptus ruficollis*) that cannot be distinguished from the extant species and a grebe which has been linked inconclusively with the genus *Podiceps* (Olson 1994). The dabchick displays an extraordinary period of stasis and the extant species are, for the most part, confined to still or slow moving bodies of fresh water, preferably with emergent vegetation. The majority of dabchick material at Langebaanweg was derived from the MPPM. Attribution of the grebe (*Podiceps*? sp.) is inconclusive as this material resembles no member of the Podicipedidae previously known in Africa (Olson 1994).

Langebaanweg represents the first Tertiary occurrences of the ibises,*Threskiornis aethiopicus* and *Geronticus apelex* (Olson 1985b). Ibises are usually closely associated with fresh water and marshes, however extant *Geronticus*species prefer open or arid areas like grasslands (Olson 1985b).Extant hamerkops are aquatic wading birds; however the hamerkop from Langebaanweg (*Scopus xenopus*) displays some adaptations indicative of a greater capacity for swimming (Olson 1984). Langebaanweg has produced at least two species of kingfisher (Alcedinidae) (Olson 1994), one of which is indicative of grasslands and will be discussed further in the next section. A ceraline kingfisher (*Ceryle* sp.) of a size-class no longer occurring in Africa, was recovered at Langebaanweg. Living *Ceryle* species are all piscivorous and the southern African species frequent the shoreline and coastal lagoons as well as inland water sources (Olson 1994). The Charadriidae are particularly diverse at Langebaanweg with as many as 15 different species, most undescribed or poorly assigned (Rich 1980). These include a number of likely plover (*Vanellus*) species. Langebaanweg represents the first appearance of the family Rostratulidae (painted-snipes) in the fossil record (Olson & Eller 1989). Members of this family are typically resident in wet, marshy or swampy areas usually with dense vegetation, although they can be nomadic (Olson & Eller 1989).

Thus the water birds of Langebaanweg generally indicate the presence of a perennial freshwater source with slow moving and marshy areas and dense associated vegetation. Olson & Eller (1989) suggested that non-marine aquatic habitats were probably restricted and ephemeral at Langebaanweg due to the complete absence, so far, of fossils of herons, flamingos, spoonbills, and other aquatic birds which commonly occur in the southwestern Cape region today. However more recent analyses of the Langebaanweg avifauna indicates a freshwater environment large enough to support an abundant and diverse population of birds. The presence of the swan suggests a large and calm water source, but the possible migratory nature of this species makes this inconclusive. It is unknown why such species as flamingo and herons are absent from Langebaanweg.

Terrestrial Woodland Birds

A substantial number of bird species from Langebaanweg can be associated with woodland environments (Manegold *et al.* 2013). These include woodpecker (Picidae), honeyguide (Indicatoridae), parrot (Psittacoidae) and a number of songbirds (Passeriformes). Modern descendants of all these birds favour woodlands. Two honeyguide species, tentatively referred to the genus *Indicator* have been

observed at Langebaanweg (Olson 1985b). Extant honeyguides avoid open savanahs and prefer forest and various kinds of woodland (Manegold *et al*. 2013). Modern honeyguides, in addition, are brood parasites (lay their eggs in the nest of other birds) with a preference for cavity nesting foster species. Barbets are typically used as fosters by honeyguides, however fossil barbets have yet to be recovered from Langebaanweg. None the less, the site would have to have habitat suitable to a cavity nesting species. Hendey (1978) remarked on the co-occurrence of honeyguides and honey badger at Langebaanweg and proposed that the alleged symbiotic relationship between the species had evolved prior to the Pliocene. However recent research has shown this relationship to be a fallacy (Dean *et al.* 1990).

The recently described woodpecker species (*Australopicus nelsonmandelai*) may have provided suitable nesting or breeding habitat for the Langebaanweg honeyguides (Manegold *et al.* 2013). Cladistic analysis of the fossil woodpecker links it to a previously unknown lineage with a Eurasian origin and strong association with woodland environments (Manegold & Louchart 2012). *Australopicusnelsonmandelai* shows morphological adaptations consistent with an arboreal lifestyle (Manegold & Louchart 2012). At least two species of parrot have been described from Langebaanweg, representing the oldest fossil Psittacoidea from Africa (Manegold 2013). These include a lovebird (*Agapornis attenboroughi*) and a parrot (*Khwenena leopoldinae*), as well as material for an additional but indefinable species (Stidham 2006; Manegold 2013). Modern species of lovebird, avoid primary forest but inhabit woodlands of different kinds (Manegold *et al.* 2013). Some species of South African lovebird (*A. roseicollis* and *A. nigrigenis*) rely on the seeds of C_4 grasses; however Manegold *et al.* (2013) consider it premature to assume a similar ecology for the fossil species. Studies of mammal bones have found no evidence for C_3 vegetation or grasses, however there is some preliminary indications for C_4 grass phytoliths (see section 4.2). *Khwenena leopoldinae* appears to be related to the genus *Poicephalus* and is likely to share those specie's preference for woodlands with tall trees (Manegold *et al.* 2013). *Poicephalus* species prefer to nest in cavities (in tall trees) provided by Sturnidae (starling) species.

Langebaanweg possesses a number of (undescribed) Sturnidae species, including the Amethest Starling (*Cinnyricinclus leucogaster*) (Manegold *et al*. 2013). *Cinnyricinclus leucogaster* does not occur in the Cape today, although it is a common component of many African woodlands and is known to nest and breed in tree cavities. There are vast numbers (several hundred) of passerine remains at Langebaanweg representing at least nine species, although none of this material has been adequately described (Manegold 2010b). The most common of the Langebaanweg passerines were remains of Sturnidae and

Hirundinidae (swallows) (Manegold *et al*. 2013). Hirundinidae remains at Langebaanweg (which canot be identified to genus or species) represent the oldest African fossils for this highly diverse group, believed to have originated in Africa (Manegold 2010b). Hirundinidae have catholic habitat and nesting preferences and are thus not useful for palaeontological interpretations. This groups is however, one of only three species of aerial insectivores recovered in Langebaanweg; the others being nightjars (Caprimulgidae) and an undescribed swift (*Tachymarptis* sp.) (Manegold 2010b). A single specimen of a nightjar, not identifiable to genus or species was recovered from Langebaanweg (Manegold 2010a). This specimen represents the first appearance of the family in the African fossil record. Extant nightjars prefer open habitats with trees and bushes close to river bodies (Manegold 2010a). An additional small bird species, a mousebird (*Colius hendeyi*), has also been described from Langebaanweg (Rich & Haarhoff 1985). Mousebirds, which still occur in the area around Langebaanweg today, live in a variety of habitats, but avoid densely forested areas.

Open grasslands and arid habitats

Taxa characteristic of open habitats and grasslands found at Langebaanweg include the ibis (*Geronticus apelex*), the stork (*Ciconia kahlia*), the buttonquail (*Turnix hottentottus*), kingfisher (*Halcyon* sp.) and the ostrich (Struthionidae) (Olson 1985b, 1994; Haarhoff 1988; Manegold *et al.* 2013). As noted when discussing ibises earlier, *G.apelex* prefers open or arid areas like grasslands (Olson 1985b). In addition wing proportions in G. *apelex* suggest migratory or nomadic propensities in this species (Olson 1985b). Buttonquail material from Langebaanweg lacks good provenance, although more material is likely to come to light from unsorted samples (Olson 1994). Extant buttonquails in South Africa prefer short, moist grasslands. A single specimen attributable to *Halcyon* sp. has been recovered from Langebaanweg (Olson 1994). Kingfishers are catholic in their habitat preferences and occur in all ecotypes excluding dessert. However they are for the most part found in open savanna and bushland environments. Ostriches are one of the most characteristic animals of open habitats and the extant species (*Struthio camelus*) prefers short-grass plains and semi-deserts (Manegold *et al.* 2013). The ostrich avoids areas with tall grass and woodlands. Ostrich was one of the first avian remains identified at Langebaanweg, but to date no analysis of this material has been undertaken (Manegold *et al.* 2013). Metrics of the leg bones of the Langebaanweg ostrich compare favourably with North African Pliocene species *S. asiaticus* to which this material has been provisionally attributed (Manegold *et al.* 2013).

Arid environments like deserts or semi-wooded savannahs are additionally indicated by the presence of sandgrouse (Pteroclidae), bustards (Otididae) and thick-knees (Burhinidae). Two species of sandgrouse from the genus *Pterocles* have been observed at Langebaanweg; which is the earliest record for the sandgrouse crown group in the world (Manegold *et al.* 2013). Extant sandgrouses are found in arid and semi-arid regions throughout Africa and Asia. A single thick-knee specimen identified up to family level only was observed at Langebaanweg. Similarly bustard remains were only characterised up to family level. Two species of bustard have been noted at Langebaanweg, separated by size. Thus open areas are found at Langebaanweg, close to water with short grass and few trees. Arid (desert or savannah) environments were also found in the vicinity of Langebaanweg. The presence of arid or desert environments are supported by Gerbilinidae and to a lesser extent Bathyergidae remains as these families are often associated with arid habitats.

Predaceous Birds

Predaceous birds form a relatively small component of the Langebaanweg avifauna (Rich 1980), although the families Falconidae and Accipitridae, as well as Strigidae are known from the site (Manegold *et al*. 2013). A description of the owls has recently been published. At least four genera of owl were present at Langebaanweg, including *Tyto, Athene, Bubo* and *Asio* (Pavia *et al.* 2015). This diversity of owls is comparable to or even greater than owl diversity in the majority of Neogene or early Pleistocene African and European fossil assemblages (Pavia *et al.* 2015). Owls and most predaceous birds are generalists with catholic habitat preferences, and the Langebaanweg sample has not proved useful for palaeoecological interpretations. Rich (1980) has previously indicated a lack of vulture remains at Langebaanweg, which she considered unexpected, as there is a large assemblage of mammalian carnivores and carcasses were probably readily available. However, recently vulture remains have been described from Langebaanweg (Manegold *et al.* 2014). Vulture remains which include over 100 specimens were attributed to a new species, *Aegypius varswaterensis*. The Langebaanweg material represents the first unequivocal and substantial crown-group Aegypiinae fossils in the Neogene (Manegold *et al.* 2014). Extant Aegypiinae are known to build their nest at the top of tall trees, however they forage by sight and thus are characteristic of open woodland, savannah and grassland environments.

Conclusions Aves

Langebaanweg preserves an excellent fossil bird assemblage with many avian families and genera making their first appearance. Most of the material remains undescribed and the full potential of the Langebaanweg bird assemblage has not been realised. What is clear, from the bird remains analysed thus far, is that the avifauna of the south African west coast had undergone a substantial turnover and restructuring. Palaeoecological interpretations based on the avifauna, note that the water birds of Langebaanweg generally indicate the presence of a large, perennial freshwater source with slow moving waters, marshy areas and dense associated vegetation. The high numbers of pelagic bird remains indicate close proximity to the coast. The pelagic environment in the vicinity of Langebaanweg had highly productive waters and many offshore islands and rocky outcrops which provide suitable nesting for marine bird species. A number of bird species are indicative of open country and grasslands, however there are much greater numbers of woodland taxa, suggesting this habitat was more extensive. There are also some species that indicate the presence of arid environments like savannah or desert in the area. Some caution must be taken when utilising the bird bones of Langebaanweg for palaeoecological interpretations. Many of these specimens represent first fossil occurrences and there are often long time gaps to other, better known fossils or to modern relatives. This usage of taxonomic inferences must always be treated with caution in such situations.

However at Langebaanweg the palaeoenvironment indicated by bird remains does compare favourably with other sources. The high abundance of woodland species would suggest a greater availability of this environment than previously believed, however possible accumulating (taphonomic) biases in birds have not been addressed. Woodland birds could be more prominent if they were in close proximity to a river or pond in which bird remains were preserved. Thus, the taphonomy of the Langebaanweg birds needs to be clarified. Rich (1980) in a preliminary taphonomic analysis of the Langebaanweg birds found that they compare favourably with small mammal remains from floodplain deposits. Element representation displayed hydraulic sorting and high levels of breakage. Complete remains and associated skeletons were rare. In this analysis, I have been able to expand upon Rich's conclusions by exploring surface modifications on bird remains. Birds, even relatively sedentary forms, have the potential to cover large distances, and the vast diversity of habitats indicated by the Langebaanweg birds may reflect a wider radius of the environment than mammals or other taxonomic groups.

4.1.3 Reptiles

Reptile remains have been recovered in Langebaanweg (Table 4.3). Tortoise remains are highly abundant at Langebaanweg, at times more common than mammals, however other reptile remains are rare. For this reason tortoises are considered separately throughout this study. From this point forward tortoise will refer to all remains of the family Chelonia and reptile will refer to all Squamata and Ophidia specimens. Squamate remains are largely unstudied (Hendey 1981). They include chameleon (Chameleontidae), gecko (Gekkonidae) and lizard (Varanidae) remains; none of which are identified below the family level. Ophidia (snakes) are likewise unstudied and it is unknown whether more than one species or genus is represented at Langebaanweg. The absence of crocodilian remains is also noteworthy and has been inadequately explained. Crocodilians are generally considered tropical taxa and their absence from Langebaanweg is usually taken as confirmation of colder climates in the Pliocene (Manegold *et al.* 2013).

Two species of tortoise have been recorded at Langebaanweg. Hendey (1973, 1981) indicates the presence of a *Chersina* species. *Chersina* are small- to medium-sized tortoises that occur commonly across Africa (Meyland & Auffenberg 1986). Fossils of this genus are common in Langebaanweg (Meyland & Auffenberg 1986). Meyland and Auffenberg (1986) additionally described a medium sized tortoise from Langebaanweg, which they named *Geochelone stromeri*. Extant *Geochelone* (*Geochelone pardalis*) from southern Africa are large tortoises (leopard tortoise) and *G. stromeri* is the only medium-sized member of the genus in Africa. In genera, most tortoises are characteristic of open, savannah habitats (Meyland & Auffenberg 1986). Results from this study suggest a greater diversity of tortoises at Langebaanweg and there is still a great deal of work that can be done with these remains. The absence of aquatic chelonian like terrapins (freshwater) and turtles (marine) is noteworthy and requires investigation. Although, thus may be an artefact of lack of research into the family.

4.1.4 Anura

Langebaanweg, in addition to the diverse mammalian and avian fauna, also contains a rich and diverse anuran (frog) fauna (Table 4.3) (Matthews *et al.* 2015). Anuran fossils have historically received little attention in the African fossil record, but recent work has identified six families (Hyperoliidae, Brevicipitidae, Pxyicephalidae, Pipidae, Heleophrynidae, Bufonidae, Ptychadenidae) and 19 taxa at Langebaanweg (Matthews *et al.* 2015; Matthews *et al*. 2016).This makes the Langebaanweg fossil frog

assemblage one of the richest in Africa (Van Dijk 2003). Currently there are only four anuran families found in the Langebaanweg region; and a high number of anuran species from these families are endemic to the southwestern Cape region (Matthews *et al.* 2015). The Langebaanweg anurans include swimmers, hoppers, leapers, burrowers and possibly climbers, suggestive of a diversity of habitats (van Dijk 2003). The presence of two species of Pipidae (clawed frogs) and of a Heleophrynidae (ghost frogs) indicate the presence of ponds or slow flowing rivers (Matthews *et al.* 2015). The latter taxon in particular (*Heleophryne* sp.) requires clear perennial mountain streams for breeding. Both these taxa are limited to, or more common in the MPPM than the LQSM. On the other hand, the presence of *Breviceps* sp. and *Tomopterna* sp. (which are limited to the LQSM) indicates terrestrial habitat with relatively sandy and open areas(Matthews *et al.* 2015).

These ecological inferences are based on preferences of modern taxa which are separated from these specimens by millions of years. Modern anurans are known to be particularly sensitive to climatic changes, particularly fluctuations in warming and moisture levels and are thus considered good palaeoenvironmental proxies (Matthews *et al.* 2015). The diverse and abundant anuran assemblage at Langebaanweg indicates high humidity and rainfall in the region. There are high numbers of (modern) endemics among the Langebaanweg anurans, possibly indicating a long history (5 million years) of endemism in the region and decreased diversity and endemism on the west coast over the last 5 million years. Anuran bones from Langebaanweg are usually recovered as isolated elements (van Dijk 2003). Preservation was much better in remains from the LQSM than from the MPPM and Matthews *et al*. (2015) indicate that mechanical excavation in consolidated sediments was the primary cause of much of the destruction. Taphonomic analyses of anuran remains have had a great deal of success in identifying accumulating agents and processes in cave settings (Llona & Andrews 1999). A future, more detailed taphonomic analysis of the Langebaanweg anurans will help clarify questions regarding the depositional setting.

The high diversity of anurans at Langebaanweg indicates much greater rainfall was experienced on the South African west coast in the Early Pliocene and that aridification of the west coast had not yet begun at the time of deposition (Matthews *et al.* 2015). Matthews and colleagues (2016) went on to utilise anurans to investigate whether the winter rainfall regime had become established on the west coast by the early Pliocene. They found two species of *Ptychadena* and the genus *Kassina*, whose modern relatives are only found in the summer rainfall zone. They thus concluded that Langebaanweg in the early Pliocene experienced summer rainfall.

4.1.5 Other faunal remains

The most abundant and diverse faunal groups have been discussed above, however Langebaanweg has also produced numerous bones from invertebrates, sharks, and fish. Most of this material is poorly studied. Invertebrate remains from the LQSM deposit were found to contain a mix of well preserved marine, terrestrial, estuarine and freshwater species (Kensley 1977). The LQSM invertebrates suggest deposition under calm conditions and Kensley interpreted the presence of fluviatile and terrestrial species as indicators for seasonal flooding. It must be noted that invertebrate remains from the Miocene KGM were indicative of warmer oceanic temperatures, while the LQSM invertebrates suggest oceanic temperatures had dropped to similar levels to today (Kensley 1972). Invertebrates did not form part of this analysis and as a result I am not going to go through the invertebrate species recovered, nor are they listed in the Langebaanweg species list. A full list of the Langebaanweg invertebrate fauna can be found in Hendey (1981). No molluscs have thus far been recorded in the MPPM deposits, however this taxonomic group has not received attention in many years and new deposits have been opened since then.

A diverse array of Chondrichthes have been recovered from the KGM of Langebaanweg (Hendey 1981). Shark material from the Pliocene deposits is unstudied. Bony fish (osteichthes) from Langebaanweg are unstudied. Thus far a single cat fish (*Tachysurus* sp.) species has been recorded (Hendey 1981). Hendey (1981) considered this species to be characteristic of marine or estuarine conditions and it was recovered in both the MPPM and LQSM.

4.2 FLORA

Floral remains are limited at Langebaanweg, no macro-plant fossils have been recovered from the site and little palynological or phytolith work has been undertaken on the MPPM and LQSM deposits. These deposits are sandy and not generally conducive to pollen preservation, which may be part of the reason for this lack. The underlying Miocene Elandsfonyn Formation, on the other hand, contains numerous peaty or clayey facies and several palynological studies have been conducted on this formation (Coetzee 1983, 1978; Coetzee & Rogers 1982; Coetzee & Muller 1984; Sciscio *et al.* 2013; Sciscio *et al*. 2016; Roberts *et al*. 2017). The terrestrial deposits of Langebaanweg preserve only the uppermost (Middle Miocene) portion of the Elandsfontein Formation, although the distal, Early Miocene parts are preserved off-shore (Sciscio *et al*. 2013; Roberts *et al.* 2017). Below we discuss the Paleogene and Neogene floral

fossil record for the South western African coast, and the importance thereof for palaeoecological interpretations.

Palaeoecological information for the southern African west coast during the Paleogene is recorded in various localities from the Namib and Namaqualand (see Neumann & Bamford (2015) for a summary of sites). Latest-Cretaceous – Early-Palaeocene vegetation is recorded from the Arnot kimberlite pipe in Bushmansland (Scholtz 1985). This locality produced elements of the Fynbos, forest and woodland biomes and include the families Proteaceae, Restionaceae, Ericaceae, Epacridaceae, Euphorbiaceae, Thymeliaceae, Chloranthaceae, Casuarinaceae, Cornaceae, Caesalpiniaceae, Anacardiaceae, Podocarpaceae and Araucariaceae. Scholtz (1985) concluded that the Arnot locality displayed relatively dry vegetation, and suggested that a vegetation gradient probably existed at this time period between the drier continental interior (Arnot) and the coastal plain. Eocene palynomorphs from the Koingnaas locality in Namaqualand indicates a forested temperate to subtropical environment (de Villiers & Cadman 2001). The Koingnaas vegetation shows similarities to the Arnot locality vegetation with shared Gondwana genera (*Propylipollis, Podocarpidites, Cyathidites*). The locality also displays links to sites of the Cape floristic region (*Casuarinidites, Margocolporites, Cupaniedites*)(de Villiers & Cadman 2001). Microfaunal remains from Lutetian (Middle Eocene) fossil localities in the southern Namibian Sperrgebiet region indicate humid, tropical conditions with summer rainfall (Pickford *et al.* 2014). Later, Bartonian(Middle Eocene) localities from the same region indicate a semi-arid palaeoenvironment with a substantial grass component (Pickford *et al.* 2014). Unfortunately, there is little botanical preservation for the Paleogene on the southern west coast. Oligocene plant fossils from southern African are absent (not preserved) (Neumann & Bamford 2015). Axelrod and Raven (1978) infer a temperate Podocarpaceae-*Araucaria-Nothofagus* rainforest with austral (Gondwana) affinities along the southern-most coast of South Africa and humid, subtropical forests in the Cape region during the Oligocene.

The Langebaanweg terrestrial deposits preserve just the uppermost section (Middle Miocene) of the Elandsfontyn Formation (Sciscio *et al*. 2013; Roberts *et al*. 2017). However, the Terminal-Oligocene - Early Miocene distal extension of the formation is preserved in marine cores from Saldanha Bay. Recent analysis of the distal Elandsfontyn has indicated subtropical vegetation with likely Podocarpaceae-dominated forests, proto-fynbos, swamp and riparian forests with palms and angiosperms (Roberts *et al*. 2017). Subtropical woodland-thicket with Combretaceae and Brachystegia may have developed on the coastal plains, with mangroves and associated ferns restricted to the estuary. All this indicates high precipitation and a summer rainfall regime. Pollens from the upper Elandsfontyn Formation have been

extensively studied, both at Langebaanweg, and from boreholes in a number of other localities around the Cape (Sciscio *et al*. 2013). Early studies identified two pollen zones within the Elandsfontyn (Coetzee 1978; Coetzee & Rogers 1982). The lower pollen zone was dominated by palms, with *Podocarpus*, tropical forest and riparian plants, also occurring. Fynbos elements were present, in low percentages, throughout the zone. The lower pollen zone displayed changes consistent with a decrease in humidity, with a reduction in forest taxa and *Podocarpus* and increased dominance of palms (Coetzee & Rogers 1982). The upper pollen zone, on the other hand, displayed a dramatic reduction in palm abundance. There was a high proportion of marsh taxa, and Coetzee and Rogers (1982) believed the pollens were deposited in a freshwater environment. These two pollen zones imply alternate wet-dry periods in the local flora of the Late Miocene (Sciscio *et al.* 2013). Although, these changes in the vegetation may also reflect local changes due to the meander and lateral migration of the palaeo-river (Coetzee & Rogers 1982). Bamford (1999) describes other Middle Miocene fossil localities in the Cape region as displaying evidence for humid forest environments. The shift observed in the Elandsfontyn Formation by Coetzee and Rogers (1982), from tropical vegetation to an environment with fynbos characteristics and decreasing palms, may also indicate a climate shift from a warm, mesic climate to a cooler and more seasonal climate (Linder 2003; Sciscio *et al.* 2013). Sciscio *et al*. (2013) found similar palaeoenvironmental indicators in an additional study of the upper Elandsfontyn Formation from a different sedimentary core at Langebaanweg. In her study, pollens indicate a warm, subhumid climate, with local variations in wet and dry (groundwater level) and occasional marine input. She reconstructs a fluvial environment transitioning upward (through the core) to estuarine conditions; due to either climatic changes or river migration. There were diverse forest taxa and Podocarpidites were abundant; Restionaceae were frequently low. There were numerous arboreal and herbal elements throughout the sequence, indicative of summer rainfall (Sciscio *et al.* 2013). Poaceae, and Fynbos elements were found (like in Coetzee & Rogers (1982)) to be well established. Changes in groundwater level, are likely induced by lateral migration or meandering of river channels with marine transgression (Sciscio *et al.* 2013). Sciscio *et al*. (2013) find evidence for strong rainfall variability with strong seasonality. These patterns differ from the global climate inferred for the Middle Miocene Africa and are believed to reflect variations in the strength and position of cloud banks, sea surface temperatures and westerly winds (Sciscio *et al.* 2013). Additionally, Sciscio *et al*. (2013) find evidence for declining Miocene sea surface temperatures, no doubt linked to activity in the Benguela Upwelling System.

Late Miocene pollens from Langebaanweg (KGM& LCSM) suggest the presence of lowland and montane subtropical rain forest in which palms were prominent (Coetzee & Muller 1984; Coetzee & Rogers 1982; Scott 1995). Abundant pollens recovered from carbonaceous sands and peats of the Langebaanweg estuarine deposits (LQSM) preserved a spectrum of species, many now extinct (Tankard & Rogers 1978). These Pliocene pollens include groups typical of the Cape Flora and of the winter rainfall zone, like Restionaceae and *Cliffortia* (Tankard & Rogers 1978; Scott *et al.* 1997). Grass pollens and *Podocarpus* were also recovered in these deposits. Tankard and Rogers (1978) concluded that the flora of the Pliocene of Langebaanweg was characterised by sclerophyllous woodland and grassland which experienced primarily summer rainfall but with a trend towards winter rainfall. The KGM and LCSM preserved palm and cycad-like phytoliths, supporting the pollen data (Rossouw *et al.* 2009). Grass phytoliths were common throughout the Varswater Formation, except in the LCSM; and there was a changeover in grass taxa from chloridoid-type grass in the LCSM to restoid in the LQSM and MPPM (Rossouw *et al.* 2009). This turnover could be related to the shift from tropical to more temperature climate, but the authors were wary of making any inferences regarding rainfall regime or photosynthetic pathways. There have been no other successful palynological studies conducted on the Varswater Formation. This may partially be a result of a lack of peaty facies suitable for preservation of organic remains like pollens. It is hoped that with expanded excavation and surveying of the quarry that more suitable environments for palynological analysis might be identified.

4.3 PALAEOECOLOGICAL INTERPRETATIONS

4.3.1 The mosaic environment of Langebaanweg

The botanical record for the west coast of Southern Africa indicates a warm, subtropical climate in the Middle Miocene (Elandsfontyn Formation), with Podocarp forests dominant and fynbos elements present. The palynological record for the latest Miocene-Early Pliocene is sparse, but there appears to be a shift towards more temperate climatic conditions, with increased emphasis on sclerophyllous vegetation and grass phytoliths. The Mio-Pliocene faunal record from Langebaanweg is much more extensive and can provide additional palaeoecological information, particularly for the Pliocene deposits. Wooded environments are underrepresented by mammal remains from Langebaanweg. The Palaeotragus is the only inferred strictly woodland or forest mammal. However, dental micro/mesowear

studies in proboscideans, giraffids and bovids from the site indicate these species were mixed feeders, that incorporated a large proportion of grazing into their diet. Due to this dearth of woodland mammals, this habitat type was for a long time considered limited at Langebaanweg, and by extension the southern African west coast, and was considered to be limited to riverine vegetation (Hendey 1981). Manegold *et al.* (2013) have recently shown, however, a preference for woodland habitats in avian remains; with preservation of lovebird, parrot, woodpecker, honeyguides and nightjars among others. Unfortunately, taxonomic affinity cannot provide enough clarity to identify the type of woodland or tree species involved and expanded palynological research into the Varswater Formation will be necessary to investigate these questions. The near lack of primate remains is noteworthy, and has not been adequately explained, given the otherwise strong woodland signal from Langebaanweg. Numerous species of birds and frogs, together with hippo indicate the presence of substantial perennial water in the vicinity of the fossil site. There are indications for both a river, likely slow moving, and for standing water in a marshy environment.

The mammalian fauna of Langebaanweg is characterised by the presence of numerous grassland or open-environment mammal species including hares, aardvark and large-bodied grazers such as equid, rhino and hippo. Additionally, the presence of ostrich, stork, ibis, mousebird and even tortoises has been used to infer a grassland component to the site. The presence of large-bodied grazers lead early researchers to infer a substantial grassy component to the Langebaanweg environment (Hendey 1976, 1980, 1981). Botanical studies, appear to corroborate this, there is evidence for the presence of grasses as far back as the Early Miocene (Roberts *et al.* 2017), and Rossouw *et al.* (2009) describe C_4 grass as the dominant phytolith type in the Varswater Formation. Isotopic studies on proboscideans, equids, rhino, hippo and even bovids from Langebaanweg, on the other hand, have shown a consistent C_3 signal (Franz-Odendaal *et al*. 2002). Meso/microwear and/or dental adaptations in many of these species indicate grazing behaviour (Hooijer 1972, 1976; Ungar *et al*. 2007; Boisserie & Merceron 2011; Stynder 2011). This is particularly interesting as isotopic studies of other members of these families in other Africa fossil localities display a C_4 signal (Franz-Odendaal *et al*. 2002; Boisserie & Merceron 2011). The C_3 grazing signal observed at Langebaanweg could be an indication of the presence of C_3 grasses which are characteristic of winter rainfall Macchia vegetation. It should however be noted, that C_3 grasses are considered an insignificant component of the Fynbos biome (Rutherford & Westphall 1994), and that the isotopic and meso/micrwear signal for this biome is not well understood. Isotopic patterns in the mammalian assemblage thus display no indication for C_4 grasses, which were expanding across the African continent at the time Langebaanweg was deposited (Cerling *et al.* 1997). However, Rossouw *et*

al. (2009) identified the presence of C_4 grass phytoliths in the Varswater Formation, in some samples making up more than 50% of the phytolith count. Other authors (Sciscio *et al*. 2013; Roberts *et al.* 2017) also identify the presence of grasses in the Elandsfontyn Formation, although it is unclear (from the literature) if they are referring to C_4 species. It seems likely from this evidence that while C_4 grasses had expanded into the Cape region by this period, they were not forming an important component of the diet in large ungulates. This may be because C_4 grasses were a relatively rare component of the vegetation at this time period and Rossouw *et al.* (2009)'s study, which was a preliminary investigation, has for some unknown taphonomic reason over-emphasised the importance of this reasource. Or perhaps C_4 grasses were common, but large ungulates, which had previously been reliant on C_3 vegetation, were slow to utilise this resource. The relative abundance of C_4 grasses at Langebaanweg is an important palaeoecological cionsideration. The spread of grasses into this region helps corroborate trends observed in other African fossil sites and is an indication for the development of a drier climate and more open environment. Establishing the point at which aridification towards the modern climate on the west coast began is essential in understanding the development of the BUS and rates and mechanisms of faunal change-over. The relationship between C_4 grasses and the spread of winter rainfall Cape Macchia vegetation, also requires further research.

The development of the fynbos (Cape Macchia) biome is a key issue for palaeoecological reconstructions of the southern African west coast. The fynbos biome is indicative of strong rainfall seasonality with winter precipitation, and is inherently linked to the development of the BUS. It has already been shown that fynbos elements can be found on the west coast and at Langebaanweg from as long ago as the Middle Miocene (Roberts *et al.* 2017), but the relative importance of Macchia vegetation at Langebaanweg and the west coast in the Early Pliocene remains unclear. Faunal associations with fynbos habitat are poor at Langebaanweg. The assemblage contains some murid species and mole-rats believed to have co-evolved with certain fynbos elements on which they are now dependent. The appearance of these taxa with fynbos in the Early Pliocene at Langebaanweg may indicate that these asscociations have existed for at least 5 Myr. Improved palynological sampling, particularly in the Pliocene parts of the Varswater Formation, will greatly improve our understanding of the role of Macchia vegetation on the west coast in that time period.

Authors have argued that the appearance of fynbos at Langebaanweg may be indicative for the establishment of the winter rainfall regime. Botanical remains from the Middle to Late Miocene suggest year-round to summer rainfall conditions (Sciscio *et al.* 2013; Roberts *et al.* 2017). Rossouw *et al.* (2009),

on the other hand, suggested that winter rainfall had become established by the Pliocene. Anurans remains from the Varswater Formation, have been used to argue for high levels of precipitation and for summer rainfall. Cape Macchia vegetation is intrinsically linked to the winter rainfall zone, although the relative prevalence of this vegetation type at Langebaanweg, in the Pliocene is unclear. No direct proxies have thus far been found to identify winter rainfall. Current evidence cannot exclude winter rainfall, but suggests that precipitation was higher through out the year (Sciscio *et al.* 2013). The substantial marine bird assemblage emphasises Langebaanweg's link to the marine realm and indicates cold water conditions and active upwelling in the BUS during the Early Pliocene. Current proxies indicate inception of the BUS between 10.5 and 10 million years ago (Heinrich *et al*. 2011). Although, marine temperatures and the BUS have fluctuated considerably in the late Neogene (Rommerschirken *et al*. 2011). The appearance of marine birds and mammals mixed with terrestrial fauna in the Langebaanweg fossil deposits, together with other characteristics of the deposits is consistent with a modern estuary environment. The palaeoecology of Langebaanweg Varswater Foramtion can be reconstructed as a mosaic environment with wooded, grassland, Cpe Macchia and open habiats, in the vicinity of freshwater and marine habitats. The relative proportions of the different habitat types is unclear, but Langebaanweg indicates that climate was shifting, on the west coast, from subtropical conditions in the Middle Miocene to more temperate conditions. Precipitation was high, and probably occurred year-round.

4.3.2 The MPPM versus the LQSM

Hendey (1976,1980) believed there was an unconformity between the LQSM and MPPM and that the members were separated by as much as half a million years. This belief was based mostly on differences in taxonomic composition between the members. Expanded sampling and analysis of remains from Langebaanweg has shown that these perceived differences were more the result of sampling bias. Differences in the faunal composition of the MPPM and LQSM are explored below, regarding palaeoecological importance.

MPPM

The MPPM and LQSM have many species in common. Both the MPPM and LQSM preserved remains from animals associated with wooded environments, however the majority of these species are shared. Only *Loxodonta cookei* and *Palaeotragus germaini* are exclusive to the MPPM, along with three bovid taxa (both reduncinis and *Damalacra neanica*). It should be noted however that the provenance of several woodland bird species (honeyguides, starlings and warblers) in the literature is uncertain. The greater diversity and abundance of open habitat species, some of which display clear grazing signals (equid, rhino), would suggest that this habitat type was more prevalent in the MPPM environment. The presence of hippopotamus in the MPPM, along with *Podiceps* sp. (grebe) and cranes (the only freshwater avians limited to the MPPM) indicates the presence of substantial and perennial freshwater. Similarly, numerous anuran genera or species were only recovered in the MPPM deposits namely; *Kassina, Xenopus, Heleophyrne* and *Amietophrynus* cf. *panthernus*. The presence of *Xenopus* and *Heleophyrne* is particularly noteworthy as these genera require streams or rivers. Some marine species are only known from the MPPM; *Phalacrocorax* sp. A (cormorant), *Nucleornisinsolitus* (penguin) and *Palaeospheniscus huxleyorum*. There is clearly proximity of the MPPM to the sea, but the means by which marine remains came to be accumulated in the terrestrial deposits of the MPPM (and LQSM) remain unclear.

The MPPM sediments are considered to record estuarine, marine and localised fluvial sedimentation (see Chapter Two for more details) (Roberts *et al.* 2011). The taxonomic representation of fossils from the MPPM support this reconstruction, which admittedly is quite broad. The majority of fossils from the MPPM were recovered from bed 3aN/S (1976/2 and the bonebed). Hendey (1981) considered bed 3a to be part of a river system with wet season and dry season channels in an estuarine environment. Smith and Haarhoff (2006), in an analysis of the bonebed concurred that the system was likely part of a fluvial channel, but suggested the bonebed was most likely deposited as a scour pool against a phosphate rock. Brumfitt and colleagues (2013), on the other hand, suggest the bonebed was part of an underground fed aquifer system. It is difficult to assess the validity of these hypotheses with taxonomic inferences. Some of the anuran remains in the MPPM would suggest a river environment over an aquifer, however most of the fauna identified in the deposit could occur in either environment.

LQSM

The primate, pangolin, bat and *Mammuthus* and *Nyanzachoerus kanamensis australis* were the only mammal remains observed in the LQSM and not the MPPM. The proboscidean, primate and pangolin are all characteristic of wooded environments. Avian remains exclusive to the LQSM include woodland species (woodpecker and nightjar), fresh water taxa (painted-snipe, ibis), open environment birds (kingfisher, sandgrouse, bustard) and marine forms (albatross, *Pachyptila*, pelican). Remains from a large number of bird species from the family Charadriidae are recorded at Langebaanweg. Rich (1980) indicated the presence of remains from this family in the LQSM, but many more specimens have been recorded since and the attribution of the new material is not available in the literature. The LQSM preserved a number of anuran taxa not observed in the MPPM including *Breviceps, Tomopterna, Amietophynus* sp. 1, sp. 2, and *Amietophrynus gutturalis*. *Breviceps* and *Tomopterna* are characteristic of terrestrial areas with sandy, open habitat. Thus the taxonomic composition of the LQSM appears to indicate much the same environment as the MPPM deposit. Mammal remains indicate more of an emphasis on wooded vegetation. Anuran remains suggest a more terrestrial habitat (instead of a river course) which is supported by the lack of mammal species characteristic of perennial freshwater.

There is some partitioning in the carnivore species. *Plesiogulo monspecculans*, *Genetta, Herpestes* sp. B, *Hyaenictis hendeyi, Amphimachairodus*, and *Dinofelis* are limited to the LQSM; while *Eucyon*, *Agriotherium africanum, Mellivora benfieldi, Sivaonyx hendeyi, Herpestes* sp. A, *Hyaenictitherium namaquensis* and *Metailurus obscurus* were limited to the MPPM. The appearance of so many carnivores in one member and not the other might suggest some sort of habitat niche separation. Niche separation is an important consideration that might explain how so many carnivores can successfully coexist at Langebaanweg. The taxonomic composition of the LQSM is consistent with previous palaeoecological interpretations of the deposit as a fluvio-estuarine environment with occasional salt marsh and tidal flats (Roberts *et al.* 2011). There is no indication for an age difference between the MPPM and LQSM as suggested by Hendey (1970a). It is in this case not surprising that the MPPM and LQSM display very similar taxonomic profiles given that they are effectively sampling from the same environment and it is the depositional setting that differs between the deposits. More detailed sedimentological and taphonomic analysis will allow better characterisation of these differences.

4.4 TAPHONOMY OF LANGEBAANWEG

Preliminary taphonomic analyses have been conducted on a handful of Langebaanweg species including murid, anuran, cetacean, and ursid. Additionally, limited taphonomic work has also been published on the Langebaanweg bonebed. Modifications on murid bones indicate deposition in a low energy environment with little transport and quick internment (Matthews 2004). Evidence of predation, probably by an owl, can be observed in murids, bathyergids and gerbilids. This would suggest that the micromammal remains in the bonebed were deposited as regurgitates from predaceous birds perching or roosting above the bed (Smith & Haarhoff 2006). Preservation of both micromammals and anurans was better in the LQSM than the MPPM, but this may be due to mechanical breakage of small remains while excavating the moderately cemented MPPM sediments. Cetacean remains were exposed for some time before burial as bones display weathering, trampling and both terrestrial and marine predator modifications. Predator modifications were also observed on remains from the ursid, along with rodent gnawing and burning. Burning is regularly observed on bones from Langebaanweg (Hendey 1980) and it has been suggested that veld fires may have been the cause of mortality in some species. Remains from the bonebed indicate hydraulic sorting, trampling and quick burial (Smith & Haarhoff 2006). What is clear is that there is still a great deal of taphonomic work to be done at Langebaanweg. An improved taphonomic understanding of the deposit will provide insight into questions regarding accumulation processes, environmental reconstructions and stratigraphic correlations.

Table 4.1. Mammal species representation from Langebaanweg

Species	Common name	MPPM	LQSM	Environment	References
Class Mammalia					
Order Insectivora					
Family Chrysochloridae	**Golden moles**				
Chrysochloris sp.		X	X	Sand dunes, arid	Pocock 1976
Family Soricidae	**Shrews**				
Myosorex sp. A		X	X	Fynbos?	Pocock 1976; Hendey 1981b; Matthews 2006
Myosorex sp. B		X	X	Fynbos?	Hendey 1981; Matthews 2006
Suncus sp.			X		Hendey 1981; Matthews 2006
Soricidae gen. & sp. not det		X	X		Hendey 1981; Matthews 2006
Family Macroscelididae	**Elephant shrews**				
Elephantulus sp.		X	X		Pocock 1976
Order Rodentia	**Rodents**				
Family Bathyergidae	**Mole-rats**				
Bathyergus hendeyi		X	X	Fynbos?	Pocock 1976; Denys 1998; Matthews 2006
Cryptomys broomi		X	X	Fynbos?	Denys 1998; Matthews 2006
Family Hystricidae	**Porcupines**				
Gen. & sp. not det. A			X		Hendey 1981; Matthews *et al.* 2007
Gen. & sp. not det. B		X			Hendey 1981; Matthews *et al.* 2007
Family Muridae	**Rats and mice**				
Subfamily Murinae	**Rats and mice**				
Aethomys adamanticola		X	X		Denys 1990a; Matthews *et al.* 2007
Aethomys modernis		X	X		Denys 1990a; Matthews *et al.* 2007
Aethomys sp. 1			X		Matthews *et al.* 2007

Species	Common name	MPPM	LQSM	Environment	References
Aethomys sp. 3		X			Matthews *et al.* 2007
Aethomys sp. 4		X			Matthews *et al.* 2007
Aethomys intermed		X			Matthews *et al.* 2007
Mus or *Acomys*-like sp.		X	X		Matthews *et al.* 2007
Small Aethomys or small Rhabdomys		X	X		Matthews *et al.* 2007
Rhabdomys sp. 1			X		Matthews *et al.* 2007
Rhabdomys sp. 2		X			Matthews *et al.* 2007
Rhabdomys intermed		X			Matthews *et al.* 2007
Euryotomys pelomyoidea		X	X		Pocock 1976; Matthews *et al.* 2007
Thallomys sp.		X		Wooded	Matthews *et al.* 2007
Zelotomys-like sp.		X			Matthews *et al.* 2007
Zelotomys sp.		X			Matthews *et al.* 2007
Subfamily Mystromyinae					
Mystromys pocockei		X	X		Denys 1991; Matthews et al 2007
Mystromys hausleitneri		X	X		Pocock 1976; Denys 1991; Matthews *et al.* 2007
Subfamily Deomyinae (Acomyinae)	**Spiny mice**				
Acomys mabele		X	X		Denys 1990b; Matthews *et al.* 2007
Acomys sp. (large)			X		Matthews *et al.* 2007
Subfamily Gerbillinae	**Gerbils**				
Desmodillus magnus		X	X	Open, arid	Pocock 1976; Matthews *et al.* 2007; Denys & Matthews 2017
Subfamily Dendromurinae	**Climbing mice**				
Dendromus averyi		X	X		Denys 1994a; Matthews *et al.* 2007
Dendromus darti		X	X		Denys 1994a; Matthews *et al.* 2007
Subfamily Delanymyinae	**Delany's mouse**				

Species	Common name	MPPM	LQSM	Environment	References
Stenodontomys saldhanae		X	X		Denys 1994a; Matthews *et al.* 2007
Family Myoxidae	**Dormice**				
Graphiurus sp.		X	X		Pocock 1976; Hendey 1981; Matthews *et al.* 2007
Order Lagomorpha					
Family Leporidae	**Hares and rabbits**				
Pronolagus sp.		X	X	Open, rocky?	Pocock 1976
Order Tubulidentata	**Aardvarks**				
Orycteropus cf. *afer*		X	X	Open	Pickford 2005; Lehmann 2006
Order Hyracoidea	**Hyraxes**				
Family Procaviidae	**Hyraxes**				
Procavia cf. *antiqua*		?	X	Open, rock?	Hendey 1980
Order Proboscidea	**Elephants and kin**				
Family Gomphotheriidae					
Anancus capensis		X	X	Wooded	Hendey 1970a, 1976; Sanders 2007
Family Elephantidae	**Elphant**				
Mammuthus subplanifrons			X	Wooded	Singer & Hooijer 1958; Aguirre 1969; Maglio & Hendey 1970; Sanders 2007
Loxodonta cookei		X		Wooded	Sanders 2007
Order Prmates					
Family Cercopithecidae	**Baboons and monkeys**				
Gen. & sp. Indet			X	Wooded	Grine & Hendey 1981
Order Chiroptera	**Bats**				
Family Vespertilionidae	**Vesper bats**				
Eptesicus sp.			X		Pocock 1976
Order Pholidota	**Pangolins**				

Species	Common name	MPPM	LQSM	Environment	References
Family Manidae					
Manis gigantea			X	Wooded	Hendey 1976; Both & Gaudin 2007
Order Carnivora					
Family Canidae	**Foxes, wild dogs and jackals**				
Eucyon sp.		X			Hendey, 1974; Rook 1993; Werdelin 2006; Werdelin and Peigné 2010; Hartstone-Rose *et al.* 2016
Family Ursidae	**Bears**				
Agriotherium africanum			X		Hendey, 1972, 1974, 1981, 1982; Wolff *et al.* 1973; Sorkin 2006; Werdelin 2006; Werdelin and Peigné 2010; Stynder & Kupczik 2012
Family Mustelidae	**Otters, badgers, weasels**				
Plesiogulo monspessulanus			X		Hendey, 1974, 1978, Kurten 1970; Werdelin 2006; Werdelin and Peigné 2010; Morales & Pickford 2005; Morales *et al.* 2005
Mellivora benfieldi		X			Hendey, 1974, 1978, 1980; Petter 1987; Werdelin 2006; Werdelin and Peigné 2010; Morales & Pickford 2005; Morales *et al.* 2005
Sivaonyx hendeyi		X			Hendey, 1974, 1978, 1980; Werdelin 2006; Werdelin and Peigné 2010; Morales & Pickford 2005; Morales *et al.* 2005

Species	Common name	MPPM	LQSM	Environment	References
Family Phocidae	**Seals**				
Homiphoca capensis		X	X	Marine	Hendey, 1974 1980, 1982; Hendey & Repenning 1972; De Muizon & Hendey 1980; Werdelin 2006; Avery & Klein 2011; Govender 2015; Govender *et al.* 2011; Govender *et al.* 2012
Family Viverridae	**Civets and genets**				
Viverra leakeyi		X	X		Hendey, 1974, 1980; Werdelin 2006; Werdelin and Peigné 2010
Viverridae gen. & sp. not det		X	X		Hendey, 1974, 1980; Werdelin 2006; Werdelin and Peigné 2010
Genetta sp.			X		Hendey, 1974, 1980; Werdelin 2006; Werdelin and Peigné 2010
Family Herpestidae	**Suricates and mongooses**				
Herpestes sp. A		X			Hendey 1980; Werdelin 2006; Werdelin and Peigné 2010
Herpestes sp. B			X		Hendey 1980; Werdelin 2006; Werdelin and Peigné 2010;
Family Hyaenidae	**Hyaenas**				

Species	Common name	MPPM	LQSM	Environment	References
Chasmaporthetes australis		X	X		Hendey 1980; Werdelin *et al.* 1994; Werdelin 2006; Werdelin and Peigné 2010; Hartstone-Rose & Stynder 2013; Hartstone-Rose *et al.* 2016
Hyaenictis hendeyi			X		Hendey, 1974, 1978, 1980; Werdelin *et al.* 1994; Werdelin 2006; Werdelin and Peigné 2010; Hartstone-Rose & Stynder 2013; Hartstone-Rose *et al.* 2016
Ikelohyaena abronia		X	X		Hendey 1980; Werdelin *et al.* 1994; Werdelin 2006; Werdelin and Peigné 2010; Hartstone-Rose & Stynder 2013; Hartstone-Rose *et al.* 2016
Hyaenictitherium namaquense		X			Hendey 1980; Werdelin *et al.* 1994; Werdelin 2006; Werdelin and Peigné 2010; Hartstone-Rose & Stynder 2013; Hartstone-Rose *et al.* 2016
Family Felidae	**Cats**				
Amphimachairodus sp. A			X		Hendey 1980; Werdelin 2006; Werdelin and Peigné 2010; Hartstone-Rose *et al.* 2016
Amphimachairodus sp. B			X		Hendey 1980; Werdelin 2006; Werdelin and Peigné 2010; Hartstone-Rose *et al.* 2016
Dinofelis			X		Hendey 1980; Werdelin 2006; Werdelin and Peigné 2010; Hartstone-Rose *et al.* 2016

Species	Common name	MPPM	LQSM	Environment	References
Metailurus obscurus		X			Hendey 1980; Werdelin 2006; Werdelin and Peigné 2010; Hartstone-Rose *et al.* 2016
Order Perissodactyla	**Odd-toed ungulates**				
Family Equidae	**Horses and zebras**				
Eurygnathohippus hooijeri		X	X	open	Bone & Singer 1965; Hooijer 1976; Franz-Odendaal *et al.* 2003; Hendey 1978; Eisenmann 1983; Bernor *et al.* 2006; Bernor & Kaiser 2006
Hipparion cf. *namaquense*		X		Open	Hendey 1981; Bernor & Armour-Chelu 1999
Family Rhinocerotidae	**Rhinoceroses**				
Ceratotherium praecox		X	X	Open	Hooijer 1972
Order Suiformes	**Pigs**				
Family Tayassuidae	**Peccaries**				
Cainochoerus africanus		X			Hendey 1976; Pickford 1988; Cooke & Hendey 1992
Family Suidae	**True Pigs**				
Nyanzachoerukanamensis australis			X		Hendey 1981; Cooke & Hendey 1992
Nyanzachoerus cf. *jaegeri*		X			Hendey 1981; Cooke & Hendey 1992
Order Whippomorpha	**Whales, dolphins, hippos**				
Family Hippopotamidae	**Hippopotamus**				
Hippopotaminae sp.		X		Freshwater	Boisserie 2006; Boisserie & Merceron 2011
Suborder Cetacea	**Whales and dolphins**				
Plesiobalaenopters-like sp.		X	X	Marine	Hendey 1981; Govender *et al.* 2016
Balaenopterid gen. et sp. unknonw		X	X	Marine	Hendey 1981; Govender *et al.* 2016

Species	Common name	MPPM	LQSM	Environment	References
Odontocetes gen. et sp. unknown		X	X	Marine	Hendey 1981; Govender *et al.* 2016
Order Ruminata	**Ruminants**				
Family Giraffidae	**Giraffes**				
Sivatherium hendeyi		X	X	Wooded	Harris 1976; Hendey 1970b, 1974, 1976, 1980
Palaeotragus cf. *germaini*		X		Wooded	Harris 1976; Hendey 1970b, 1974, 1976, 1980
Giraffa sp.		X	X	Wooded	Harris 1976; Hendey 1970b, 1974, 1976, 1980
Family Bovidae	**Antelopes, buffalo**				
Tribe Tragelaphini					
Tragelaphus sp. A		X	X	Open	Gentry 1970, 1980; Stynder 2011
Mesembriportax (or *Miotragocerus*) acrae		X	X	Open	Gentry 1970, 1980; Stynder 2011
Tribe Bovini					
Simatherium demissum		X	X	Open	Gentry 1970, 1980; Stynder 2011
Tribe Reduncini					
Kobus subdolus		X		Open	Gentry 1970, 1980; Stynder 2011
Kobus sp. B		X		Open	Gentry 1970, 1980; Stynder 2011
Tribe Alcelaphini					
Damalacra neanica		X		Open	Gentry 1970, 1980; Stynder 2011
Damalacra acalla		X	X	Open	Gentry 1970, 1980; Stynder 2011
Tribe Antilopini					
Raphicerus paralius		X	X	Open	Gentry 1970, 1980; Stynder 2011
Gazella sp.		X	X	Open	Gentry 1970, 1980; Stynder 2011
Bovidae not det.					
Ovibovini gen. & sp. not det		X	X	Open	Gentry 1970, 1980; Stynder 2011

Table 4.2. Avian species representation from Langebaanweg

Species	Common name	MPPM	LQSM	Environment	References
Class Aves	**Birds**				
Order Struthionidae	**Ostrich**				
Struthio cf. *asiaticus*		X		Open	Rich 1980; Manegold *et al*. 2013
? *Struthio* sp.		X			Rich 1980; Manegold *et al.* 2014
Order Sphenisciformes	**Penguins**				
Family Spheniscidae					
Inguza predemersus		X	X	Marine	Simpson 1971, 1973, 1979a, b; Olson 1983, 1985b
Dege hendeyi		X	X	Marine	Simpson 1971, 1973, 1979a, b; Olson 1983, 1985b
Nucleornis insolitus		X		Marine	Simpson 1971, 1973, 1979a, b; Olson 1983, 1985b
Paleospheniscus' huxleyorum		X		Marine	Simpson 1971, 1973, 1979a, b; Olson 1983, 1985b
Order Podicipediformes	**Grebes**				
Family Podicipedidae					
Podiceps? sp.		X		Fresh water	Olson 1994
Tachybaptus ruficollis	dabchick	X	X	Fresh water	Olson 1994
Order Procellariiformes	**Marine birds**				
Family Diomedeidae	**Albatrosses**				
Diomedea sp.			X	Marine	Olson 1985a
Family Oceanitidae	**Storm petrels**				

Species	Common name	MPPM	LQSM	Environment	References
Subfamily Oceanitidae					
Oceanites zaloscarthmus		X	X	Marine	Olson 1985a
Family Procellariidae	**Petrels, shearwaters, prions etc.**				
Pachyptila salax		X	X	Marine	Olson 1985a
Pachyptila sp. B		X	X	Marine	Olson 1985a
Pachyptila sp. C			X	Marine	Olson 1985a
Puffinus sp.		X	X	Marine	Olson 1985a
Gen. & sp. indet		?	X	Marine	Olson 1985a
Order Pelecaniformes	**Pelicans and related**				
Family Pelecanoididae					
Pelecanoides cymatotrypetes			X	Marine	Olson 1985a
Family Sulidae	**Gannets and boobies**				
Sula sp.		X	X	Marine	Olson 1983, 1985b
Family Phalacrocoracidae	**Cormorants**				
Phalacrocorax sp. A (small)		X		Marine (?)	Olson 1983, 1985b
Phalacrocorax sp. B (medium)		X	X	Marine (?)	Olson 1983, 1985b
Phalacrocorax sp. C (medium)		?	?	Marine (?)	Olson 1983, 1985b
Order Ciconiiformes	**Wading birds**				
Family Ciconiidae	**Storks**				
Ciconia kahli		X	X	Open	Haarhoff 1988; Manegold *et al.* 2013
Family Scopidae	**Hamerkop**				
Scopus xenopus		X	X	Fresh water	Olson 1984
Family Plataleidae	**Ibises and spoonbills**				
Geronticus apelex		X	X	Open	Olson 1985c; Haarhoff 1985
Threskiornis aff. a*ethiopicus*			X	Fresh water	Olson 1985c; Haarhoff 1986

Species	Common name	MPPM	LQSM	Environment	References
Family Anatidae	**Ducks, geese, swans**				
Order Anseriformes					
Gen. & sp. not det, sp. A (small)		?	?	Fresh water	Rich 1980; Manegold *et al.* 2013
Gen. & sp. not det, sp. B (small/medium)		?	?	Fresh water	Rich 1980; Manegold *et al.* 2013
Gen. & sp. not det, sp. C (medium/large)		?	?	Fresh water	Rich 1980; Manegold *et al.* 2013
cf. *Afrocygnus* sp.		?	?	Fresh water	Rich 1980; Manegold *et al.* 2013
Order Falconiformes					
Family Accipitridae	**Eagles, hawks, vultures**				
Gen. & sp. not det, sp. A		?	?		Rich 1980
Gen. & sp. not det, sp. B		?	?		Rich 1980
Gen. & sp. not det, sp. C		?	?		Rich 1980
Gen. & sp. not det, sp. D		?	?		Rich 1980
Gen. & sp. not det, sp. E		?	?		Rich 1980
Family Falconidae	**Falcons and Kestrels**				
Gen. & sp. not det			X		Rich 1980
Order Galliformes					
Family Phasianidae	**Francolins, quail, pheasant**				
Francolinus sp.		?	?	Open	Rich 1980; Manegold *et al*. 2013
Dendroperdix aff. *sephaena*		?	?	Open	Rich 1980; Manegold *et al.* 2013
cf. *Coturnix* sp.		?	?	Open	Rich 1980; Manegold *et al.* 2013
Order Gruiformes					
Family Gruidae	**Cranes**				
Gen. et. sp. not det		X		Fresh water	Rich 1980; Manegold *et al.* 2013

Species	Common name	MPPM	LQSM	Environment	References
Family Rallidae	**Rails, crakes, moorhens**				
Gen. & sp. not det		X	X	Fresh water	Rich 1980; Manegold *et al.* 2013
Family Otididae	**Bustards and Korhaans**				
Gen. & sp. not det, sp. A (small)			X	Open	Rich 1980; Manegold *et al.* 2013
Gen. & sp. not det, sp. B (larger)			?	Open	Rich 1980; Manegold *et al.* 2013
Order Charadriiformes	**Waders, gulls, auks**				
Family Turnicidae	**Buttonquail**				
Turnix cf. *hottentottus*		?	?	Moist grasslands	Olson 1994; Manegold *et al.* 2013
Family Burhinidae	**Thick-knees**				
Gen. et. sp. not det			X	Open	Rich 1980; Manegold *et al.* 2013
Family Recurvirostridae	**Stilits**				
Himantopus sp.			X	Fresh water	Rich 1980; Manegold *et al.* 2013
Family Scolopacidae	**Sandpiper**				
aff. *Gallinago* sp.			X	Fresh water	Rich 1980; Manegold *et al.* 2013
Family Rostratulidae	**Painted-snipe**				
Rostratula minator			X	Fresh water	Rich 1980; Manegold *et al.* 2013
Family Laridae	**Gulls**				
Laris sp. A (medium)		?	?	Marine ?	Olson 1983, 1985b; Manegold *et al.* 2013
Laris sp. B (large)		?	?	Marine ?	Olson 1983, 1985b; Manegold *et al.* 2013
Sterna sp. A (medium)		?	?	Marine ?	Olson 1983, 1985b; Manegold *et al.* 2013
Sterna sp. B (large)		?	?	Marine ?	Olson 1983, 1985b; Manegold *et al.* 2013
Family Charadriidae					
Charadrius sp. A (size - *C. pecuarius*)		?	?	Marine / Freshwater	Rich 1980; Manegold *et al.* 2013

Species	Common name	MPPM	LQSM	Environment	References
	Charadrius sp. B (size - *Pluvialis apricaria*)	?	?	Marine / Freshwater	Rich 1980; Manegold *et al.* 2013
	Charadrius sp. C (small *Charadrius*)	?	?	Marine / Freshwater	Rich 1980; Manegold *et al.* 2013
	Charadrius sp. D (*C. marginatus*)	?	?	Marine / Freshwater	Rich 1980; Manegold *et al.* 2013
	Charadrius sp. E (*C. placidus*)	?	?	Marine / Freshwater	Rich 1980; Manegold *et al.* 2013
	Charadrius sp. F (*C. leschenaultii*)	?	?	Marine / Freshwater	Rich 1980; Manegold *et al.* 2013
	Charadrius sp. H (*C. tricollaris*)	?	?	Marine / Freshwater	Rich 1980; Manegold *et al.* 2013
	Charadrius sp. I (*C. mongolus*)	?	?	Marine / Freshwater	Rich 1980; Manegold *et al.* 2013
	cf. *Vanellus senegallus*	?	?	Marine / Freshwater	Rich 1980; Manegold *et al.* 2013
	cf. *Vanellus crassirostris*	?	?	Marine / Freshwater	Rich 1980; Manegold *et al.* 2013
	cf. *Vanellus albiceps*	?	?	Marine / Freshwater	Rich 1980; Manegold *et al.* 2013
	cf. *Vanellus armatus*	?	?	Marine / Freshwater	Rich 1980; Manegold *et al.* 2013
	Charadriidae (*Stephanibyx*)	?	?	Marine / Freshwater	Rich 1980; Manegold *et al.* 2013
	Charadriidae (*P. apricaria*)	?	?	Marine / Freshwater	Rich 1980; Manegold *et al.* 2013
Order Columbiformes					

Species	Common name	MPPM	LQSM	Environment	References
Family Pteroclidae	**Sandgrouse**				
Pterocles sp. A			X	Open	Rich 1980; Manegold *et al.* 2013
Pterocles sp. B			X	Open	Rich 1980; Manegold *et al.* 2013
Family Columbidae	**Pigeons and doves**				
Gen. & sp. not det		X	X		Rich 1980; Manegold *et al.* 2013
Gen. & sp. not det		X	X		Rich 1980; Manegold *et al.* 2013
Order Psittaciformes					
Family Psittacoidea	**Parrots, cockatoos etc.**				
Agapornis attenboroughi	Lovebird	X	X	Wooded	Rich 1980; Stidham 2006; Manegold 2013
Khenena leopoldinae		X	X	Wooded	Rich 1980; Stidham 2006; Manegold 2013
Gen. & sp. not det (large)		?	?	Wooded	Rich 1980; Stidham 2006; Manegold 2013
Order Strigiformes					
Family Strigidae	**Typical owls**				
Athene inexpectata		X	X		Pavia *et al.* 2015
Bubo sp.		?	?		Pavia *et al.* 2015
Asio sp.		X	X		Pavia *et al.* 2015
Gen. & sp. indet		X	X		Pavia *et al.* 2015
Family Tytonidae					
Tyto richae		X	X		Pavia *et al.* 2015
Order Caprimulgiformes	**Nightjars**				
Family Caprimulgidae					
Gen. & sp. indet			X	Wooded	Manegold 2010
Order Apodiformes					
Family Apodidae	**Swifts**				
cf. *Tachymarptis* sp.		X			Rich 1980; Manegold *et al.* 2013
Order Coliiformes					

Species	Common name	MPPM	LQSM	Environment	References
Family Colidae	**Mousebirds / colies**				
Colius hendeyi		X	X	Open	Rich & Haarhoff 1985
Order Alcediniformes					
Family Alcedinidae	**Kingfishers**				
Ceryle sp.			X	Fresh water	Olson 1994
Halcyon sp.			X	Open	Olson 1994
Order Piciformes	**Woodpeckers etc.**				
Family Picidae					
Australopicus nelsonmandelai		?	X	Wooded	Manegold & Louchart 2012
Family Indicatortidae	**Honeyguide**				
cf. *Indicator* sp. A		?	?	Wooded	Olson 1985d; Manegold *et al.* 2013
cf. *Indicator* sp. B		?	?	Wooded	Olson 1985d; Manegold *et al.* 2013
Order Passeriformes	**Song birds**				
Family Hirundinidae	**Swallows**				
Gen. & sp. not det sp. A		X	X		Manegold 2010
Gen. & sp. not det sp. B		X	X		Manegold 2010
Family Sturnidae	**Starlings**				
Gen. & sp. not det sp. A		?	?	Wooded	Manegold *et al.* 2013
Gen. & sp. not det sp. B		?	?	Wooded	Manegold *et al.* 2013
Gen. & sp. not det sp. C		?	?	Wooded	Manegold *et al.* 2013
aff. *Cinnyricinclus leucogaster*	Amethest starling	?	?	Wooded	Manegold *et al.* 2013
Sylvioidea gen. et. sp. indet		?	?	Wooded	Manegold *et al.* 2013

Table 4.3. Reptilian and anuran species representation from Langebaanweg

Species	Common name	MPPM	LQSM	Environment	References
Class Reptilia					
Order Squamata					
Suborder Lacertilia					
Family Chamelentidae	**Chameleons**				
Gen. et sp. not det		X	X		Hendey 1981
Family Gekkonidae	**Gecko**				
Gen. et sp. not det		X	X		Hendey 1981
Family Varanid	**Lizards**				
Varanus sp.			X		Hendey 1981
Suborder Ophidia	**Snakes**				
Gen. et sp. not det		X	X		Hendey 1981
Order Chelonia	Tortoises				
Chersina sp.		X	X		Hendey 1981; Meyland & Auffenberg 1986
Geochelone stromeri		X	?		Hendey 1981; Meyland & Auffenberg 1986
Class Amphibia					
Order Anura	**Frogs**				
Family Hyperoliidae	**Sedge & Bush frogs**				
Hyperolius	African reed frog	X	X		Matthews *et al.* 2015
Kassina	Running frogs	X			Matthews *et al.* 2015
Family Brevicipitidae	**Rain frogs**				
Breviceps sp 1			X	Terrestrial, open, sandy	Matthews *et al.* 2015
Breviceps sp 2			X	Terrestrial, open, sandy	Matthews *et al.* 2015

Family Pxyicephalidae					
Tomopterna	Sand frog		X	Terrestrial, open, sandy	Matthews *et al.* 2015
Family Pipidae	**Clawed frogs**				
Xenopus sp 1 large		X		ponds, slow flow river	Matthews *et al.* 2015
Xenopus sp 2 small		X		ponds, slow flow river	Matthews *et al.* 2015
Family Heleophrynidae	**Ghost frog**				
Heleophryne		X		ponds, slow flow river	Matthews *et al.* 2015
Family Bufonidae	**True toads**				
Cf. *Amietophrynus* sp 1	Toads		X		Matthews *et al.* 2015
Cf. *Amietophrynus* sp 2	Toads		X		Matthews *et al.* 2015
Amietophrynus cf. *panthernus*	Panther toad	X			Matthews *et al.* 2015
Amietophrynus cf. *gutturalis*	Guttural toad		X		Matthews *et al.* 2015
Family Ptychadenidae					
Ptychadena sp.		x	x		Matthews *et al.* 2015; Matthews *et al.* 2016

CHAPTER FIVE

MATERIALS AND METHODS

5.1. INTRODUCTION AND AIMS

The aims of this study were to characterise the sediments of the MPPM and LQSM in three localities within E-Quarry, and to investigate the taphonomy of vertebrate remains from those deposits. The results from the three localities could be compared and contrasted in order to investigate differences between the localities or between the MPPM and LQSM that may be related to changes in depositional environment or local ecology. These results could also be utilised to characterise the lithology and taphonomy of the greater E-Quarry. No taphonomic study has ever been conducted at Langebaanweg before, despite the importance of understanding taphonomic pathways when attempting to infer previous environments. Below the chosen study areas are outlined and methods utilised in this analysis are described.

5.2. SAMPLING LOCATIONS (Profiles One, Two and Four)

An initial survey of Langebaanweg E-Quarry and a review of the literature (See Chapters Two to Four) identified five potential localities for investigation. These were assigned arbitrary field numbers namely, Profile One to Profile Five. Three of these localities were chosen for excavation due to their high potential to produce bones and their position within interesting collecting localities at Langebaanweg. Profile One was positioned in the southern part of the quarry, approximately 200 m away from the bed 3aN/S river channels (Figure 5.1). Profile Two was located within the 1976/2 (bed 3aN) excavation, under the small tunnel and Profile Four was located beneath the large tunnel at the northern end of the current bonebed excavation. The Profile locations are outlined in detail below.

5.2.1 Profile Four

The big tunnel, also often called the main dig site, covers the world famous Langebaanweg bone bed. The excavations housed in the big tunnel were opened (as a test trench, squares F8 – F13, and E8) in 1999 by the Archaeology Contract Office (ACO), Cape Town; as a pilot study, in preparation for the inauguration of the West Cost Fossil Park. Over the next 10 years, the excavations were expanded to cover an area of 80 m^2. This excavation clearly shows the presence of an incredibly dense bone bed that contains marine, freshwater and terrestrial species. The bonebed is located between the 1976/1 and 1976/2 excavation and is presumed to sample the bed 3aN flood channel deposits, however a quick glance can show that preservation in this area is profoundly different to anywhere else in the quarry. The composition of remains in the bone bed is striking, with the mixing of megafauna like Sivathere and whales with small animals, micromammals and frogs. Preservation is excellent with conspicuous trampling fractures preserved as if they were freshly crushed (Smith & Harhoff 2006). Associated skeletons and partial skeletons have been observed, however anatomical articulation of remains is very rare. The depositional environment and taphonomic pathway of the bonebed is contentious and a number of conflicting hypotheses have been postulated and debated in the literature. I believed that undertaking a study of the lithology and taphonomy of the bonebed would go a long way towards resolving some of these issues and thus a test pit was located in the bonebed deposit, namely; Profile Four.

To the north of the exposed bone bed, up against the bottom cut wall on the edge of the quarry, is a large heap of (almost certainly) disturbed material, likely moved there by mining equipment. A small prospecting trench (approximately 4 m X 4 m) has been cut into this material, going up to the quarry wall. This trench was part of a section cut by the ACO in 1998 (Figure 5.2), prior to opening the bone bed deposit. The ACO's section cut consists of two clearly visible 1 m^2 blocks on a north-south trend; with the southern square offset (from the other) to the west by 5-10 cm. The floors of these sections cuts were covered by a plastic tarpaulin after excavation. This tarp was discovered buried beneath a large amount of debris eroded from the trench walls. The debris was cleared away and the Profile Four excavation was located on the old excavation square.

The Profile Four excavation was located on the unexcavated northern side of the bonebed as I wished to find previously undisturbed deposits, where it might be possible to observe the sediments, fossil stacking in the bonebed, and any changes through the deposit that might relate to changes in depositional environment. In addition, many specimens have been left in-situ in the bonebed to allow

for palaeontological outreach and education of the general public. These bones have become very fragile and it is best not to disturbed them if possible. I considered the ACO section cut area to be ideal as equipment and bodies would not be in the way of the fossil tour groups and visitors could observe the activity and interact with the excavators. Finally, the density of remains in nearby squares of the bone bed suggested that there was a good likelihood of encountering the bone bed in this square.

5.2.2 Profile Two

Hendey's 1976/2 excavation was left exposed and uncovered for many years after Hendey completed his excavations. In time, the West Coast Fossil Park management arranged for it to be covered with a horticultural tunnel which still stands. There are two of these tunnels at Langebaanweg, one over the 1976/2 excavation and the larger one over the current bonebed excavation; both can be seen clearly in the satellite photographs (Figure 5.1). The 1976/2 locality is now often referred to as the small tunnel. The 1976/2 excavation was located in the bed 3aN river channel. This excavation produced a vast concentration of fossils including many *Agriotherium* remains (Hendey 1980). Bed 3aN in the 1976/2 area was laid down on the unconsolidated sandy substratum of the LSQM. The contact between the MPPM and LQSM can be clearly observed in the walls of the 1976/2 excavation. Hendey believed the 1976/2 excavation sampled the wet season part of the river channel where flood waters allowed the river to breach over and around the phosphate rock observable in the big tunnel. Bones and sediments in the 1976/2 excavation area are expected to show riverine depositional characters with high flow velocities.

The 1976/2 excavation conducted by Hendey consists of six longitudinal trenches running very roughly east to west. The trenches were 5 m to 6 m long and 1.5 m to 2 m wide and each was separated by a narrow bulkhead of earth. Superimposed over the trenches is a meter squared grid, setup diagonally over the trenches. The grid appears to be aligned to the Global Positioning System and true north and is probably linked to the grid over the bonebed excavation. In the current study, a test pit was dug in the southern most trench of the 1976/2 excavation, in the southeast corner of the excavation and named Profile Two. This square was selected as it displayed a large cross section through the southern wall of the old bulkhead and some bedding could be observed within that wall, suggesting there might be good potential for the preservation of bedding lower down. The lithology of the bulkhead was not assessed, as it is not known how much of this material is disturbed and how intensively it has been affected by

weathering after decades of exposure. The MPPM – LQSM contact could be observed in trenches at slightly higher elevations within 1976/2, and it was believed that the contact should be found close to the surface in this square. The test pit provided an ideal locality to investigate lithology and sedimentology of the bed 3aN river channel. Profile Two was excavated to a depth of 0.5 m, intersecting both the MPPM and the LQSM deposits.

5.2.3 Profile One

Profile One (S32°57'85"; E018°06'637") was located in the southern part of E-Quarry, approximately 200 m south of excavation 1976/2 and the bone bed (Figure 5.1). This area was selected as it appears to be outside the bed 3aN/S river channel environment described by Hendey (1980) and Smith and Haarhoff (2006). As a locality outside the river system, Profile One would act as a control and could provide a picture the lithology and taphonomy of the greater E-Quarry, beyond the river system. This control sample would then be utilised to test conflicting hypotheses regarding the taphonomic pathways and depositional environments of the bonebed and bed 3aN/S.

Much of the MPPM was mined away in the southern parts of E-Quarry and in some areas the LQSM is now exposed on the surface (Figure 5.3) (Roberts *et al.* 2011). Profile One was located near the edge of the overburden wall, where according to Roberts and colleagues (2011), some MPPM sediments are preserved close to outcrops of KGM. The MPPM in this region of the quarry can be observed as vegetated mounds or bands of slightly (<0.5 m) raised ground. In some instances, such as the Profile One location, fossils can be observed eroding out along the sides of these banks in high abundance. One concern with excavating in this locality was the extensive degree to which is region of the quarry was subjected to mining operations and the possibility of the sediments having suffered disturbance as a result. The nature of the sediments and particularly the MPPM-LQSM contact in Profile One suggests that the deposit was undisturbed.

No previous excavations have been undertaken in this area and no previous grid system has been extended to cover this part of the quarry. Thus, a new grid was laid, orientated to true-north but not linked to the Global positioning system (GPS). Profile One was excavated to a depth of 0.4 m in most parts, with one corner excavated down a further spit to 0.5 m experimentally. All fossils greater than 2 cm in maximum length were collected and their positions recorded by hand and sketched. Given the

high number of small fragmentary remains within this size, it was decided in subsequent excavations to only piece-plot identifiable specimens. More information on excavation procedures is presented below.

5.3. EXCAVATION PROCEDURES

Test pits were excavated following standard archaeological methods. Excavations preceded in 10cm spits, numbered from the top so increasing numerical size reflects increasing depth. Attempts were made to follow stratigraphic units, particularly at the LQSM-MPPM contact, but the sedimentary units were found to intermingle so finely, in both lateral and vertical extent, as to make following a particular unit impossible. Trowels and brushes, as well as other standard archaeological excavation equipment were used in excavations. Sediments at Langebaanweg, particularly in the MPPM, were found to be incredibly indurated and compacted. The MPPM is weakly cemented by calcareous material (Roberts 2006c). The only solution is to wet the MPPM sediments before excavation, and for our purpose, overnight soaking was found to be best. Wetting caused immediate softening of the sediments, although constant re-wetting was needed during excavations. The LQSM sediments were found to be much softer and sandier, and did not require wetting. A combination of wet and dry sieving was utilised. Sediments that had been soaked were easy to excavate, but the wet material could not be effectively dry sieved and could take days to dry. Thus, this material was wet sieved. When wet sieving, jugs of water were poured over the sediments as they lay on the sieve, and excess water was collected in a bucket positioned below the sieve. Wet sieving was in any event considered advantageous as it has been found to produce the best results in terms of the highest retrieval of small remains (McKenna 1962). A 3.5 mm sieve was utilised. Fine sieves have been shown to improve sample sizes of small bones (like microfauna and frogs) that are known to be abundant at Langebaanweg (Buss & Borges 2008). However, as the identification and analysis of microfauna was not the focus of this project, the 3.5 mm sieve was considered adequate. Sediments from Profile One (in the southern parts of the quarry) were subjected to additional sieving in a fine mesh (1 mm), in order to provide a reference sample of very small remains. This microfaunal sample was not analysed in this study, but it gives an indication of 'background' frequencies of microfauna and emphasises the importance of fine sieving when excavating at Langebaanweg. As excavations were limited to test pits, a total station was not considered necessary in this analysis.

All diagnostic or identifiable remains or bones of large animals were manually recorded in three-dimensional space with tape measures and plotted on paper. Smaller and undiagnostic bones were bagged by spit. Photographs and sketches were created where necessary to show articulation or association between remains, or to show any other characteristics that might be of interest. All bones, including remains recovered in the sieves, were cleaned with fresh water and laid out to dry in the laboratory before further taphonomic analysis. Soft brushes were used, where necessary, to clean the bones. After cleaning, bags of small bones and sieved remains were sorted by hand, and diagnostic and identifiable small bones were removed for taphonomic analysis. Remaining (unidentifiable) bones were bagged and group recorded (see more in the taphonomy section below). The profile number, spit number and date were recorded for each specimen or bag, and plotted specimens were given an arbitrary field number. Following the completion of excavations, each test pit was covered in heavy duty tarpaulin shade cloth secured with sand bags to protect it, and allow a return to the deposits later if needed. Photographs were also taken at the beginning and end of each spit. Lithological characters were recorded for all sedimentary units and samples were taken for grain analysis in the laboratory.

5.4. SAMPLING FOR SEDIMENTARY ANALYSIS

Each test pit is represented by a profile wall, which has been photographed and sketched. This profile wall displays the sedimentary characters of each test pit and was used to compare those characters between the different profiles. Fine colour and textural changes, where apparent, were recorded during excavations and are indicated in the profile photographs and sketches. Sedimentary samples of approximately 1 000 g were taken from the MPPM and the LQSM deposits in each Profile, as well as any other interesting sedimentary units. Samples were taken using a hollow steel pipe (approximate diameter 50 mm) and a hammer. Sediment samples were bagged and labelled with the date, profile number and spit number from which they were derived, and given an arbitrary field / sample number. They were kept in a cool, dark place until laboratory analysis.

5.5. SEDIMENTOLOGY

Lithological analyses are a corner-stone of palaeontological research, as without a firm understanding of the sediments, fossil assemblages cannot be effectively contextualised. Sedimentary analysis can

indicate the age of a deposit, the depositional environment, and can even provide an insight to the palaeoecology or palaeoclimate at the time of deposition (Boggs 2011). Three primary properties are usually described in sediments; structure, texture and composition (Lewis & McConchie 1994). Sedimentary structures are geometrical attributes (like bedding patterns) given to grain assemblages by depositional and early post-depositional processes. Texture refers to the size, shape and grain properties of the sedimentary particles and is often used to assess flow rate and transport conditions (Boggs 20011). Composition refers to the mineralogical or chemical characteristics of the sedimentary particles (Lewis & McConchie 1994).

This lithological analysis will follow standard methodologies as outlined by Coe (2010) and Boggs (2011). The analysis consisted of both field descriptions (including colour, induration, sedimentary structures, fabric etc) and laboratory analysis (sedimentary texture and composition) following the methodologies of Coe (2010), Lewis & McConchie (1994) and Griffiths (1967). These results were then utilised to create stratigraphic sections of each Profile. Comparison of the sedimentary characters between each Profile should indicate potential differences in depositional environment. Once these differences have been identified, a more detailed and unified understanding of the Pliocene sediments in the Langebaanweg E-quarry should be possible. The sedimentary characters analysed in this study are outlined in detail below.

5.5.1 Size (Texture)

Grain size is a fundamental attribute of sedimentary deposits and as such, is one of the most important descriptive properties (Boggs 2006). The size of particles in sediments is controlled by several processes including weathering, erosion and transportation. Grains can vary widely in size, and it is now general practise to use a logarithmic or geometric scale such as the Udden-Wentworth scale for analysing grain size. Grain texture is a measure of the relative proportions of different sizes of sedimentary particles, particularly large (sand), medium (silt) and small (mud) particles within the sediment. The relative proportions of these grain sizes are controlled by depositional environment, such as current strength. Thus, grain texture can inform on changes in depositional environment within the sedimentary sequence. Grain texture was analysed in the laboratory.

Grain texture analysis was conducted on a total of seven sedimentary samples. The sedimentary samples and their origins are outlined in Table 5.1; they include MPPM and LQSM samples from Profiles

One and Two and samples from three sedimentary units observed in Profile Four (see Chapter Six for details). Sedimentary samples of 500 g each were dry sieved though ten meshes of decreasing aperture size from 2 mm to 0.38 mm (Table 5.2 shows the sieves used and their grain size fraction). Dry sieving was conducted with the aid of a mechanical shaker. The sieve stack with the sediment sample in the top sieve was placed in the mechanical shaker and agitated for 10 mm, before the separated sediments were weighed. Grain size was classified per the (Wentworth scale), as outlined by Coe (2010). The mass of sediment retained in each sieve was measured and the relative percentage of the total sample mass was calculated. This information was used to draw up a histogram displaying the relative frequencies of grain size classes in each sample and to create cumulative percentage curves. It will be noted that the sieves utilised in this investigation can only separate out grains larger than coarse silts. Typically, smaller grain material is separated by means of settling and hydrometer analysis. Smaller material was found in almost all samples to constitute less than 2% of the sample mass. For this reason, along with a lack of availability to equipment and chemicals, dry sieving was considered sufficient.

5.5.2 Colour

Colour is a common characteristic used to distinguish between rock units (Lewis & McConchie 1994). In general, sediment colours reflect the abundance of organic matter and/or the state of oxidation of iron and its compounds (Lewis & McConchie 1994). Sediment colour can give an indication (if corroborated with other characteristics) of the depositional environment or conditions. Colour is usually recorded with reference to a standardised colour system (in this case a Munsell Chart) which expresses the hue, value and chroma of a colour. Hue reflects a base colour like red, yellow, green or blue and is given by a number and a letter. The value reflects the lightness or darkness of that colour while the chroma reflects the strength or saturation of the colour (Lewis & McConchie 1994). So, a colour value like 10YR 5/6 means a hue of 10 yellow-red, a value of 5, and a chroma of 6. Colour was assessed following the methodology of Compton (1962) using a Munsell colour chart (1994). Colour of sediments in the test pits was analysed *in-situ* on the section wall in both the MPPM and LQSM.

5.5.3 Sorting of Sediments

The degree of sorting (of different particle sizes) in a sediment can give an indication as to the degree to which a sediment has been winnowed or reworked by transporting agents (Compton 1962). Sorting gives a valuable indication of the rate and environment of deposition. The degree of sedimentary sorting was analysed by taking a small sample of sediment (approximately 5g) in a petri-dish and examination with a hand-lens (X20 magnification), with reference to a field chart of sorting categories. Degree of sorting was classified per the standard system as presented by Coe (2010).

5.5.4 Grain Morphology (Angularity)

Grain morphology is measured by the angularity of grains and the sphericity. Grain morphology gives an indication of intensity of abrasion of the grains or distance travelled. It is a useful character when investigating fluvial systems. Sphericity is literally an indication of how rounded the grains are and high sphericity can indicate a high degree of abrasion or transport within the system. Grain angularity can be described as a measure of the roughness of the grain surface. A grain with a coarse surface with many sharp points or edges has high angularity; while a grain with a smooth surface displays low angularlity and has undergone more transport or abrasion. Grains of different sizes were analysed under magnification and angularity and sphericity were classified per the methodology outlined by Coe (2010).

5.5.5 Sedimentary Bedding

The presence of any sedimentary structures or bedding (for example lamination or cross-stratification) were noted, described and sketched in the test pit profiles. Note that many types of structures may not be observable at such a small scale ($1m^2$). Types of structures and methods of recording follow standard methodology as presented by Coe (2010). Sedimentary bedding was described in terms of the bed character, bed thickness, and character of bed boundaries. The placement of beds within the sedimentary profile (in each test pit) and the association of sedimentary beds between test pits was plotted in order to test for similarities or differences between the test pits. All of this was compared to the stratigraphic column produced by Roberts *et al*. (2011).

5.6. TAPHONOMY

5.6.1 Taxonomic composition

All identifiable bone remains were entered as an individual record into a customised Microsoft Access database. The specimen number, profile and spit were recorded for each specimen as well as the x, y and z co-ordinates (where appropriate). Unidentifiable bones were bagged and counted. All specimens were identified to Linnaean class (Mammalia, Aves, Reptilia, Amphibia, Pisces), Family (Carnivora, Bovidae, Equidae etc), and where possible to genus and species. Material was identified with reference to the modern comparative collection from the University of Cape Town (UCT) Archaeology Department. Material that could be attributed to class but not family was coded as indeterminate (ex mammal indeterminate or tortoise indeterminate). It can be argued that there is little taphonomic value to material that is not identifiable below class; however, given the large relative proportions of chelonian and mammalian remains and questions regarding chelonian preservation, I believe it was worthwhile to investigate all remains identifiable at class level.

All remains were assigned to body size classes following the methodologies of Brain (1974), Driver (2005) and Val (2014). Table 5.3 displays the size classes, estimated body mass and example species for all taxonomic groups. Note that size classes in aves and chelonian are not directly comparable to those of mammals or bovids. For example, size class four in mammals represents large bodied taxa over 1000 Kg, while in aves size class four represents birds larger than guinea fowl but smaller than herons. Body size class in this analysis is not a mathematical concept, but is merely used to assess whether relatively smaller or larger sized members of a family or taxonomic class were more affected by destructive forces. No size class cut-off was utilised in mammals, birds or reptiles. Size class 0 remains or microfauna were bagged and counted and set aside for later analysis. Researchers have found that taxa of differing body size will display differential preservation (Cruz 2008). This is an important characteristic of fossil assemblages and an improved understanding of the manner and causes of differential taphonomic modification on bone remains from different sized taxa will greatly improve our understanding of past community structure (Behrensmeyer & Dechant-Boaz 1980).

Chelonia are, by definition, members of the reptilian group. However, tortoises display a vastly modified body plan and differ widely in their ecology from other reptiles. Additionally, Chelonian remains are excessively common at Langebaanweg, while all other reptiles are rare and their bones extremely small. Thus, Chelonia will be analysed as a separate taxonomic category from reptiles. Extant chelonia material

utilised for comparison in this study included, but was not limited to: various padlopers (*Homopus* spp.); the geometric tortoise (*Psammobates geometricus*; adult and subadult); numerous angulate tortoises (*Chersina angulata*; adult and subadult) and the leopard tortoise (*Geochelone pardalis*; adult and subadult). I created four arbitrary size classes for tortoise remains based on modern species. Size class one consisted of small specimens up to or similar in size to the Karoo padloper (*Homopus boulengeri*), which can reach a maximum mass of approximately 110 g. Size class two is represented by small angulate tortoise which can reach as maximum mass of just over 2 Kg. Size class three contained specimens larger than the 2 Kg angulate tortoise but smaller than the reference material of the leopard tortoise housed in the collection. Size class four contained extremely large material consistent with the leopard tortoise. Angulate tortoises cover a wide size range, depending on maturity of individual and under this system could be classified (depending on age) as either size class two or size class three. To the best of my knowledge the only way to age chelonian remains is to measure the size of appendicular remains, which is hardly a useful criterion if the species and adult size of an individual is unknown. Parsimony would suggest these two size classes are combined. However, as the taxonomic composition of the Langebaanweg chelonian is poorly understood, I have decided to err on the side of caution and keep these size classes separate.

Estimates of body size in chelonia were judged by eye, usually on general size or thickness of shell and are wholly subjective. Tortoise shell remains were extraordinarily abundant but highly fragmented. All material (irrespective of size) that was identifiable to shell element (ex. marginal or epiplastron) was entered into the database. Initially a size cut-off of 20 mm was applied to all tortoise remains. However, it soon became clear that this cut-off was removing all size one tortoise shell and much of the size class two sample. Thus, it was decided to suspend the cut-off for size class one and two tortoise shell. The size cut-off was continued in the larger tortoises (size class three and four). Applying an un-even and arbitrary cut-off could strongly influence taxonomic composition in the analysis. It is our contention and will be shown in the results however that the high level of fragmentation resulted in few identifiable remains and thus this cut-off did not affect estimates of the MAU or MNI. But it is a consideration to be born in mind when comparing NISP values of small and large tortoises.

5.6.2 Anatomical composition

For identifiable remains, the element, skeletal portion, side, state of epiphyseal fusion, types of surface modification, fracture patterns and length were recorded. Skeletal element and element portion were coded following the methodology outlined by Driver (2005) for mammals, birds and reptiles. Chelonia shell remains were coded as carapace, plastron or carapace/plastron where it was not possible to differentiate. Terminology in the chelonia shell, appendicular and axial skeleton followed the methods of Grieg (1979), Sampson (1998) and Thompson & Henshilwood (2014) and is shown in Figure 5.4. Epiphyseal fusion was utilised as an indicator of age (in mammals) and was coded as fused, just fused, unfused, foetal, neonatal or indeterminate (Driver 2005). Epiphyseal fusion was recorded for the proximal/anterior end and for the distal/posterior end. Side was coded as left, right, indeterminate or not applicable. Fracture patterns follow Driver (2005) and were coded as intact, eroded, and broken during excavation, chewed by carnivores, gnawed by rodents, splintered, spiral fracture, transverse fracture and irregular fracture. But see also Villa & Mahieu (1991) for definitions and examples of these modifications. Length of identified specimens was coded as 1 (0 – 0.9 cm), 2 (1 – 1.9 cm), 3 (2 – 2.9 cm etc) as no further detail was required. Surface modifications were observed using a microscope (up to 40X magnification) and were based on standard criteria as outlined below. Surface modifications investigated in this analysis included weathering, burning, carnivore modifications, rodent gnawing, abrasion and polishing, pathology, staining and root etching.

5.6.3 Calculating skeletal abundance

Skeletal part frequencies are essential in analysing key characteristics of an assemblage's taphonomic history. In order to estimate these frequencies, the taxonomic and skeletal element identification must be determined. Fundamental quantitative measures employed in analysing skeletal part frequencies include the number of identifiable specimens (NISP); minimum number of elements (MNE); minimum animal unit (MAU); and %MAU.

NISP

The NISP is the number of *identified* specimens (Grayson 1989; Klein & Cruz-Uribe 1984); separate from the total number of specimens, which includes all identifiable and unidentifiable bones. This count

refers to those specimens within a whole assemblage that are identifiable at least to skeletal part; each identifiable specimen holds a single count in the NISP.

MNI

Minimum number of individuals or MNI is defined by Shotwell (1958) as the "smallest number of individuals which is necessary to account for all of the skeletal elements or specimens of a particular species observed in an assemblage". Calculation of MNI is based on symmetry (White 1953), on separating components into left and right and using the greater number as the unit of calculation. This does not give the actual number of individuals that contributed to the assemblage but provides an indication of the smallest number necessary to account for the remains under analysis. In practise, actually pairing elements can be very difficult and most often specimens are paired on the basis of symmetry rather than biological matching. Although factors such as age, sex and body size can be used to improve estimates (Bökönyi 1970, Chaplin 1971). Sample size can greatly affect MNI, which has been shown to correlate with the number of specimens and the number of taxa in a sample (Reitz & Wing 1999). In addition, the manner in which the sample is aggregated during analysis will influence the MNI (Grayson 1973, 1984). In this analysis, sediments were excavated in arbitrary levels but the MNI was calculated with reference to natural stratigraphic levels, in this case in the MPPM and the LQSM. MNI is estimated for the lowest taxonomic level and is not normally estimated for a higher taxonomic category if specimens within that category could relate to lower taxa. MNI is probably the most common estimate for skeletal frequency, many of the problems inherent in calculating the MNI can be overcome with careful excavation and evaluation of the data (Reitz & Wing 1999). Additional frequency calculations have been developed to expedite and ameliorate calculations of skeletal frequencies like the MNE, MAU and %MAU which are discussed below.

Thompson and Henshilwood (2014) advocate the use of the fraction summation method (Marean *et al.* 2001) in estimating skeletal frequencies in chelonia, due to the efficiency and accuracy of the method. In this analysis shell remains were often so fragmentary that no estimate of the fraction preserved could be made, thus fraction summation proved of little value in shell elements. Thompson and Henshilwood, in their analysis, found tortoise elements "fragmented in consistent portions and at consistent landmarks compared to mammals", making identifications simple. Many remains in their analysis were recovered complete or near complete and only two species of vastly different sizes were identified in

their sample. At Langebaanweg, little of the tortoise material was complete or near complete and the overlap of different species and higher species richness exasperated difficulties in identifications so that the number of remains that could not be assigned to true element was much higher.

MNE

The minimum number of elements or MNE is defined by Binford (1984:50) as "the minimum number of elements or minimum number of different specimens referable to a given anatomical part used in classification". He derived the MNE by determining how many elements are represented by the fragmentary remains, based on the presence of overlapping landmark features (Bunn 1982, 1986; Bunn & Kroll 1986). There are however numerous permutations. Lyman (1994b:290) recommends basing MNE on the number of whole elements that can be reconstructed from the identified specimens. He defines the MNE as the" minimum number of complete skeletal elements necessary to account for all observed specimens". In other words, what is the smallest number of a given element required to account for all fragments of that element in the sample. In considering the MNE for chelonia appendicular and axial bones we considered the element and element portion, the body size class, stratigraphic level (MPPM vs. LQSM) and the fraction (fraction-summation) of that element represented.

MAU

MAU or Minimum Animal Unit is a normed version of the MNE, which is derived by dividing the MNE by the representative number of times a skeletal category appears in a complete skeleton (Lyman 1994; Binford 1984).

%MAU

In this skeletal frequency estimate, the MAU is calculated slightly differently; the number of specimens (NISP) for each element is divided by the number of that element present in a complete skeleton, instead of calculating the MNE first (Binford 1978; 1984; Thomas & Mayer 1983). Once the MAU has been derived, the largest MAU value is used as a standard and all the other MAUs in the assemblage are divided by the standard and multiplied by 100 to establish a normed scale (% MAU).

5.6.4 Surface Modifications

Weathering

Weathering is the process by which organic and inorganic components of bone are removed or destroyed by physical and/or chemical agents operating on the bone (Behrensmeyer 1978). Behrensmeyer (1978) found that the organic breakdown of bone could be separated into six definable stages (0 – 5) that were associated with the length of time a bone was exposed on or near the surface (Figure 5.5). Her method is still the primary means by which archaeozoologists measure weathering on fossil bone. In general, Behrensmeyer (1978) found that bones displaying stage 0 could be considered fresh, and thus exposed for less than one year. Bones displaying stages 1-2 could be considered slightly weathered, and had probably been exposed for 3-5 years. Bones with stages 3-5 weathering were considered well weathered and had been exposed anywhere from 5-15 years. The degree of weathering can vary across a bone depending on exposure conditions and Behrensmeyer advocated using the most advanced weathering stage, which covered patches larger than 1 cm^2 to combat this. In the current investigation, weathering was coded as stage 0 – stage 5 following Behrensmeyer's methodology.

Fragmentation

Bone breakage was coded following the methodology of Driver (2005) and included the following categories: intact, eroded, broken during excavation, chewed by carnivores, splintered, gnawed by rodents, spiral fracture, transverse fracture and irregular fracture. Eroded breaks are where the end of the bone has been worn smooth or rounded by natural processes like sand or water abrasion. Eroded breaks will often show exposure of cancellous bone on a smooth surface. Bones broken during excavation can be recognised by the distinct colour difference between the broken surface (which is usually lighter) and the remainder of the bone. Bone ends that had been chewed by carnivores should also display scoring, furrowing, punctures, and scooping out or crenulated edges (Haynes, 1980, 1983). Note that other carnivore modifications (that do not affect the bone ends) were coded separately. Splintered bone ends exhibit a series of transverse fractures that terminate at different points. Splintered bone is a result of weathering, and is usually associated with weathering cracks (although weathering on the bone surface is also recorded separately). Irregular fractures are where the fracture is neither perpendicular nor parallel with the long axis of the bone, and displays a "zig-zag" appearance. Spiral fractures follow the outline of Villa & Mahieu (1991) in showing a curved break with fairly smooth

surfaces (Figure 5.6). They are considered indicative of bones broken while fresh or green. Transverse fractures display a simple snap break at right angles to the long axis of the bone, these are typical of bones which have been weathered or broken when dry and are often seen on burnt bone. In addition to the bone breakage classes already described, the fracture angle of breaks (on long bones) were analysed following Villa & Mahieu (1991). Fracture angle could be obtuse, acute (green bones) or right angle (dry bones) to the long axis of the bone. Fracture angle could also be classified as mixed. The breakage and fracture angle of both the proximal/dorsal/anterior end, as well as the distal/ventral/posterior end of each bone was analysed. For teeth, the occlusal and root ends were analysed, where possible.

Abrasion and Polishing or Sheen

Abrasion can be described as the removal of external laminar bone to create smoothing or rounding (Behrensmeyer 1982; Fisher 1995). Abrasion can be caused by processes operating before, during or after burial; such processes can include trampling, erosion by wind blow sediments, and fluvial action (Fisher 1995; Shipman 1981). Abrasion (from wind or water-borne particles can also result in smoothing of edges (Shipman 1981). The principal characteristic of abrasion is considered to be rounding, which Fernández-Jalzo and Andrews (2016) categorise as slight, moderate, great or extreme. Examples of experimentally abraded bones are shown in Figure 5.7 and Figure 5.8. Extremely rounded or abraded bones develop a pebble-like character. Rounding in bones is typically a factor of long-term movement of the bone with sediment and water, and it takes a considerable amount of energy to produce significant rounding on bones, particularly when fresh (Fernández-Jalzo and Andrews 2016). The degree of rounding does not neccesarily reflect distance travelled, for example, bones on a beach setting can show strong modification, without leaving the immediate area where they are interred. Sedimentary settings are thus essential considerations before making inferences. Fernández-Jalzo and Andrews (2016), additionally describe and figure scratches, grooves and notches on bone surfaces caused by abrasion. Surface scratches and marks are good indicators for abrasion but cannot be utilised to distinguish sediment type or distance travelled. Other surface modifications like gastric etching from ingestion by a carnivore can mimic some characters of abrasion, such as rounding. In all cases a suite of surface modifications and characteristics were utilised to identify and distinguish between different agents of modification. Characteristics like trampling and carnivore modifications (see below) were analysed separately in this investigation, and these characters were used in conjunction with abrasion to infer depositional environment or cause of death. Abrasion was analysed following the methods of Spencer

and colleagues (2003), into four classes based on the relative percentage of modification (Table 5.4). These modification categories were defined relative to each other and must be considered as relative terms (Reynard 2014).

Polishing or sheen can be considered a special case of abrasion (LeMoin 1994). Polishing is created by abrasion at a very small level, with removal of tiny particles of material from the surface, which causes a surface that is smooth and reflective (Figure 5.9) at a molecular scale (LeMoin 1994). Fernández-Jalzo and Andrews (2016) found polishing in bones abraded with sediment in water or from wind erosion. They observaed the most extreme polishing from wind abrasion, usually covering the whole bone surface. Fernández-Jalzo and Andrews (2016) found that polishing and brightness increased with sedimentary grain size, in that gravels produced a greater degree of brightness than silts. They also found fossils or weathered bones were more greatly affected. In this investigation, I prefer to use the term sheen, as polishing suggests abrasion when there are other surface modifications that can result in sheen (Reynard 2014). Sheen is coded on the same classification system as abrasion.

Trampling

A broad body of archaeological research has investigated the effects of trampling on bone and has found that it is a significant source of carnivore and anthropogenic-like markings (Olson & Shipman 1988; Nielsen 1991; Nicholson 1992; Dominguez-Rodrigo *et al.* 2009 and Reynard 2014). Trampling can be defined as the pressure exerted by the transit of biological agents on the sediment and associated fossil remains (Blasco *et al.* 2008). In addition to the surface striations (Figure 5.10) described by other researchers, Blasco and colleagues found that bones that were experimentally trampled also displayed notching on oblique fracture edges. They found that dry bones were more affected by trampling, as were bones on or close to the surface. Similarly, Myers *et al*. (1980) found that slightly weathered bones (stage 1 – stage 2) broke more easily than fresh bones but still exhibited spiral breaks. We have followed the methodologies of Reynard (2014) in characterising the following modifications as evidence of trampling namely; scratches, lines, grooves, pits, elongated pits and sheen. Scratches are inconspicuous (only visible under X40 magnification), shallow, fine striations. Trampling marks were classified into three categories based on the relative amount of modifications (Table 5.5) following the methodology of Reynard (2014).

Burning

Burning has long been recognised as an important taphonomic agent, and a great number of archaeological and experimental investigations (Shipman *et al.* 1984; Nicholson 1993; Stiner *et al.* 1995; Shahack-Gross 1997; Asmussen 2009; Bentsen 2012, 2013) have been undertaken on this subject. Early analyses noted that bone changed colour depending on the temperature of the fire (Brain, 1993). Heated bones, it was noted, appear to pass through a continuum of appearance from unburnt to non-incinerated or smoked bone (blackening on edges) to incompletely incinerated (dark brown or black) to completely incinerated or calcined (bluish-white or grey) (Shipman *et al.* 1984) (Figure 5.11). Colour changes largely reflect sequential decomposition of organic and inorganic components with increasing heat (Asmussen 2009). However, colour has been shown to be extremely variable and is now considered insufficient to identify the temperature of burning (Shipman *et al.* 1984; Nicholson 1993). In addition, post-depositional staining (particularly manganese or iron-oxide staining) can mask or confuse burning (Shahack-Gross *et al.* 1997). Therefore, this must always be considered when analysing assemblages where staining is common. Researchers have utilised chemical or even X-ray diffraction methods to separate stained and burnt bones in fossils assemblages (Clark & Ligouis 2010); however, such methods can be time consuming, expensive and/or invasive. Asmussen (2009) advocates the use of additional external characters like surface fracturing to identify burnt and stained bones. Clark & Ligouis (2010) found when investigating bones from Sibudu Cave that visual characterisation of burnt or stained bones was often correct.

In this analysis, I identified burning on the basis of colour, along with the presence of surface fracturing (Asmussen 2009) and other burning characters. I coded burning following the methodology of Stiner *et al.* (1995) using a seven stage system based on colour changes outlined in Table 5.6. The location of burning was recorded (relative to the element part) to see if there were any patterns that could indicate when burning occurred relative to time of death. For example, burning located on the inside of tortoise shells would indicate that fire occurred after death.

Staining

Dark coloured mineral staining from Manganese-oxide or iron-oxides are common in many fossils assemblages (Adams *et al.* 2007; Berger *et al.*2003). Staining has been observed in many fossils from Langebaanweg (Olson 1985a, b; Brumfitt *et al.* 2013). Brumfitt *et al.* (2013) identified minor amounts of

black manganese-oxide staining in sediments, and on bones and teeth in the Langebaanweg bonebed. According to Brumfitt *et al.* (2013), the manganese was likely leached from the surrounding sediments by reducing ground waters permeating the sediments. These ground waters later became oxidising, resulting in precipitation of manganese as well as other apatite minerals. Alternatively, studies have shown that manganese-oxides can be formed by manganese-oxidising bacteria (Dorn & Oberlander, 1981; Shahack-Gross *et al.* 1997). Such bacteria prefer moist environments with near neutral pH and clay minerals on which they can absorb; under these conditions, the bones themselves can even provide a source of nutrients (Shahack-Gross *et al.* 1997). Whether such bacteria were active at Langebaanweg is a question that has yet to be addressed, and therefore, is not within the scope of this work. Organic acids in soils can cause brown staining on bones, while a reddish colour can be the result of oxygenated soils rich in iron (Fernández-Jalzo and Andrews 2016). In this analysis, caution will be used in characterising both stained and burnt bones and only bones that can be confidently coded (as burnt or stained) will be analysed. Figure 5.12 displays examples of stainined bones recovered in this investigation. Staining was coded, following Spencer and colleagues (2003), on the same classification system as abrasion (Table 5.4). A separate column was also used for any further comments regarding the colour or condition of staining.

Insect Damage

A diversity of different types of insects have been shown to modify bones, including dermestid beetles, tenebrionid beetles, clerid beetles and termites (Xing *et al.* 2013 and references therein). Insect damage has been observed on bones dating from the Cretaceous (Pirrone *et al.* 2014) and has been recorded on fossils from the African Plio-Pleistocene (Newman 1993; Kaiser 2000; Val *et al.* 2015) and Late to Middle Stone Age (Backwell*et al.* 2012). Pirrone, Buatois and Bromley (2014) describe a number of characteristic insect modifications including grooves, striae, pits, bores, and channels (among others). Backwell and colleagues (2012) identified eight macroscopic and microscopic modifications produced by termites (*Trinervitermes trinervoides*) (Figure2.13). These features were the result of gnawing on edges, elevated areas, or around vascular canals by the termites. Of these features the most distinctive were concluded to be multiple-parallel striations usually found on edges of openings or ridges, clusters of sub-parallel striations and star-shaped marks, with the latter proving the most diagnostic. I followed the methodology of Kaiser (2000), and Backwell and colleagues (2012), in identifying multiple-parallel striations (edge gnawing), clusters of sub-parallel striations and star-shaped marks as insect

modifications. Additional modifications attributed to insects in the literature, like surface erosion (Backwell*et al.* 2012), could easily in my opinion be confused with surface erosion caused by other taphonomic agents, like acid etching (from carnivore digestion), and careful analysis was required before these marks were attributed to insects. Star-shaped pit marks, consist of a smooth central cavity, which displays no or very faint grooving, associated with radially arranged individual U-shaped grooves or striations that have a smooth internal morphology (Backwell *et al.* 2012). These pits can reach diameters of up to 8mm, and depths of up to 3 mm are not unheard of (Kaiser 2000). Edge gnawing consists of multiple parallel striations located along and perpendicular to broken edges or ends; the striations have a u-shaped profile and smooth internal morphology (Backwell *et al.* 2012). Clusters of randomly orientated sub-parallel striations with a u-shaped profile and smooth internal morphology can also be considered diagnostic of insect modifications. These striations, unlike the edge gnawing, are mainly located on the periosteum or body of bones and away from the edges (Backwell *et al.* 2012). Insect striations are microscopically visible (Backwell *et al.* 2012). The abundance of insect marks is coded between 0 and 3, following the methodology of Reynard (2014) for trampling marks (Table 5.5). The type of insect modification will be indicated in the comments section where appropriate.

Root Etching and other Post Depositional forms of destruction

Dendriti root etching is defined as a series of branching channels that have grooved the surface of the bone (Thompson 2005; Binford 1981). These linear marks are U-shaped and smoothly concave (Fernández-Jalzo and Andrews 2016). These etched lines are caused by acids associated with plant roots that have grown against the bone (Fisher 1995). The channels may be deep or shallow and can be either widely spaced or closely packed (Figure 5.14). Thompson (2005) goes on to describe pocking, exfoliation, smoothing, and sheen as post-depositional forms of destruction. However, all other types of modifications have been caused by other taphonomic processes, in addition, there is little information as to what might cause these modifications after deposition. For these reasons, these characters are not considered post depositional in this analysis. The abundance of root marks is coded between 0 and 3, following the methodology of Reynard (2014) for trampling marks (Table 5.5).

The formation of cracks and superficial flaking is very common in fossil bone assemblages (Fernández-Jalzo and Andrews 2016). Various agents or processes can cause flaking and cracking including weathering, heating (fire or boiling), digestion, root marks, alkaline sediments, and sedimentary

pressure (Figure 5.15). The controls and affects of these modifications on bone cracking and flaking are poorly understood, but can usually be recognised together with a suite of other damages associated with those modification agents (Fernández-Jalzo and Andrews 2016). Damp or wet sedimentary conditions frequently cause cracking and flaking of bones (Fernández-Jalzo and Andrews 2016). Humidity causes characteristic cracks with sides (of the crack) that appear warped, elevated and contorted. This type of modification has been described from the Langebaanweg bonebed previously (Fernández-Jalzo and Andrews 2016).

I follow Fernández-Jalzo and Andrews (2016) in defining surface corrosion as a modification arising out of chemical attack from either biological or geochemical action. Corrosion occurs in moist chemically reactive conditions with little exposure to air and is considered here separately from digestive corrosion. This can occur in buried bones or bones immersed in still or stagnant water. Corrosion commonly affects all exposed surfaces and all parts are equally affected. This is one of the main ways in which corrosion from burial or water immersion can be distinguished from digestive corrosion. Corrosion can appear locally concentrated under certain conditions, like with intense root etching, but will usually be associated with other modifications. Corrosion from immersion, can result in patches of the bone surface becoming lost and developing a mottled appearance. However, flaking and cracking are not observed. There is no systematic classification system for characterising the degree of corrosion.

Breakage and fragmentation patterns have already been discussed but a number of patterns are considered indicative of post-depositional breakage, usually from sediment compaction. Transverse breaks usually occur in mineralised bones and are considered indicative of post-depositional modification (Fernández-Jalzo and Andrews 2016). Post-depositional sediment compaction will additionally, distorted bones and a can cause a low frequency of splitting. The post-depositional modifications outlined above were classified according to the system outlined by Spencer *et al.* 2003, relative to the percentage of the surface damaged (Table 5.4). The type of post-depositional modification was noted in the comments section.

Carnivore Modifications

Carnivore Tooth marks

Early taphonomic researchers were quick to recognise the potential of carnivores as modifiers of bones and to begin to document the bone modification attributes of these carnivores (Binford 1981; Brain 1981; Haynes 1980, 1982, 1983). These early analyses have blossomed into a broad array of taphonomic research centred on carnivore modifications (Sutcliffe 1970; Skinner *et al.* 1980; Pickering & Carlson 2004). Large carnivores, like hyenas, are considered potential competitors for early hominids and much research has gone into characterising hominid and/or carnivore activity on bones in order to investigate the role of hominids, be they scavengers or carnivores, in palaeoecosystems (Blumenschine 1988, 1995; Cavallo and Blumenschine 1989; Marean *et al.* 1992; Domínguez-Rodrigo 1999; Pickering 2002; Faith *et al.* 2007; Domínguez-Rodrigo *et al.* 2009). Leopard and hyenas have been shown to contribute bones from large mammals, like bovids, to fossil assemblages, especially in cave settings (Klein *et al.* 1999; Pickering *et al*. 2004; Pokines & Peterhans 2007; de Ruiter *et al.* 2008; Kuhn *et al.* 2010). These analyses spurred further investigations into how small mammal bones came to be accumulated. Raptors, particularly owls, were found to be important accumulators of microfauna (Mayhew 1977; Dodson & Wexlar 1979; Korth 1979; Hoffman 1988; Kusmer 1990) and occasionally larger prey like hyrax or hare (Hockett 1991, 1994, 1996; Berger & Clarke 1995; Crux-Uribe & Klein 1998; Lloveras *et al.* 2009). The potential of small carnivores like canids, small felids and viverrids or mustelids to act as accumulating agents has likewise received much work (Andrews & Evans 1983; Andrews 1990; Schmit & Juell 1994; Fernández-Jalvo 1995; Matthews 2002; Lloveras *et al.* 2012; Cohen & Kibii 2015).

Tooth mark types observed in this analysis include pits, punctures, furrows, scores and crenulated edges (Figure 5.16). Pits are small shallow depressions, which often show internal crushing (Horwitz & Smith 1988; Domínguez-Rodrigo, 1999). Punctures, unlike pits, penetrate partially or completely through the cortex (Fisher 1995). Both pits and punctures are caused by the high cusps of carnivore dentition (Maguire *et al.* 1980), and pits often occur in multiple sets (Domínguez-Rodrigo 1999). Superficial, longitudinal scratches on the bone surface, which displayed a U-shaped cross section, were identified as scores (Blumenschine *et al.* 1996; Horwitz & Smith 1988). Furrowing consisted of deep, wide trough-like indentations (Horwitz & Smith 1988). Crenulated edges are caused by gnawing by carnivores on the edges of a bone, and correspond to Maguire and colleague's (1980) ragged-edged chewing (Binford, 1981). Crenulated edges were observed on long bones and more delicate bones like scapula and innominate. The abundance of tooth marks was coded between 0 and 3, following the methodology of

Reynard (2014) for trampling marks (Table 5.5). Only marks that could be confidently attributed to tooth marks were recorded (Blumenschine *et al.* 1996). The type of tooth marks as outlined above was noted under comments in order to investigate if any particular tooth mark type was more prevalent than another.

Digestive erosion

It has long been recognised that carnivores like hyenas ingest bones which are later regurgitated or eliminated within scats (Sutcliffe 1970). Ingested bones display acid etching which may include characters like scalloping of the surface, very sharp edges between eroded surfaces and circular holes (Sutcliffe 1970). Andrews (1990) and Fernández-Jalvo and Andrews (1992) studied ingested microfaunal remains from a wide variety of predators including raptors, owls and small carnivores. They characterised digestion modification on bones and teeth into five categories including null, light, moderate, heavy and extreme. These categories were expanded by Lloveras and colleagues (2008) for application to rabbit bones from carnivore and raptor accumulations. Six degrees of digestion were distinguished by these authors and are outlined in Table 5.6. Digestion was evaluated separately for bones and dental remains.

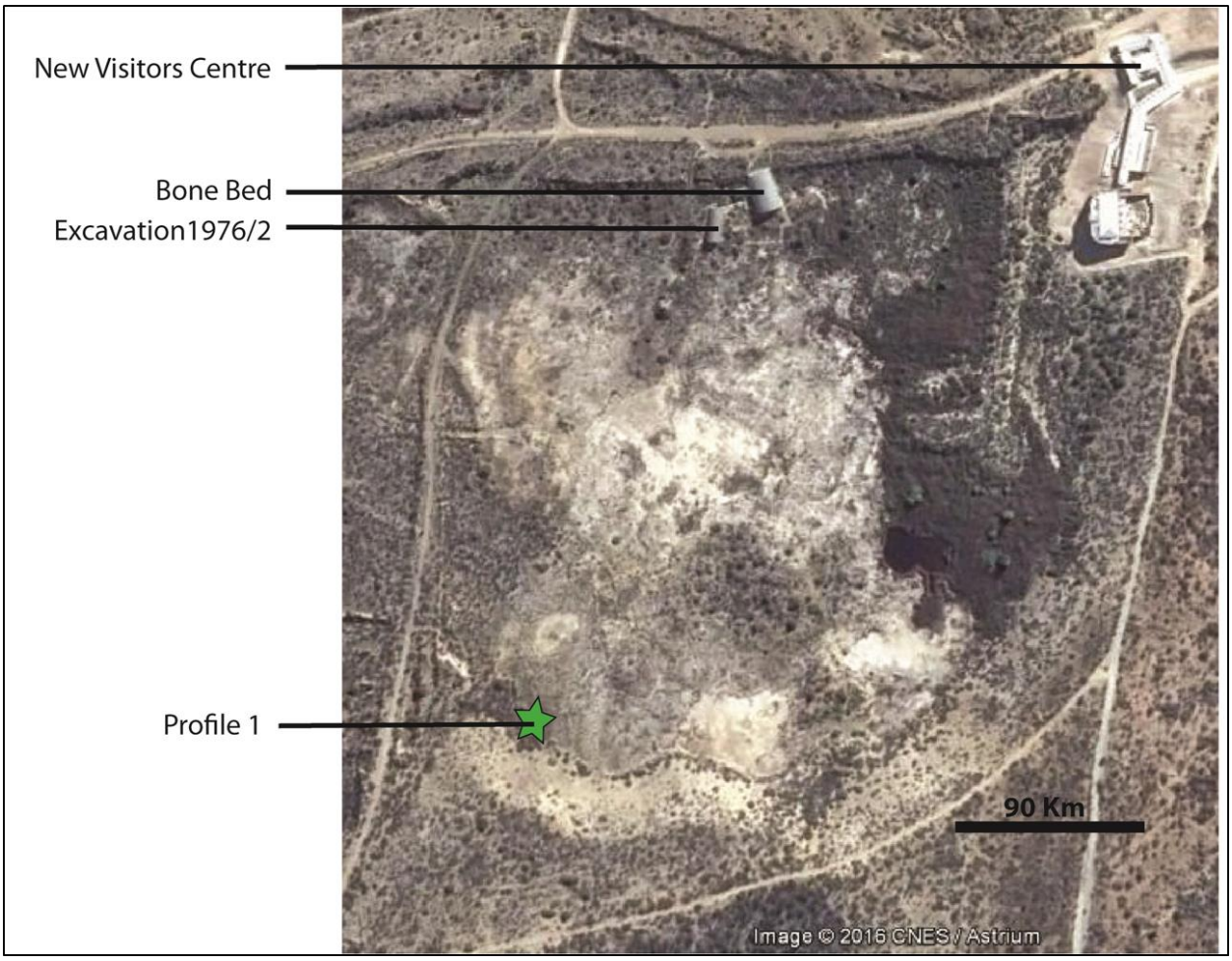


Figure 5.1. Satelite photo showing location of Profile One, Profile Two (Excavation 1976/2) and Profile Four (Bonebed).

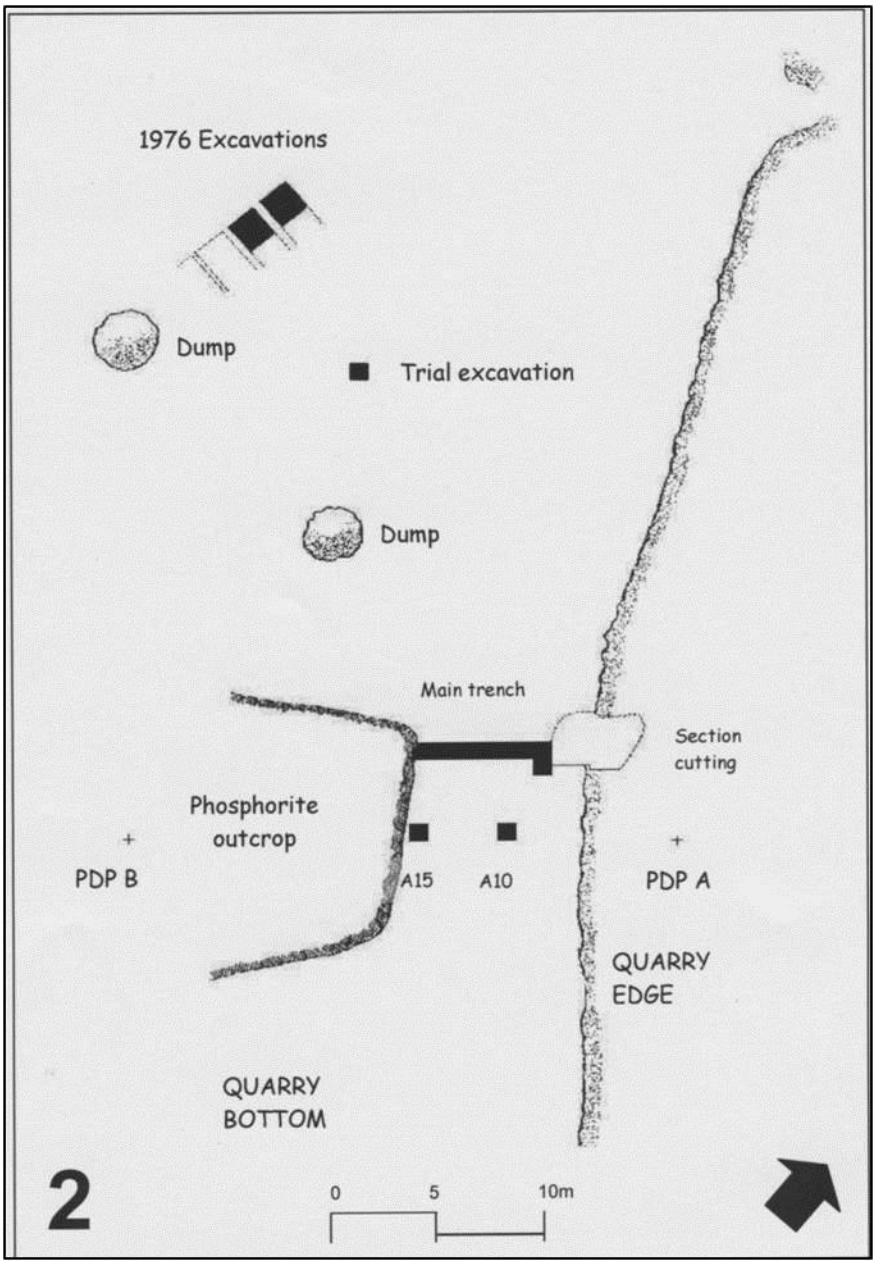


Figure 5.2. Excavations and quarry plan, Langebaanweg E-Quarry, 1999. Adapted from Archaeology Contract Office (ACO) report (1999). Note location of section cutting on right side of sketch. This is where Profile 4 was located

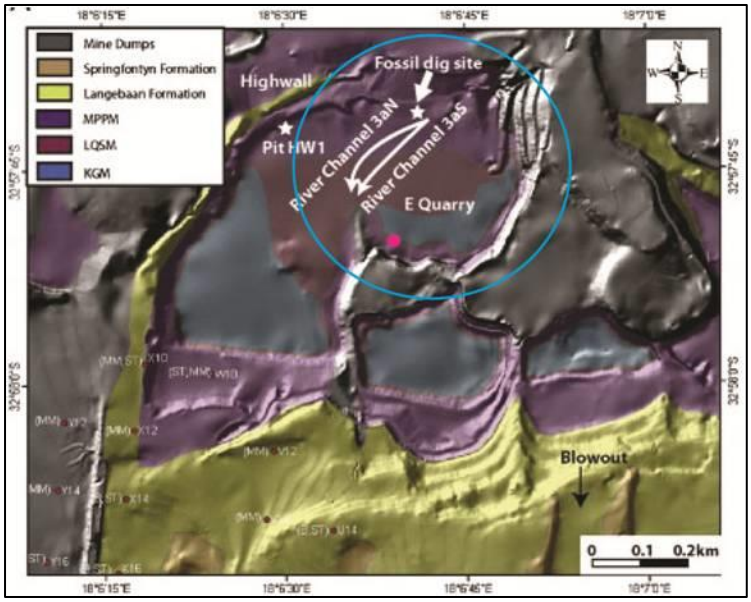


Figure 5.3. Geological map of Langebaanweg E-Quarry, showing present topography, old excavation sites and the inferred course of the palaeo-river. Note the present exposure of the MPPM and LQSM members. Area of interest in this analysis is circled in blue. Location of Profile 1 (in MPPM sediments is shown with a pink circle. Adapted from Roberts *et al.* (2011).

Table 5.1. Origins and descriptions of sedimentary samples

Test Pit	Lithological Member	Description
Profile Four	MPPM	Undifferentiated MPPM
Profile Four	MPPM	Disturbed unit
Profile Four	MPPM	Bonebed
Profile Two	MPPM	Profile 2 MPPM
Profile Two	LQSM	Profile 2 LQSM
Profile One	MPPM	Profile 1 MPPM
Profile One	LQSM	Profile 1 LQSM

Table 5.2. Sieve aperture size and wentworth grain size scale

Sieve Aperture Size (mm)	**Wentworth Size Class**
2	Coarse Fraction (>2mm) Very Coarse Sand (2mm – 1mm)
1.4	Very Coarse Sand
1	Coarse Sand (1mm – 0.5mm)
0.85	Coarse Sand
0.5	Medium Sand (0.5mm – 0.25mm)
0.25	Fine Sand (0.25mm – 0.125mm) Very Fine Sand (0.125mm – 0.63mm)
0.63	Coarse Silt (0.63mm – 0.38mm)
0.38	Coarse Silt Fines (Medium silt to clay - <0.38mm)

Table 5.3. Body size classes in mammals, chelonian and aves

	Mammals		Bovids		Birds	Chelonia
	Body mass (Kg)	**Species**	**Body mass (Kg)**	**Species**	**Species**	**Species**
Size Class 0	<1	rodents	<0 Kg	-	-	-
Size Class 1	<10	Viverrids, hyrax, hare	0-23	Duiker	< Laughing Dove	Paloper
Size Class 2	10-40	jackal, fox	23-84	Blesbok	Dove - Guineafowl	Angulate
Size Class 3	40-100	wild dog	84-296	Wildebeest / Roan	<Guineafowl	Intermediate
Size Class 4	100-500	lion, seal	>296	Eland / Buffalo	Guineafowl-Heron	Mountain tortoise
Size Class 5	>500	bear, rhino, Sivathere	-	-	>Heron	-

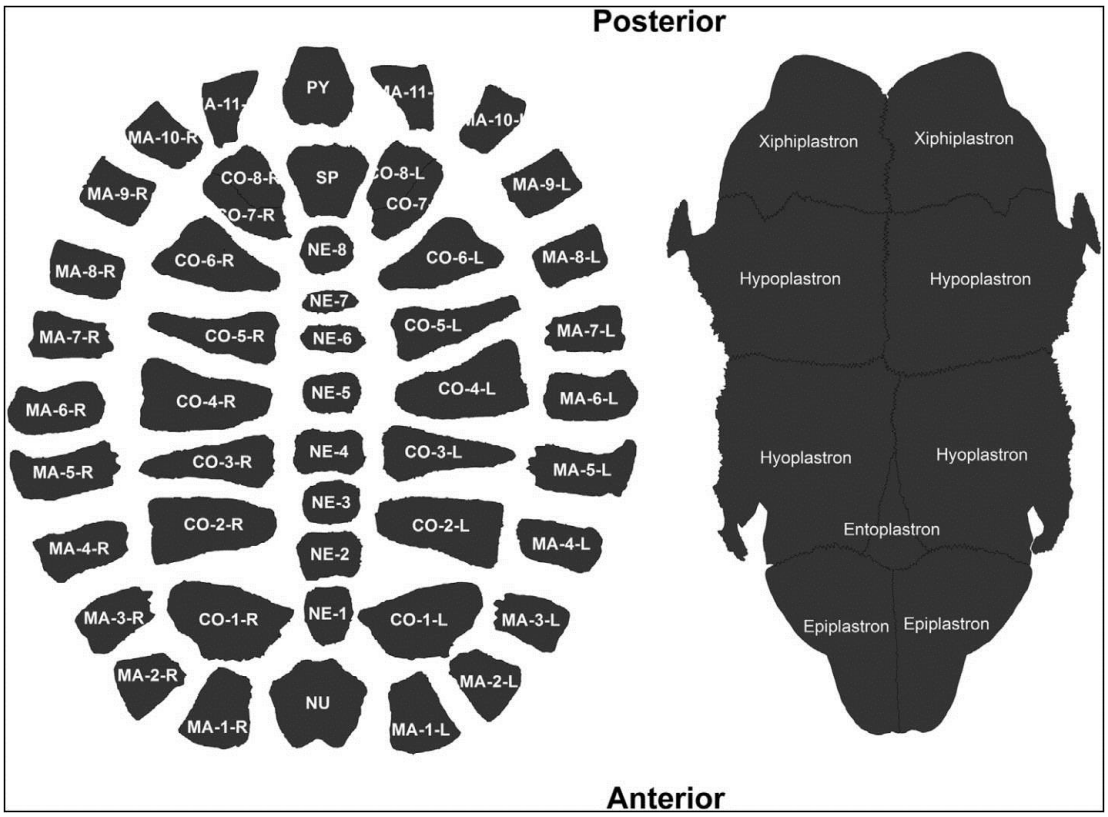
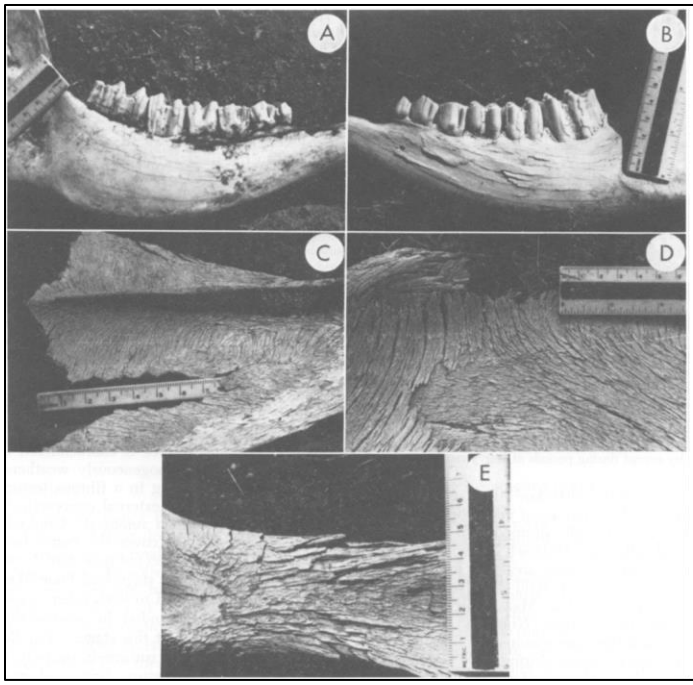


Figure 5.4. Configuration of typical tortoise carapace (left) and plastron (right) boney elements. NE, Neural; NU, nuchal; SP, suprapygal; PY, pygal; CO, costal and MA, marginal. Reprinted from Thompson & Henshilwood (2014), Journal of Archaeological Science, 41, pp. 218.



Stage 0 – not pictured. Bone surface unmodified. Bone usually still greasy, soft tissue may be found in marrow cavities or adhering to parts of surface.

Stage 1 – (A) Cracking parallel to bone fibers visible. Soft tissue may or may not be present.

Stage 2 – (B) Outermost thin layers of bone show flaking. Flaking initially superficial but become deeper and more extensive over time. Soft tissue is occasionally observed.

Stage 3 – (C) Characterised by patches with a rough, fibrous texture Weathering remains superficial at this stage and does not penetrate deeper than 1.5 mm. Bone fibers remain firmly attached to each other

Stage 4 – (D) Surface coarsely fibrous and rough with large and small splinters. Weathering penetrates into inner cavities.

Stage 5 – (E) Bone falling apart and splintered.

Figure 5.5. Weathering stages in bones. Reprinted from Behrensmeyer (1978), Paleobiology, 4(2), pp. 151-152.

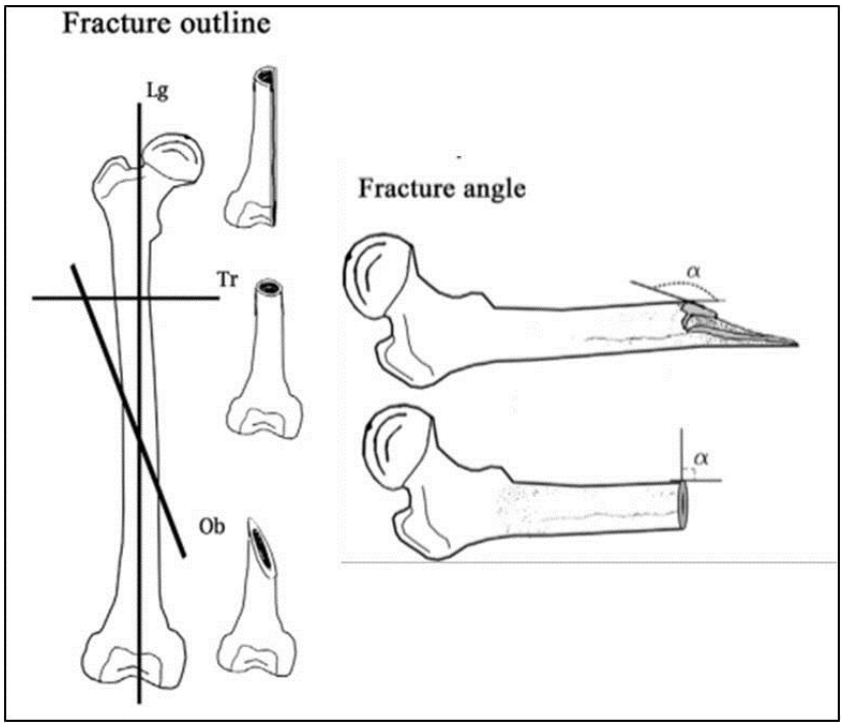


Figure 5.6. Fracture outline (left) and Fracture angle (right) in long bones. Abreviations: Lg, longitudinal; Tr, transverse; Ob, Oblique (in this analysis spiral). Obtuse or oblique fractures are shown in upper right and right angle fractures in lower right. Reprinted from Sala et al. (2015), Journal of Archaeological Science, 55, pp. 115.

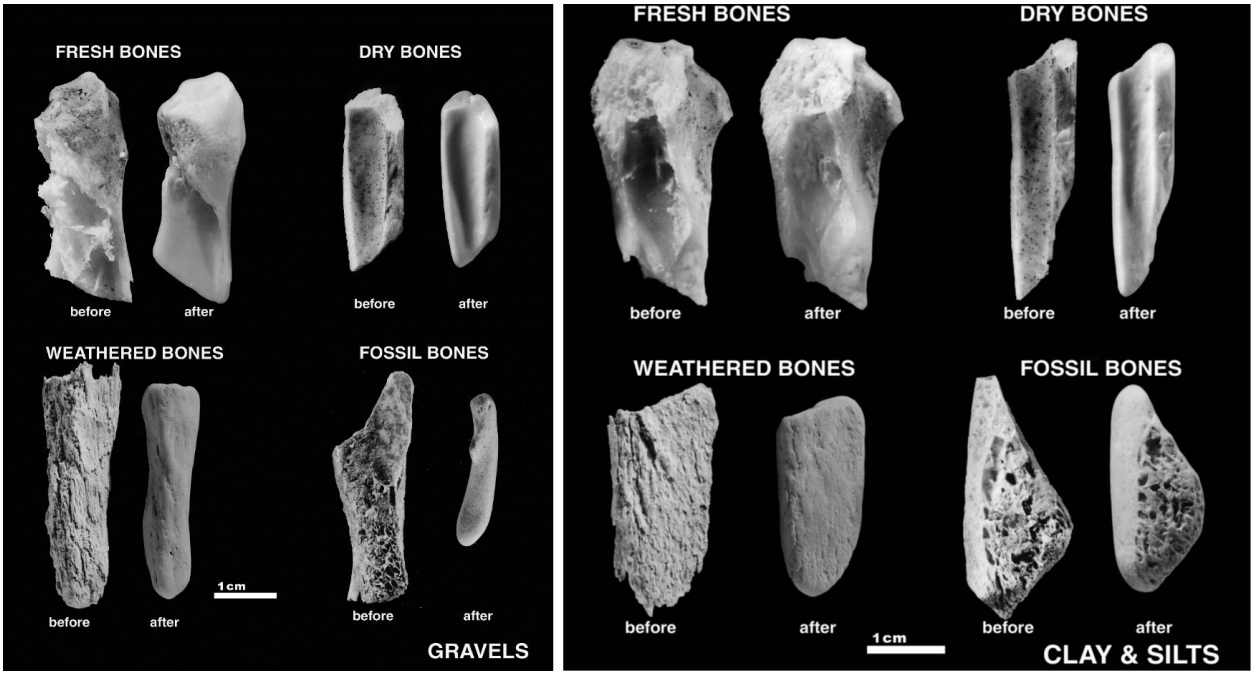


Figure 5.7. Examples of experimentally abraded bones, showing heavy to extreme rounding in the gravel sample and slight to moderate rounding in the clay sample. Reprinted from Fernández-Jalvo and Andrews (2003), Journal of Taphonomy, 1(3), pp. 154-156.

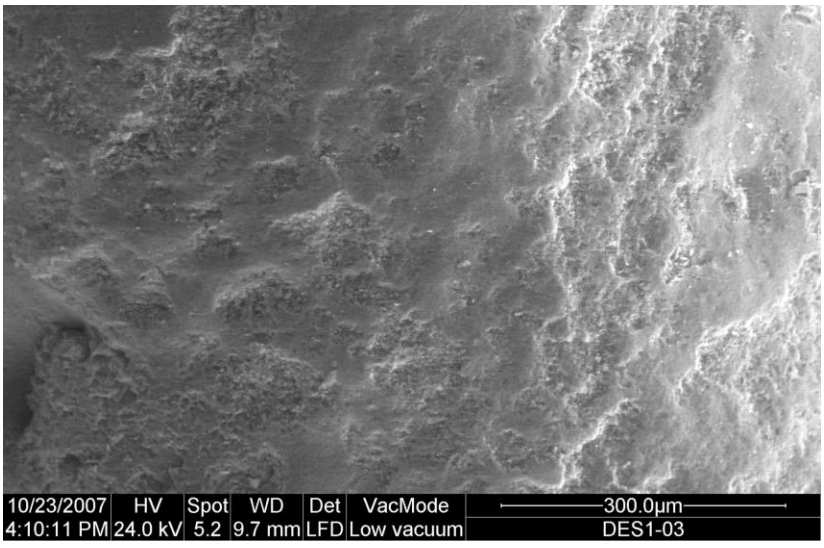


Figure 5.8. Scanning electron micrograph of surface pitting on experimentally abraded bone. Reprinted from Fernández-Jalvo and Andrews (2016), Springer, pp. 119.



Figure 5.9. Highly polished surface on experimentally abraded fossil bone. Reprinted from Fernández-Jalvo and Andrews (2016), Springer, pp. 182.

Table 5.4. Classification system for quatifying taphonomic modifications like abrasion. Adapated from Spencer *et al*. 2003.

1 - Minimal	**Slight abrasion at one or two points**
2 - Light	**less than 25% of the bone shows abrasion**
3 - Moderate	**25 – 50% of the bone is affected by abrasion**
4 - Heavy	**more than 50% of the bone has been abraded**

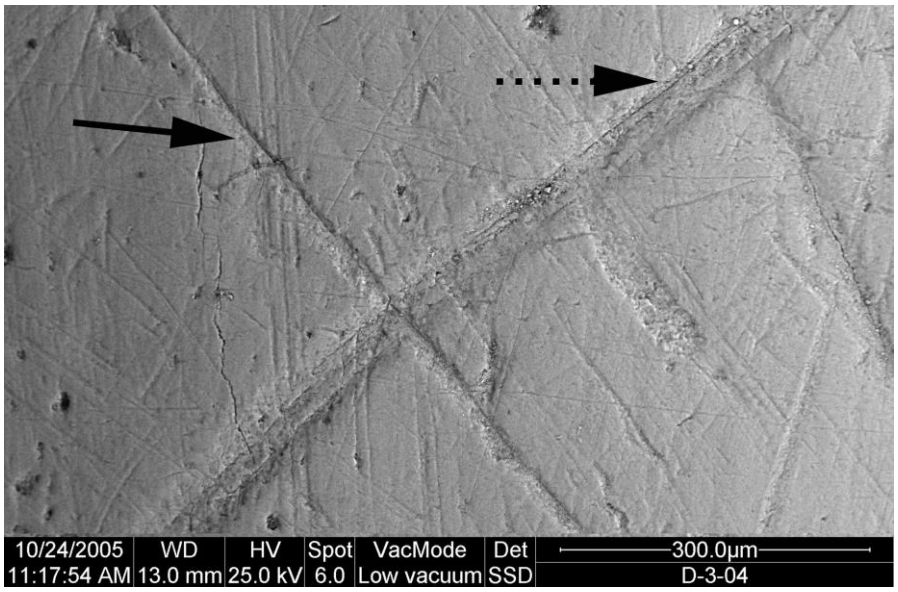


Figure 5.10. Characteristic example of trampling marks, showing sets of multi-striations (fine scratches), groves or scores (solid arrow) and pits (above dotted arrow). Reprinted from Fernández-Jalvo and Andrews (2016), Springer, pp. 53.

Table 5.5. Classification system for quantifying the extent of taphonomic modifications like trampling. Adapated from Reynard (2014).

1 - Light	**Few marks**
2 - Moderate	**Fair amount of modification**
3 – Heavy	**Many incidence of modification**

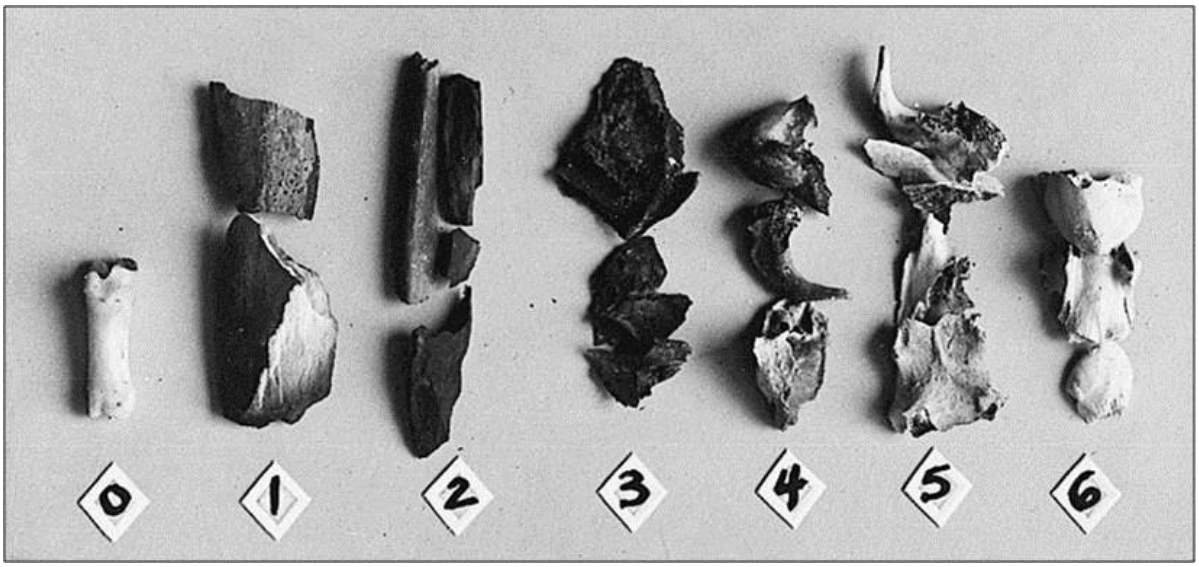


Figure 5.11. Experimentally burnt bones showing colour changes and burning categories. Adapted from Stiner *et al.* (1995), Journal of Archaeological Science, 22, pp. 226.

Table 5.6. Intensity of burning on bone. Adapted from Stiner *et al.* (1995)

0	Not Burnt	Cream / Tan colour
1	Slightly burned	Localised and less than half carbonised
2	Lightly burned	More than half carbonised
3	Fully carbonised	Completely black
4	Localised calcinations	Less than half calcined More black than white
5	Strongly calcined	More than half calcined More white than black
6	Fully calcined	Completely white

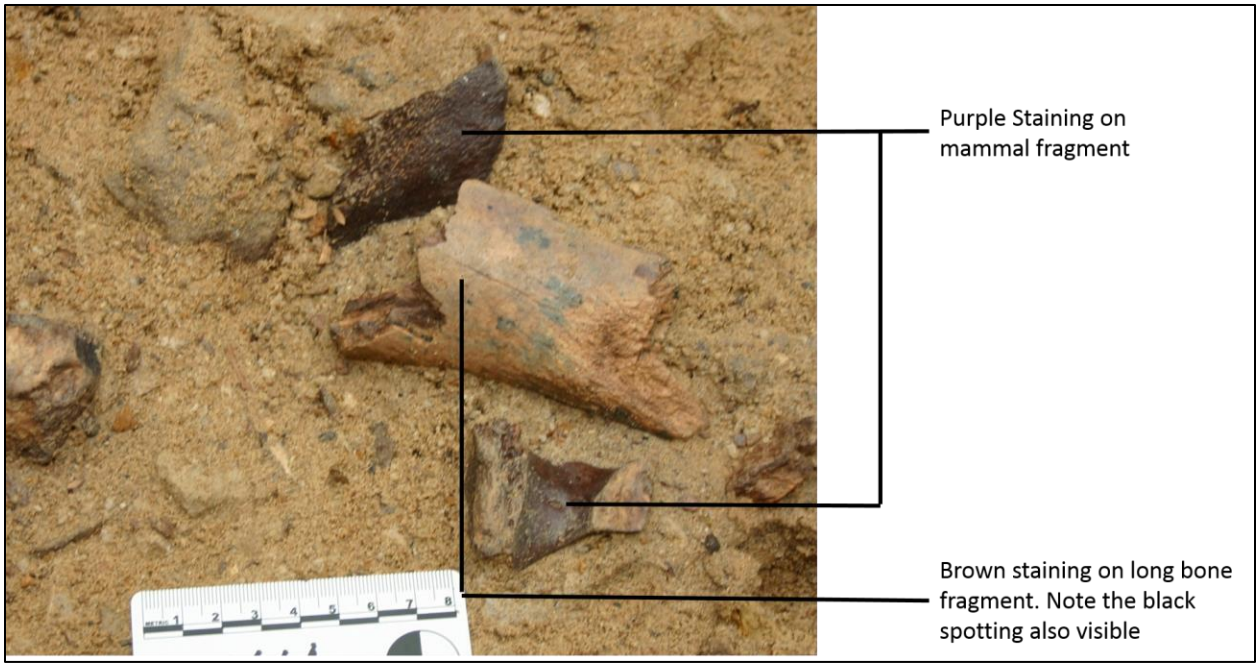


Figure 5.12. Bones from Profile Four displaying staining

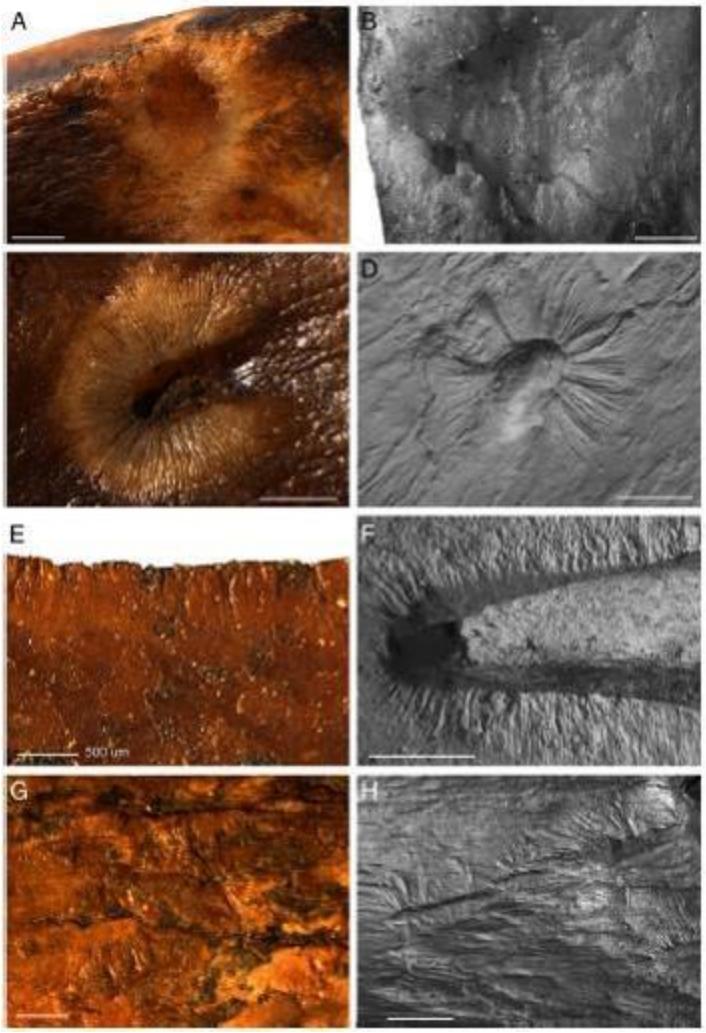


Figure 5.13. Insect modifications on bone. A-B) surface pits C-D) star-shaped pit marks; E-F) edge-gnawing; G-H) sub-parallel striations. Reprinted from Backwell et al. 2012, Palaeogeography, Palaeoclimatology, Palaeoecology, 337-338, pp. 72-87.

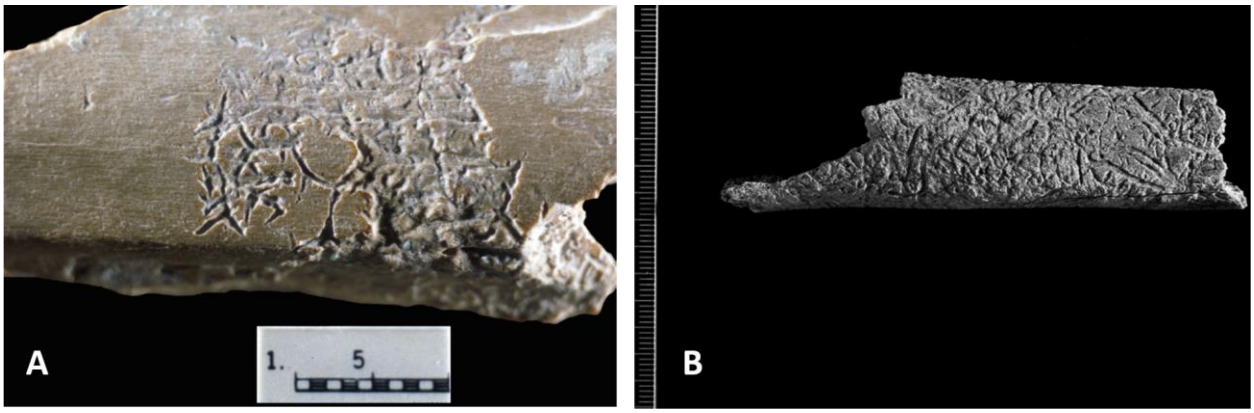


Figure 5.14. Root etched bones, A) deep root etching on bone; B) extreme root etching. Reprinted from Fernández-Jalvo & Andrews (2016), Springer, pp. 25-100.

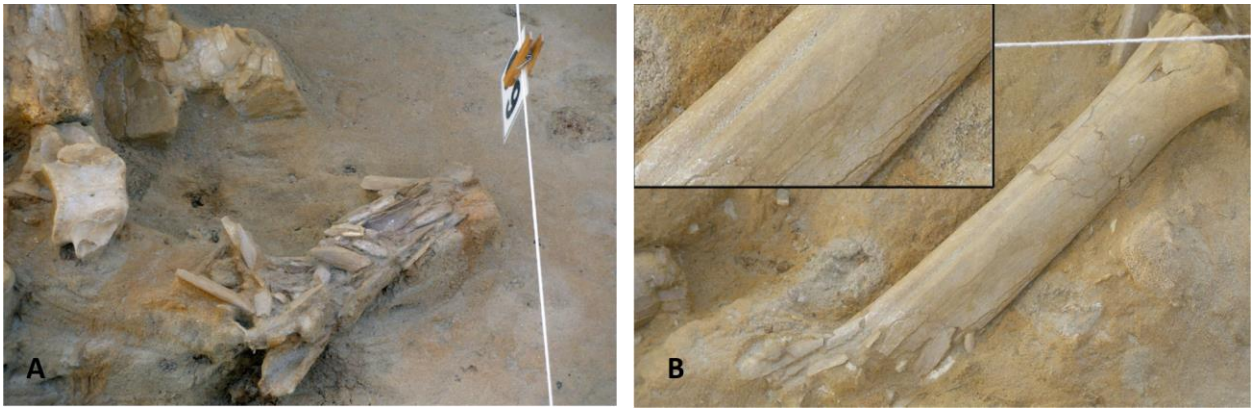


Figure 5.15. Examples of post-depositional modifications from the Langebaanweg Bonebed. A) Fossil which experienced flaking and exfoliation prior to burial; B) Surface cracks with warped edges. Reprinted from Fernández-Jalvo & Andrews (2016), Springer, pp. 201-234.

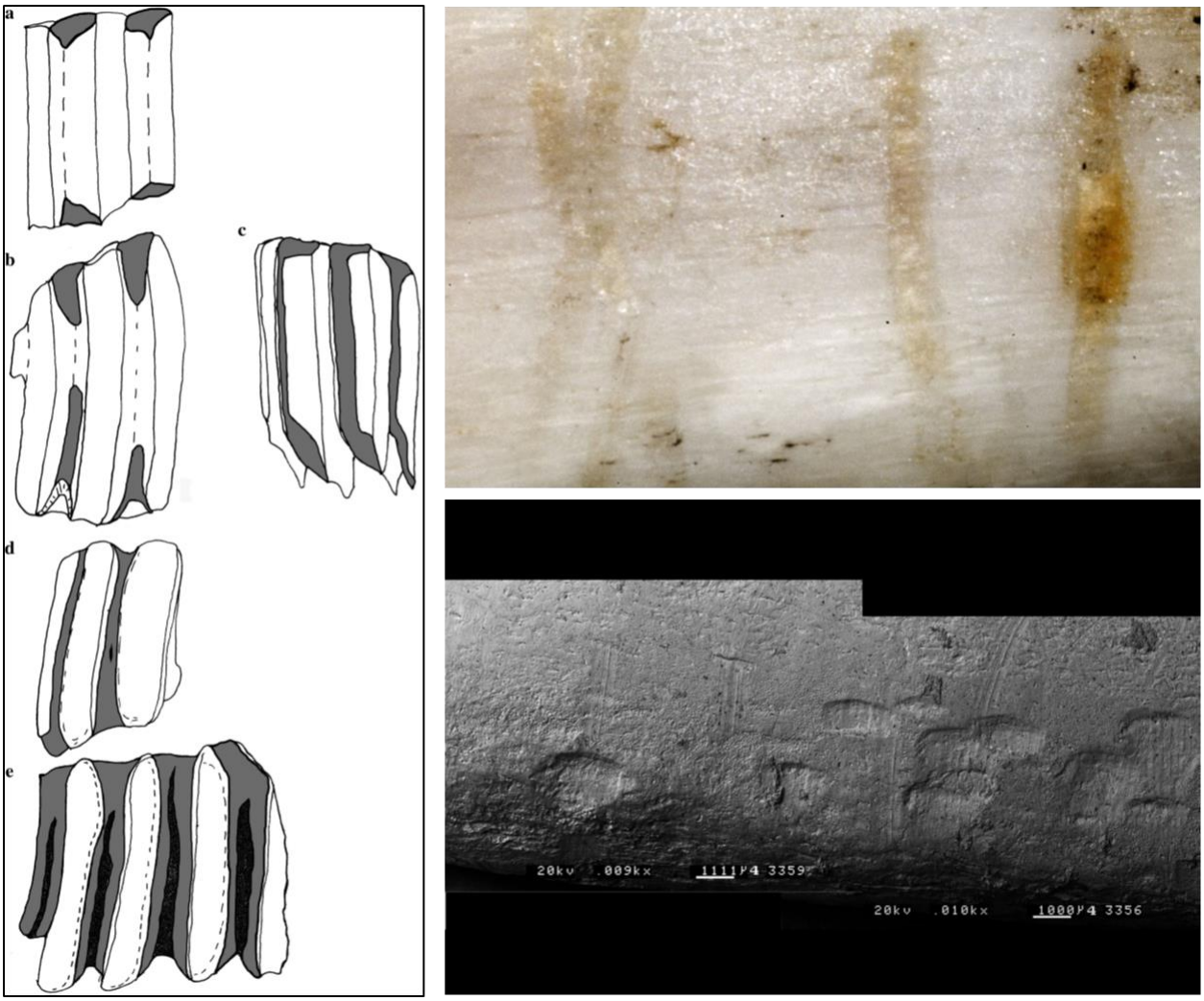


Figure 5.16. Digestion categories (left) and tooth mark examples (right); tooth scores (top right) and tooth pits (bottom right). Reprinted from (left) Fernández-Jalvo & Andrews (1992), Journal of Archaeological Science, 19, pp. 412; and (right) Fernández-Jalvo & Andrews (2016), Springer, pp. 25-100.

Table 5.7. Characteristics of digestion categories in bones and teeth.

Category	Dentition	Bone
1 - Slight	Slight penetration of enamel. Deeper penetration extremely localised.	Bone rarely broken. Digestion occurs almost entirely on articular or projecting surfaces and processes.
2 - Light	Digestion does not penetrate through the enamel to the dentine. The corners of the teeth are rounded and the salient edges flattened. Some digestion of dentine in the incisor.	Digestion is localised. Articular ends may be extensively digested. Digestion may penetrate deeply into the shafts. There may be slight surface etching and splitting of the surface. Broken edges may be slightly rounded. Usually less than 25% of the bone surface is affected.
3 - Moderate	Enamel has been removed from along half or the entire length of the salient angle, leaving a smooth edge. Some pitting of the enamel surface may occur.	Digestion of the shafts is more extreme. Pitting is more intense with further splitting and rounding of broken edges. Localised bone destruction can occur. Usually between 25 and 75% of the surface is affected.
4 - Heavy	The enamel has been extensively removed from the entire length and the dentine is exposed and flattened in some cases. Enamel may be heavily pitted. The corners are strongly rounded with deeply penetrated edges.	The great majority of bones are broken and the broken edges show extensive rounding. The articular ends are heavily digested. Surface appears split and cracked, in a manner similar to weathering but at a very fine scale. Small holes may be present (at low magnification) in the surface. This advanced destruction normally covered more than 50% of the bone.
5 - Extreme	Teeth rarely identifiable. Digestion of dentine considerable, causing collapse of overlying enamel.	The bone structure has been destroyed by corrosion. There is strong rounding of edges. The entire bone surface is affected and identification may be difficult.

Categories adapted from Andrews (1990), Fernández-Jalvo and Andrews (1992) and Lloveras *et al.* 2008.

CHAPTER SIX

PROFILE FOUR – RESULTS

6.1 SEDIMENTOLOGY

Profile Four was located in the large tunnel approximately 1 m to the north of the exposed bonebed excavation. The intention in excavating this area was to intercept fresh exposures of the bonebed deposit. Profile Four was located in an old archaeological prospecting trench excavated by the ACO (Archaeological Contracts Office) group in 1999 (see Chapter Five - Methodology). After clearing away large amounts of accumulated surface debris, the floor of the previous excavation was discovered beneath a covering tarp (Figure 6.1). Below the tarp the excavation surface was smooth and firm and did not appear to have been disturbed.

6.1.1 Excavations

Cleaning overburden

The excavation area was covered by a large amount of loose windblown sands and washed out debris from the surrounding slopes. Beneath the overlying material was a black plastic tarpaulin covering the surface of the old excavation, left by the ACO in 1999 (Figure 6.1). The overburden material was removed with shovels, brushes and buckets and dumped.

Spit One (0-10cm)

The floor of the ACO excavation was firm, smooth and indurated, but softened after soaking with water. Sediments in spit one were fine-grained sandstone of a consistent grey-brown colour, typical of the MPPM. There were rare and localised patches of orange (iron) staining. Many of the bones embedded in this layer were heavily stained, with a purple-brown colour, possibly the result of phosphate or apatite deposition (Figure 6.2).

Spit Two (10-20cm)

In spit two, it first became apparent that there was some disturbance to at least part of the deposit. At the time, the nature of the difference between the sedimentary units and the possible cause of the disturbance was unclear and thus, it was decided to continue to excavate the spit as a single unit. Sediments in the western half of the square were soft and loose, completely unlike all other sediments excavated at Langebaanweg. This part of the excavation showed root traces and recent insect activity, to which I initially attributed the disturbance. There was a clear line of demarcation (Figure 6.3) between the disturbed region and the other sediments. There was no apparent difference however, between bone preservation or specimen density in the two halves of the spit. There was some colour mottling between the grey-brown sediments and paler, almost white sediments. There was however no difference in texture, indicating that these colour changes do not reflect changes in lithology or grain size (as was observed in the MPPM-LQSM contact zone).

Spit Three (20-30cm)

Spit three displayed much the same characteristics as spit two with half the deposit containing firm sediments with colour mottling and the other half unconsolidated disturbed sediments with insect and root disturbance throughout. In spit three the disturbed material contains numerous small pebble- sized phosphate, calcrete and assorted rock clasts. Near the base of the spit larger phosphate rock cobbles were encountered in the north-western corner of the square. There is some colour mottling in spit three but the iron-staining evident higher in the section has all but disappeared. After completing spit three the excavation was temporarily closed (with shade cloth and sandbags) for approximately six months between field seasons.

Spit Four (30-40cm)

In spit four the disturbed part of the deposit becomes more gravelly, comprising a chaotic melange of unsorted medium to large bones, phosphorite, granite, and calcrete stones (Figure 6.4). Many of the bones, which were heavily apatite stained (purple colour), were mammal bones. The bone density greatly increased in the disturbed area from the background density and compared to the rest of the deposit. This bone rich conglomerate deposit has many characteristics of recently reworked material.

Upslope at the head of the trench, there is clear evidence for recent water flow, during heavy rains; it appears likely that these remains have been secondarily deposited as a lag in an erosion gulley. Towards the base of spit four the area of the disturbed portion diminishes. The firm sediments in the eastern half of the square are much the same as in overlying levels, with occasional bands of iron-staining.

Spit Five (40-50cm)

The disturbed region (described above) was still observed in the upper reaches of the spit, but quickly disappeard and the entire square then sampled the firm grey-brown sediments. A complete large bovid (size class four) thoracic vertebra was recovered in the lower parts of this level. This specimen, when first encountered, appeared to have many of the preservation characteristics of the bone bed, but the specimen was isolated. It was however later concluded that this spit marks the top of the bonebed unit. Lithology remained consistent from spit five downwards.

Spit Six (50-60 cm)

The sediments in spit six have the same colour and consistency as those of spit five, but with very few fossil bones from both large *in-situ* specimens and small bones recovered from the sieves. Figure 6.5 shows the uniformity of the spit six sediments.

Spit Seven (60-70cm)

Sediments in spit seven continue to have the same characters as the overlying spit. Large bones were rare and most of the bones recovered from this spit were collected from the sieve samples. Bone density increased in the lower parts of the spit. The spit displayed intermittent bands of iron staining.

Spit Eight (70-80cm)

Sediment texture and consistency and well as bone density were the same in spit eight to that observed in the overlying spits.

Spit Nine and Ten (80 – 100 cm)

The upper parts of the bone bed were intersected in spit nine. Sediment texture and consistency remained the same throughout spits nine and ten. The density of large bones increased in these spits compared to the overlying sediments and clearly associated skeletal elements were encountered. A few of these associated skeletons were observed in spit nine and extend all the way through spit ten, hence both layers are discussed together here. The first associated skeleton, encountered at a depth of approximately 900 mm, consisted of associated plastron remains from a large chelonia (size class four) with various other shell and appendicular bones observable in close proximity (Figure 6.6). A second associated chelonia of a smaller individual (size class two) was uncovered in the same square. This chelonia was located against the northern wall of the pit, approximately 300 mm further north and 50 mm deeper than the first associated chelonia. The bones from this skeleton were jumbled together and the shell appears to have been deposited at an angle tilting downwards and into the northern wall of the pit. Thus it was not possible to recover the entire skeleton. Figure 6.7 shows progressive exposure of bones from this skeleton with depth. Appendicular elements can be observed in Figure 6.7 associated with the carapace and plastron elements. Additional larger, appendicular chelonia elements occur in close proximity to the skeleton jumble and may be associated with that individual.

Associated vertebral remains from a large bovid (size class four) were observed just below the location of the first associated chelonia (depth about 980 mm). This skeleton consisted of seven complete (or mostly complete) vertebra with some associated rib fragments. Figure 6.8 displays three of the vertebra, showing the close association of remains, but without anatomical connections. The overall good preservation of bones can be observed in Figure 6.8. Bones are largely complete, uncrushed and unweathered, but with some natural breaks visible *in-situ*. In the lower parts of spit ten many small bones are jumbled together with the vertebrae but, despite their close proximity, they are not part of that skeleton. For example, a number of chelonia shell and appendicular remains can be seen associated with the mammal vertebra. In some cases, chelonia shell elements have become cemented onto the vertebrae by calcrete formation. Some calcareous encrustations were observed on some of the larger bones from as early as spit 5 but it is not common in this profile. Figure 6.9 displays a view of the (western) profile wall showing the spits and sedimentary units discussed.

6.1.2 Sedimentological Analysis

The Profile Four pit is located entirely within the MPPM and did not penetrate the underlying LQSM. The depth of the LQSM in this area is unknown as no part of the previous bonebed excavations encountered this deposit. But given the position of the LQSM close to the surface in the nearby small tunnel (1976/2), it is likely that the bonebed lies at or very near the base of the MPPM. This excavation was halted at the end of spit ten due to time constraints and the impracticality of excavating a 1 m^2 pit. It is likely that the bonebed extends deeper. In other exposed parts of the bonebed, the bed appears to have an average depth of approximately 300 mm. Questions regarding the thickness of the bonebed and its relative position with regards to the LQSM, will need to wait for future research. Three sediment samples were recovered from Profile Four, these were collected from the three lithofacies namely: the fine grained phosphatic sandstone in the upper part of the excavation (undifferentiated MPPM), the bone and phosphate rock clast-supported conglomerate (reworked deposit), and the bonebed sediments.

Undifferentiated MPPM

The MPPM sandstone was mainly light grey in colour (10YR 7/2; Munsell). Although there was some variation in colour between individual clasts and orange iron staining (closest match 10YR 7/6) was common at many depths. The sediment was compacted and cemented, with a grain-supported and poorly sorted texture. Grains were sub-angular to rounded with low sphericity. The unit appears to be structureless with no visible sedimentary grading or bedding planes.The boundary between this unit and the disturbed unit is sharp and irregular. There is no noticeable change in sedimentary character between this unit and the bonebed layer and it is probable that they are part of the same sedimentary unit and depositional processes.

Grain size analysis found that the undisturbed MPPM sediments in Profile Four were made up predominantly (98%) by sandy material (Figure 6.10) with 2% of the assemblage represented by fine grains with a diameter of 0.63 mm (coarse silt and finer). Over 10% of the MPPM consisted of coarse (>2 mm) grains and sandy material was skewed with a bimodal distribution towards fine to very fine sands (Figure 6.11).

Disturbed Unit

The unconsolidated sediments in this unit, with the high proportion of intraformational clasts and rolled bones, initially suggested that this unit had been recently derived from material eroded from the nearby quarry face. This unit can thus be regarded as *ex-situ* disturbed material. The colour of this unit, very pale brown (10YR 7/4), is similar to the surrounding sediments, but slightly darker. The clasts observed in this unit include large cobbles of phosphate rock, phosphocrete, iron-stained bones, and assorted stones (such as granite). The unconsolidated nature of the sediments of this unit (very unusual for Langebaanweg) would suggest the removal of the cementing material by flowing water and the transportation of the sediment and intraclasts downslope in a run-off gulley. Material from this unit displayed recent biological activity from insects (likely termites) and plant roots, which likely contributed to the disturbance. The unit had a gravel texture in places and clasts and bones of all sizes were common and occur at much higher concentrations than in the adjacent unit.

The sediments of this unit were grain-supported and poorly-sorted. Grains were, for the most part, rounded to well-rounded and sphericity was low. From the exposure available for study, the bedding appears irregular but it is difficult to detect larger bedding features in such a small cross section. The boundary between this unit and the surrounding sediments was abrupt and clear. All of these characters are consistent with flowing water eroding the MPPM sediments and transporting the clasts and bones downstream, dumping them as a channel lag deposit in the vicinity of Profile Four. Immediately to the north, the head of the trench is laid into an old runoff feature developed in the bottom cut wall of the quarry. The same feature can be seen in images from the 1999 excavations by the ACO excavators (Figure 5.2), suggesting that this runoff gully was the result of mining activity.

During grain size analysis, large clasts were removed, so that their presence would not skew the results. Silts and clays were rare, making up less than 2% of the mass of the sample (Figure 6.12). Coarse material over 2 mm in size, was likewise rare (2.7%). The majority of the sample is made up of fine to very fine sands (Figure 6.13). It is remarkable that this unit, which has many of the characteristics of a lag deposit, does not have a high coarse fraction (2 mm) compared to the undisturbed MPPM parent material. Fluvial action is a typical mechanism for grain size separation, although it is unlikely to have removed just the coarse fraction while leaving both larger clasts and finer material in abundance. The depositional history of the disturbed unit is clearly more complicated and will benefit from further investigation in the future.

Bonebed

Sediment colour in the bonebed unit was very pale brown (10YR 8/2), lighter in colour than the overlying undifferentiated MPPM sediments. The bonebed is hosted by well cemented, fine grained sandstone with rare calcrete encrustations around individual bones. These sediments were grain supported and poorly- to very-poorly sorted. Grains were sub-angular to rounded, with low sphericity. The bonebed has an irregular wavy character, in that the bed appears to thicken and thin out in irregular waves. The top surface of the bonebed in Profile Four was encountered at a lower depth from surface than in square F8, the closest square of the previous excavation. No textural grading was visible in the bonebed sediments. Bones from the bonebed layer were well preserved in that they are uncrushed, unweathered and mostly complete and there is no evidence for long distance transport, multiple reworking episodes or long periods of sub-aerial exposure before burial. However transport of whole or partial carcasses before decomposition and disarticulation cannot be ruled out. The slight disarticulation of some remains (like the bovid vertebra) does suggest some movement in a low energy environment.

Fine sedimentary particles were particularly rare in the bonebed with less than 1% silt and smaller particles (Figure 6.14). The bonebed follows the overlying MPPM deposit in containing predominantly fine to very sand grains, although the bimodal distribution is skewed in favour of fine sands (Figure 6.15). The coarse fraction in the bonebed was slightly smaller than in the overlying MPPM.

Sedimentary Bedding in Profile Four

Profile Four was structureless and massive. The bed appears homogenous and lacking in internal structures. Truly massive beds like this are rare and difficult to explain. They can occur as a result of very rapid deposition from suspension or deposition from very highly concentrated sediment dispersions during sediment-gravity flows (Boggs 2011). Given the terrestrial - fluvial nature of the fauna and previous reconstructions of the bonebed deposit, the former condition seems more likely.

The massive structureless character of Profile Four does not match the characteristics of river point bars or braid bars. Point bars, which are attached to the river bank on the inward bend, consist of material eroded from the outside bends of the river and deposited by lateral accretion on the point bar, as cross-bedded and upward-fining sequences with moderate to poor sedimentary sorting (Boggs 2011). Braid bars occupy midchannel positions and thus experience lateral accretion on both sides of the bar. Braid

bars can migrate downstream or remain stable long enough to be colonised by vegetation and become islands (Boggs 2011). Profile Four thus, does not show characteristics consistent with a river channel. However a 1 m^2 profile gives only a small snap-shot of the lithology and cannot be considered definitive evidence on its own.

6.2 TAXONOMY

Profile Four produced a total of 20 487 bones (Table 6.1); of which 1 589 of these bones were identifiable, representing 7.8% of the assemblage. The remaining 16 855 bones were unidentifiable to taxon or element and are not considered further in this analysis. Profile Four produced the largest assemblage of (identifiable and unidentifiable) bones in this study, but it should be remembered that it was almost twice the depth of any other profile. A particularly large sample (2043) of microfauna was recovered from Profile Four. The large numbers of microfauna are noteworthy in this profile considering the relatively coarse mesh size (> 1.5 mm) utilised during excavations. The largest proportion of bone remains was recovered from spit four (313, 19.7%) and spit five (228, 14.3%) (Table 6.2, Figure 6.16). This area of high specimen density coincides with the basal part of the disturbed unit. Below this, in spit six, the density of bones is substantially less (55, 3.5%) before increasing again toward the bonebed layers (spits nine – ten). Microfauna remains were recovered from all depths (Table 6.3), but were most common in spits four (14.8%), seven (18%), eight (14.1%) and nine (21.5%) (Figure 6.17). This would suggest higher frequencies of microfauna in the disturbed unit and in the bonebed. Previous excavations in the Langebaanweg bonebed have recovered large assemblages of microfauna (Matthews *et al.* 2007) so the drop-off in microfaunal frequency in spit ten, might suggest some localised variation in deposition of the bonebed remains.

6.2.1 Taxonomic composition in Profile Four

The Profile Four assemblage was made up mainly of chelonia (55.8%) and mammal (39.6%) bones (Table 6.4). The assemblage also produced rare remains of aves (3.1%), pisces (2%) and reptilia (0.5%) (Figure 6.18). The upper portion of the profile will hereafter refer to all material from spits one - six from both the undifferentiated MPPM sediments and the disturbed unit. Mammals were common in the upper part of the assemblage, particularly spit one (77.2%) and spit four (69.6%) (Figure 6.19). From spit six

and lower however, chelonia become the most prominent taxonomic group. The relative proportion of mammals is particularly low in spit six which only produced 2 (3.6%) mammal specimens. This is likely a factor of the low overall bone frequency in this spit. It is unclear why mammal remains should be more common in the upper part of the deposit. Piscine specimens become more common in the lower levels, particularly in the bonebed; spit nine (5.6%) and spit ten (5.9%). The disturbed unit also produced a number of fish specimens (Spit four, 0.6% and spit five, 1.8%; respectively). This would suggest the bonebed was sampling a more aquatic habitat than the overlying sediments.

6.3 TAPHONOMY

6.3.1 Bone size frequency distribution and fragmentation pattern

There is a large disparity between the average maximum length of bones from Profile Four, which was 22.8 mm (Table 6.5) and the largest specimen which measured 117 mm. The histogram in Figure 6.20 shows that the vast majority of bones have a maximum diameter of less than 50 mm and larger specimens were a rare occurrences. The very large specimens were all recovered as complete bones from the bonebed unit. Maximum diameter measurements of all bones encountered in Profile Four display a bimodal size frequency distribution with a cluster at 10 – 20 mm and another at 25 mm – 30 mm.

6.3.2 Bone Surface Modifications

Bone Weathering

Bone surface modifications attributed to pre-burial sub-aerial weathering were observed in 278 (17.5%) specimens from Profile Four (Table 6.6). Weathering damage was light in Profile Four. The majority (13.2%) of remains display stage one modification (Figure 6.21) and only 1 specimen displayed stage three weathering, the most intense stage observed in this profile. Pre-burial bone weathering was observed in mammals, chelonia, aves and pisces but not in reptiles. It was particularly prevalent (22.6%) in mammals, but uncommon (6.1%) in aves (Figure 6.22). Mammals and chelonia were the only taxa to display moderate (stage two or three) weathering and only in relatively low proportions (Figure 6.23). This would suggest that mammal bones, and to a lesser extent chelonia bones, were exposed on the

surface for a short period (ie < 1 year) before complete burial. Weathering was observed on bones at all levels in the profile (Table 6.7), but was particularly prevalent in spit ten (27.5%), spit one (24.4%) and spit four (21.4%) (Figure 6.24). Spit eight displayed the lowest (10.4%) relative occurrence of weathering. It is possible that this reflects a greater degree of weathering of the bones in the disturbed deposit and in some of the remains from the bonebed. Stage two weathering was observed, at low frequencies, in all spits; while stage three weathering was only observed in spit five.

Burning

A total of 84 (5.3%) bones from Profile Four display modifications attributed to burning (Table 6.8). All six stages of burning were observed in Profile Four, although stages two (2.2%), three (1.2%) and one (1.1%) were by far the most common (Figure 6.25). Discoloration attributed to burning was observed on bones of all taxonomic groups including mammal, chelonia, aves, pisces and reptilia. Reptiles, despite the small sample size display a particularly high (12.5%) frequency of burning (Figure 6.26). Mammals, on the other hand, were rarely (1.8%) affected. Burning was also prevalent in aves (8.2%) and chelonia (7.6%). Burning in fish and reptiles was limited to stage three (Figure 6.27). Acute burning (stages 4 – 6) was observed in mammals, chelonia and aves. Burning damage on the fish bones indicates exposure of these skeletons on a dry surface prior to final burial. Burnt bones were observed at all levels of Profile Four (Table 6.9), but burning was most prevalent in spits six (7.3%), seven (11.5%), eight (10.9%) and nine (9.4%) (Figure 6.28). This suggests that burning was more extensive in the taphonomic pathway leading to the accumulation and final burial of the bonebed. Most of the acute burning (Stage 4 – 6) was observed in levels where the frequency of burn modification was highest (Figure 6.29).

Colour mottling and staining

Surface staining on bones in Profile Four were recorded on 902 (56.8%) specimens (Table 6.10), but was most common in mammals (79.5%) and reptiles (87.5%) (Figure 6.30). The majority of staining was light, stage one (32.2%) or two (16.6%) and intense staining, stage four (0.2%) was rare (Figure 6.31). Intense (stage three and four) staining was only observed on bones of mammals, chelonia and aves (Figure 6.32). Stage one staining was most common in all taxonomic groups except aves, whereas stage three was more common in the latter group. Staining was most prevalent (75% – 85%) in the upper levels of

Profile Four (Table 6.11) and was least common in spit six (23.6%) and spit seven (18.5%) (Figure 6.33). Similarly stage two and three staining were more prevalent in the upper parts of the deposit, while stage four was observed infrequently in spit four and spit eight (Figure 6.34). The majority of stained bones in Profile Four were brown (62.6%), although some remains displayed purple (18.1%) or black (16.2%) staining (Table 6.12); some rare examples with orange (3.2%) staining were also observed (Figure 6.35).

Bone abrasion

The most commonly occurring surface modification of bones in Profile Four was mechanical abrasion which was observed on 1327 or 83.5% of remains (Table 6.13). Four stages of abrasion were observed, although most (40.6%) specimens display minor (stage one) damage and severe abrasion with almost complete removal of the surface cortex was rare (4.7%) (Figure 6.36). Abrasion was observed in bones of all taxonomic groups. Mammals, chelonia, reptiles and pisces display similar high levels of abrasion; while this modification was less frequent in aves (Figure 6.37). In all, taxa abrasion was predominantly light (stage one) (Figure 6.38). Stage two abrasion was most prevalent in mammals, chelonia and aves. Abrasion in reptiles was limited to stage one and two; while stage three abrasion was observed in mammals, chelonia, aves and pisces. Severe (stage four) abrasion was rarely recorded in mammal and chelonia specimens. Abrasion was extensive (>74%) throughout the deposit (Table 6.14), only dropping-off in frequency in spit nine (67.6%) and spit ten (51%) (Figure 6.39). Stages one to three abrasion were observed at all depths (Figure 6.40). Stage four abrasion was most prevalent in the upper parts of the deposit, as well as spit ten. Light abrasion was observed throughout the deposit, with no preference for any level; although the bonebed layers show substantially less abrasion. This indicates that most bones in the Profile Four assemblage have undergone transport over short distances or mechanical abrasion in a low energy environment.

Sheen and Polish

A total of 367 specimens from Profile Four, representing 23.1% of the assemblage displayed sheen or polishing (Table 6.15). Sheen was observed in all taxonomic groups, but was particularly extensive (55.1%) in fossil bird bones (Figure 6.41). Four stages of sheen were observed in the Profile Four deposit,

although the majority (13.7%) of remains display light modification (Figure 6.42). Well developed sheen was rare (0.1%) and was only observed in mammal remains (Figure 6.43). Pisces and reptiles displayed only stage one sheen; while stage two and three were most prominent in aves. Bones displaying sheen were observed in all spits (Table 6.16). Sheen was most commonly observed in spit nine (30.5%), spit eight (27.9%) and spit six (27.3%). Spit ten displayed the lowest (13.7%) relative frequency of polished bones (Figure 6.44). Stage three sheen was observed in all layers except in spit ten, while stage four was limited to spit four (Figure 6.45). There is thus, no correlation in intensity of sheen with spit depth in the profile. Sheen or polishing on bones is usually considered indicative of a bone submerged in flowing water (Denys 2002). In the case of Profile Four indications are for low energy water flow. There is no correlation between sheen and spit depth so either flowing water activity was patchy or bones were previously polished before incorporation into the Profile Four assemblage. It is unclear why avian bones should display a higher prevalence of sheen.

Trampling

Marks attributed to trampling were recorded in 457 bones recovered from Profile Four, representing 28.8% of the fossil assemblage (Table 6.17). The majority (24%) of trampling modifications were light in intensity and heavy (stage three) trampling was rare (0.3%) (Figure 6.46). Trampling was observed in mammals, chelonia, aves and pisces, but was absent from reptile remains (Figure 6.47). Trampling marks were most common in aves (32.7%) but were rare in pisces remains (3.1%). The latter taxon displayed only stage two modification (Figure 6.48). Aves displayed the highest relative frequency of stage two trampling; while stage three was limited to rare mammal and chelonia remains. Trampling was observed on bones recovered from all levels but was most common in the disturbed unit (spit four, 33.9% and spit five, 33.8%) and in the bonebed (spit ten, 35.8% and spit nine, 33.8%) (Table 6.18). Spit seven displayed the lowest proportion of trampling marks (18.5%) (Figure 6.49). Stage three trampling was observed in spits three, four, five and eight (Figure 6.50). Stage two trampling was observed at all levels, but shows a particularly high frequency in spits two (7.4%), eight (9.8%) and ten (7.8%). Trampling marks observed in Profile Four include pits, scores, and scratches (as defined by Reynard 2014) (Table 6.19). Many bones would display multiple types of trampling, like pits and scores, and thus the number of trampling marks (524) exceeds the number of specimens (457) which display trampling. Pits were by far the most common (79.6%) type of trampling mark observed (Figure 6.51). Scratch marks appear to be more prevalent in stage two and three than pits or scores (Figure 6.52). One of the most characteristic

features of the bonebed excavations is large bones bearing green-stick fractures and trampling marks from large bodied animals (Smith & Haarhoff 2006). Profile Four did not produce any remains with large trampling marks as observed in other parts of the deposit. In fact most trampling (which was at the fine and sometimes microscopic level) was light, indicating that trampling was not highly frequent, occurring on less than 30% of remains. Whether Profile Four reflects background levels of trampling modification or was somehow protected from this modification will need to await further investigation of bones from the bonebed excavations.

Carnivore Modifications

Tooth Marks

Carnivore tooth marks were observed on 64 specimens from Profile Four, representing a mere 4% of the total number of bones recovered from this profile (Table 6.20). Tooth marks were observed in mammal (3.3%), chelonia (4%) and aves (18.4%) specimens only (Figure 6.53). Stages one to three tooth marking were observed in Profile Four, however the vast majority (3.7%) of remains display only stage one modification (Figure 6.54). Despite aves displaying the highest abundance of tooth marks, they were restricted to stage one in this taxonomic group (Figure 6.55). Mammals and chelonia display stage two tooth marks while mammals were the only group with stage three modification. Stage two and three tooth marked bones were so infrequent that they were combined with stage one in order to investigate tooth marking and depth. Tooth marked bones occurred at all levels except spit two (Table 6.21); and were most common in spit ten (21.6%) (Figure 6.56). Tooth mark types observed in Profile Four include pits, punctures, scores and notches (Table6.22). In many cases multiple tooth mark types were observed on the same bone, but individual marks were counted separately in order to investigate relative frequencies of different mark types. Hence the number of tooth marks (92) is greater than the number of specimens that display tooth marks (64). The most commonly occurring tooth marks were scores (41.3%), followed by pits (38%) and notches (8.7%) were rare (Figure 6.57).

Digestion

Digestive corrosion was observed on 51 specimens from Profile Four, representing 3% of the assemblage (Table 6.23). Similar to the frequency distribution of tooth marks, digestive corrosion was observed in

mammals, chelonia and aves but was most common (10.2%) in the latter group (Figure 6.58). Digestive corrosion in Profile Four was predominantly light (2.1%) with occasional moderate (0.5%) and heavy (0.6%) modification (Figure 6.59). Stage two and three digestion were infrequent in mammals and chelonia (Figure 6.60); however the majority (6.1%) of avian remains display stage three digestion, rather than stage one. Bones bearing digestive corrosion were observed at all levels except in spit six (Table 6.24). Similar to tooth marked remains, spit ten produced the highest (17.6%) number of digested bones; however, there is also a smaller peak (8.3%) of digested bones from spit seven (Figure 6.61). Digestive modifications observed in Profile Four remains were limited to corrosive pitting (64.1%), surface etching (32.8%) and rare foramen enlargement (3.1%) (Table 6.25, Figure 6.62).

The low frequency of carnivore modifications indicates that predators made limited contributions to the Profile Four assemblage. Both tooth marks and digestion were most commonly observed in aves remains, which may indicate how these animals came to be accumulated in the assemblage. There is some indication that carnivore modifications are more common in the bonebed as spit ten produced the highest frequency of this modification, however carnivore modified bones were rare in spit nine.

Root etching

A total of 415 specimens from Profile Four, representing 26.1% of the assemblage displayed root etching (Table 6.26). Root etching was predominantly stage one (17.7%) or two (6.7%) in intensity but occasional examples of stage three (1.6%) were also observed (Figure 6.63). Root etching was observed in remains of mammals (32.2%), chelonia (23.7%) and aves (14.3%) (Figure 6.64). Light root etching was common in all taxonomic groups and heavy etching was only observed in a small portion (0.7%) of chelonia remains (Figure 6.65). Bones with root etching were observed throughout the deposit (Table 6.27). In general, the amount of root etched bones decreases with spit depth (Figure6.66); however, root etching was particularly extensive in spits four (36.7%) and six (36.4%). This would suggest that there is some link between increased root etching and the disturbed unit. Stage two and three root etching were more prevalent in the upper parts of the deposit (Figure 6.67).

Root etching was generally more frequent in the upper parts of the deposit and was particularly prevalent in the disturbed unit. This unit contained modern root and insect burrows, possibly as a result of the unconsolidated and uncemented nature of the sediments. The greater prevalence of root marks towards the surface of the deposit would suggest this modification is a recent occurrence, as opposed to

modification that occurred prior to or at the time of burial. Langebaanweg has an especially high potential for modern root marking as the deposits have been exposed for many years. At this stage I do not know of any means by which ancient root etching can be differentiated from modern modification. It would be very beneficial in the future, if root marks on fossil bones could be utilised to assess the type of plant modifier and the residence time of those bones within the soil. However to the best of my knowledge, no experimental work regarding root etching has been undertaken (Denys 2002).

Insect Modifications

Insect modifications were only observed on mammal remains and will be discussed in more detail in the mammal section.

6.4 MAMMAL TAXONOMY AND TAPHONOMY

6.4.1 Taxonomic composition of mammals

A total of 614 specimens identified as mammals were recovered from Profile Four, contributing to 38.6% of the assemblage (Table 6.28). Profile Four mammal diversity was high with over ten families identified; these include Bovidae, Equidae, Giraffidae, Canidae, Felidae, Hyaenidae, Phocidae, Herpestidae, Leporidae, Bathyergidae and Rodentia (Figure 6.68). The vast majority (87.9%) of mammal remains from Profile Four, as in all the other deposits investigated, were unidentifiable to family level. Bovidae (6.8%) were the most commonly recovered family, followed by indeterminate carnivores (1.8%). Indeterminate carnivores here refers to all specimens identifiable to the family Carnivora, but not to genus or species and is differentiated from other carnivore families. The majority of mammal remains were derived from size class three (34.9%) and four (33.6%) individuals, size class one (6.8%) mammals and megamammals (4.6%) were rare (Figure 6.69). Mammal remains were recovered from all levels (Table 6.29). Mammals were relatively more common (> 5%) in the upper parts (spit one - five) of the deposit than the lower, (Figure 6.70) and were particularly abundant (35.5%) in spit four. Mammals were virtually absent from spit six, which produced only 2 (0.3%) specimens. The relative percentage of mammals in the bonebed was low. Mammal family groups are discussed in greater detail below. They are grouped into large mammals (consisting of bovids, equids and giraffids), carnivores (all large and small carnivores) and small mammals (leporids, mole-rats and large rodents). Note that small mammals are separate and different from microfauna.

Bovidae and large mammals

Bovidae were the most commonly recovered mammal family from Profile Four. Previously, Gentry (1980) described a small (size class one) bovid from Langebaanweg as *Raphicerus paralius*, a steenbok-like animal. This materia,l which is known from assorted cranial and postcranial remains, is somewhat larger than modern *Raphicerus* species. The Profile Four excavation produced a single small bovid specimen, comparable in size to the modern Duiker (*Sylvicapra grimmia*), which I have attributed to *R. paralius* (Table 6.28). There is no directly comparable material from *R. paralius* available for contrast and until more material from this species comes to light it would be most parsimonious to assign the Profile Four specimen to *R. paralius*. Near the base of the deposit (in the bonebed) a series of associated vertebra from a single large (size class four to five) bovid were recovered (Figure 6.8). Based on size,

these remains are most likely from the boselaphine *Mesembriportax acrae* (Gentry 1980). *Mesembriportax acrae* is only known from craniodental specimens and thus it is not possible at this time to confirm this identification. There are, in addition to this material, numerous bovid specimens identifiable to the family level only, and refered to here as indeterminate bovid. The *R. paralius* specimen was recovered from spit ten, while the *M. acrae* vertebrae were recovered in spits nine and ten (Table 6.30). Indeterminate bovid remains include all size classes, but were predominantly (54.3%) derived from size class four individuals (Figure 6.71). Bovid indet. remains were recovered from spits one to six, spit nine and spit ten; with spit four (29.4%) producing the largest sample (Figure 6.72).

A single equid (size class four) was recovered from spit four. Giraffidae were represented by 4 (0.7%) specimens of *Sivatherium hendeyi*. This species is a size class five individual, however a single small specimen, possibly from a juvenile was also uncovered and was coded as a size class four, pending further investigation. The *S. hendeyi* material was collected from spit one (25%) and spit four (75%) (Figure 6.72). MNI in bovids from Profile Four is two; *R. paralius* and *M. acrae* each represent a single individual, while the numerous indeterminate remains could belong to either or neither of these species and are thus not counted (Table 6.31). From this point onwards, large mammals will refer to all specimens from Bovidae, Equidae and Giraffidae.

Carnivora

Carnivore remains from Profile Four were abundant and diverse, including 21 specimens totalling 3.4% of the mammal assemblage. Two, size class two, canids were recovered (Table 6.28, Figure 6.73). One specimen is consistent in size and morphology with a fox and has been assigned to this genus pending the recovery of more complete material. Fox remains have been identified at Langebaanweg previously as *Vulpes* sp. (Werdelin 2006) and this material is attributed to this taxon in the meantime. The remaining canid material was well outside the size range of the fox and compared favourably with modern jackal (*Canis mesomelas*). An early canid of the genus *Eucyon* has been described from Langebaanweg (Spassov & Rook 2006), but its affinity remains controversial and for the time being the larger canid material recovered in this study will be assigned to affinity *Canis*. The fox remains were recovered from spit one and the *Canis* from spit eight (Figure 6.74).

Two felid specimens were identified from Profile Four, a small (size class two) cat and a medium (size class three) felid. These specimens, which were not identifiable below the family level, were derived

from spits one and three, respectively. Langebaanweg has produced numerous felids (Werdelin 2006) including the large *Amphimachairodus* sp., the medium-sized *Metailurusobscurus*, *Dinofelis* sp. and Felidae sp.

Spit two produced a single partially erupted fourth premolar, consistent with the extinct hyena *Ikelohyaena abronia.* A full set of adult dentition from this taxon were also recovered in Profile Two. Phocid bones were recovered in spit four but they are not identifiable below the family level, although both specimens were on the small side for members of this family and were thus coded as size class three individuals. Previously, a single seal taxon has been described at Langebaanweg, *Homophoca capensis* (Hendey & Repenning 1972; De Muizon & Hendey 1980; Avery & Klein 2011). Recently however, Govender *et al.*(2012) have recorded the potential existence of at least two other seal morphotypes at Langebaanweg. Thus, until the taxonomy of seals from the site has been clarified the Profile Four material will remain at the family level.

Three specimens belonging to small (size class one) carnivores were recovered from Profile Four. A number of small carnivores from the families Vivarridae and Herpestidae have been identified at Langebaanweg (Hendey 1974; Werdelin 2006). The Langebaanweg small carnivores require reanalysis and further investigation, and until this has been done the Profile Four material will simply be attributed to the family Herpestidae. A further 11 specimens were only identifiable as carnivoran remains. These specimens were derived from size class one (9.1%), two (27.3%), three (54.5%) and four (9.1%) carnivores. Indeterminate carnivore remains were recovered from spits four (54.5%) and five (9.1%), and spits seven (9.1%), eight (18.2%) and nine (9.1%). Remains from at least seven carnivore individuals (MNI) have been recovered from Profile Four (Table 6.32). This includes the two canid species, two cats, a hyeanid, a seal and a small carnivore.

Small mammals

The term small mammals, here refers to size class one and two non-carnivorans such as rabbits, hyraxes and large rodents. The majority of the rodent remains recovered in this investigation form a major component of the microfaunal sample which was not studied as part of this analysis. A single specimen with close morphological affinity to the rock hare *Pronolagus crassicaudatus* was recovered from spit three (Table 6.28). *Pronolagus* sp. has been identified at Langebaanweg previous (Hendey 1980) and this new specimen was attributed to this genus. Additional lagomorph bones recovered from spit four

(Figure 6.75) and assigned to Leporidae, show some affinity with modern *Lepus* and are tentatively assigned to this genus. *Lepus* has not been previously recorded at Langebaanweg. Two mole-rat specimens were recovered from spits one and three in Profile Four. There are two known Bathyergid species at Langebaanweg (Denys 1998; Matthews 2006) and it is currently unclear which species these specimens represent. A single size class one rodent was recovered from spit nine. The MNI for *Pronolagus*, *Lepus* and the rodent is one, respectively; while at least two mole-rat individuals contributed to the assemblage (Table 6.33).

Indeterminate mammals

A large percentage (87.9%) of the mammal remains recovered from Profile Four lacked diagnostic characteristics and could not be identifed to lower taxonomic group. These include examples from all size classes, although the majority of indeterminate mammals were derived from size class four (35.2%) and size class three specimens (34.8%) (Figure 6.76). Size class one (5.6%) and five (3.9%) indeterminate remains were rare. Indeterminate mammal remains were recovered from all spits (Figure 6.77). They are generally more common in the upper parts of the deposit and were particularly extensive in spit four (35.7%). The indeterminate mammal sample seems to comprise remains from at least four individuals based on number and relative body size of vertebra (Table 6.34). It is impossible, however, to estimate how much of this material may have been derived from the families already discussed.

6.4.2 Anatomical Composition of mammals

Bovidae and large mammals

In Profile Four, *R. paralius* is represented by a proximal ulna (Table 6.35); while the *M. acrae* remains included a single thoracic vertebra and 6 lumbar vertebrae. Numerous fragmentary dental remains were recovered in the indeterminate bovid assemblage including premolar (2.1%), incisor (2.1%) and molar (10.6%) remains. Small compact bones of the autopodium (including metapodia, astragalus, patella and phalanges) were common in the indeterminate mammal assemblage. Other (indeterminate) mammal remains include femur, humerus, a fragmentary horncore, rib and vertebra elements. Equidae were represented by a fragment of tibia, recovered from spit four (Table 6.36). The Sivathere was represented by dental remains; all recovered from spit four or spit five.

Carnivora

Table 6.37 displays the anatomical composition of carnivoran remains from Profile Four. In the Canidae, the fox was identified based on a proximal phalange, while the *Canis* was identified on the basis of a tibia. Felidae were represented by rib and radius; Phocidae by tibia and carpal/tarsal elements. The hyena, as noted before was represented by a partially erupted premolar. Small carnivore (Herpestidae) remains included a partial mandible, an isolated canine and a proximal phalanx. Indeterminate carnivore remains include primarily autopodial elements (metapodia, calcaneus, phalanges) as well as craniodental remains. All indeterminate carnivore material was derived from spit four, except for caudal vertebra, proximal phalanx and some (33.3 %) middle phalanges (Table 6.38).

Small mammals

The *Pronolagus* was identified based on a single femur; while the *Lepus* was represented by proximal phalanges and tarsal/carpal elements (Table 6.39). Two mole-rat mandibles and a size class one humerus were recovered. Leporidae bones were found in spits three and four, the remaining small mammals from spits one, three and nine (Table 6.40).

Indeterminate mammals

The majority (72%) of indeterminate mammal bones were long bone fragments (Table 6.41), most of which were derived from size class three (41.6%) or four (31.9%) individuals. Small compact bones of the autopodium (metapodial, phalange, tarsal/carpal) were common, particularly in size class one indeterminate mammals. Vertebra (7%) and rib (3.7%) fragments were numerous. Isolated cranial remains were observed in size classes two, three and four; as were scapula, humerus, radius, ulna, femur and tibia elements.

6.4.3 Bone Size Frequency Distribution and Fragmentation Pattern of mammals

Maximum length

The average maximum diameter of mammal remains from Profile Four was 31.5 mm with a minimum of 3 mm and a maximum recorded length of 117 mm (Table 6.42). There is a general pattern of increased average length with increasing body size class, particularly between size class one (14.3%) and two (24.8%) and size class four (37.5%) and five (48.6%). Maximum bone length in the combined mammal sample is clustered around 25 mm to 40 mm but with a long tail towards larger sized remains (Figure 6.78). In size class one remains do not exceed 45 mm in length and are clustered around 10 mm to 25 mm, with a bias towards the smaller sizes (Figure 6.79). Size class two mammals display a similar range, but with slightly larger sizes, with the majority of specimens clustered around 25 mm to 35 mm in length (Figure 6.80). In size class three mammals the majority of specimens display a maximum length around 25 mm to 45 mm (Figure 6.81). Large sized fragments (up to 60 mm) become more frequent in size class three, although there are a number of outliers. Fragmented bones of size class four mammals show a large spread of maximum length, up to 90 mm, but skewed towards 25 mm to 35 mm (Figure 6.82). There are outliers on both sides of the mean in size class four specimens. Size class five remains are clustered between 20 mm and 65 mm but with a number or large outliers (Figure 6.83). The most commonly occurring length of size class five remains was 30 mm and 40 mm.

Fusion of epiphyses

The state of epiphyseal fusion of bones could be recognised on 87 (14.2%) mammal remains from Profile Four (Table 6.43). The majority (69%) of these were adult specimens although juvenile (21.8%) and rare subadults (9.2%) were also observed (Figure 6.84). The relative percentage of juvenile remains increases with mammal size classes (Figure 6.85). It is possible that juveniles appear to increase with size class as larger specimens are more robust than smaller sized juvenile remains. Subadults were mostly commonly (20%) recorded in size class three mammals and were absent from size class five. No fusion information could be recorded from mammal remains in spit six (Table 6.44). Subadult remains were observed in spits five, seven, nine, and ten and were much more frequent in the bonebed layers (35.7%, respectively) (Figure 6.86). This would suggest a broadly catastrophic mortality profile, consistent with death in a flash flood, veld fire or sustained drought (Klein 1982). However, lithology in Profile Four does not support a catastrophic event.

Completeness

A total of 39 mammal bones were unbroken, representing a mere 6.4% of all mammal remains (Table 6.45). Complete bones were observed in bovids (23.8%), carnivores (33.3%), small mammals (50%) and very rarely in indeterminate mammals (3.5%) (Figure 6.87).The most common complete bones were small compact bones of the autopodium, particularly phalanges; although some dental remains and vertebra were also recovered complete. In the Bovidae, all remains from *M. acrae* were recovered complete, as were a few indeterminate bovid remains. In the carnivores, Phocidae, Hyaenidae and Herpestidae specimens were recovered complete along with some indeterminate remains. *Lepus*, rodents and a large number of indeterminate mammals also show completeness. The majority (15) of complete remains were recovered from size class one, however size class two displays the highest frequency of complete remains (Figure 6.88). Complete remains were absent from spit ten (Table 6.46) and were most common in spits six (3.6%), seven (3.8%) and to a lesser extent nine (2.8%) (Figure 6.89). Thus, with the exception of remains from the bonebed, complete specimens were limited to small compact bones from small sized individuals.

Breakage Patterns

Tables 6.47 - 6.49 displays the element parts and breakage patterns observed in mammals from Profile Four. Vertebra were most commonly represented by centra (25.5%) or transverse processes (21.8%), although neural arches (12.7%), spinal processes (3.6%), epiphyses (9.1%) and isolated zygopophyses (7.3%) were also recovered (Table 6.47). Complete (18.2%) and fragmented (14.5%) vertebra were also recovered. Long bones (including metapodia and phalanges) were most commonly represented by proximal ends (37.7%), shaft fragments (24.6%) and distal ends (21.7%) (Table 6.48). Rarely, complete (15.9%) long bones were also observed. Ribs were most commonly (57.1%) recovered as dorsal fragments containing some portion of the rib head. Other remains (like compact bones, mandibles, maxilla and dentition) were recovered as fragmentary (70%) remains or complete (30%) elements (Table 6.49).

Fracture Shape - Outline

The shape of bone fractures was analysed on 559 (62.2%) long bone shafts out of a possible 898 specimens from Profile Four (Table 6.50). Fracture outlines in mammal long bones include spiral, transverse, splintered and irregular. The majority (67.1%) of long bone shafts displayed spiral breaks (Figure 6.90), indicating most of them were fractured while relatively fresh, before demineralization and collagen decomposition. Transverse (17.4%) and splintered (14.8%) breaks occurred in similar proportions, which suggests that slightly less than 20% of remains were dry or lightly weathered when damaged. Irregular (0.7%) breaks were rare. A high proportion (77.8%) of fracture outlines could be characterised in size class five long bones, while in size class one (32%) this value is much smaller (Figure 6.91). Size class five specimens did not display transverse breaks but there was a high prevalence (27.8%) of splintered breaks, suggesting many of these bones were weathered prior to damage. On the other hand, in size class one, splintered breaks were absent and a tiny percentage (2%) of transverse breaks were observed. Irregular breaks occurred at very low frequencies in size class one, three and four. In most spits, over 50% of all long bone breaks could be characterised (Table 6.51). Spit ten (80%) displayed high numbers of fracture outlines, while in spit seven (37.5%) the preservation of fracture outlines was low and in spit six, they were absent (Figure 6.92). There is a slight trend towards a lower frequency of splintered breaks in the deeper parts of the deposit. Spit ten, however, displays a higher prevalence of splintered breaks and a very high prevalence (20%) of irregular breaks. The only other locations where irregular breaks were observed was spit four. Splintered breaks were absent in spit eight. There is thus little correlation with the degree of breakage or the state of bone prior to breakage with spit depth.

Fracture shape - Angle

A total of 592 fracture outlines could be characterised out of 898 mammal long bone ends from Profile Four (Table 6.52). These fracture outlines included oblique- angled, right- angled and mixed-angled breaks (Figure 6.93). Oblique (35.6%) and right (34.5%) angled fractures occurred in Profile Four at similar frequencies, although oblique fractures were slightly more common. The prevalence of fracture outlines was low (34%) in size class one long bone ends (Figure 6.94). Size class one also displays a low prevalence (6%) of right angled breaks. No fracture angles could be characterised in spit six (Table 6.53). In the lower parts of the deposit, starting from spit seven, the frequency of fracture angles is low

(33.3%) but increases. Similarly the relative percentage of right angles was low in spit seven (8.3%) and increases from there. This would suggest that fractures angles, particularly right angles were low in the bonebed, compared to the rest of the deposit.

6.4.4 Surface Modifications of mammals

Bone Weathering

Weathering was observed on 139 specimens representing 22.6% of the mammal assemblage of Profile Four (Table 6.54). Weathering in mammals was predominantly light, with stage one (17.8%) modification most prevalent and stage three (0.2%) rarely occurring (Figure 6.95). Weathering was particularly common in large mammals (44.7%); although it was also observed in small mammals (33.3%), indeterminate mammals (20.7%) and carnivores (19%) (Figure 6.96). Weathering in small mammals was limited to stage one, while stage three weathering was only observed in a single (0.2%) indeterminate mammals (Figure 6.97).

Burning

Burning was rare in mammals, occurring on only 11 specimens or 1.8% of mammal remains (Table 6.55). Burning in mammals was limited to unidentifiable mammals and did not occur on any other family. Within the unidentifiable mammals, burning was most prevalent in size class two bones (46.2%), but was also observed in size class one (4.8%), three (11.1%) and four (4.2%) but not five (Figure 6.98). Mammal remains displayed stages two, three, four and six burning; stages one and five were not observed. Mammals displayed primarily (1%) stage three burning (Figure 6.99). Size class one mammal remains display stages two and six burning (Figure 6.100). Size class two showed primarily (30.8%) stage three burning with stage four. Size class three remains recorded stages one and three burning; while size class four was limited to stage three burning. Burning was overall rare in animal bones from Profile Four, and occurred most commonly on small sized (unidentifiable) animals at a moderate intensity. It is unclear why burning should be so rare in mammals and only affect small specimens when it is more common in chelonia and aves.

Staining

Staining was particularly prevalent in mammal remains, occurring on 488 (79.5%) remains (Table 6.56); where 56.8% of the assemblage was stained. Stage one (36.5%) was the most common form of staining and higher degrees of modification were increasing rare, so that stage four was represented by a single (0.2%) mammal specimen (Figure 6.101). Staining was most common in large mammals (83%) and unidentifiable mammals (80.2%), but was also observed in small mammals (66.7%) and carnivores (57.1%) (Figure 6.102). In small mammals, stage two (33.3%) was the most common modification; while stage four was only observed in large mammals (Figure 6.103). It is unclear why staining should be so much more prevalent in mammals than other taxonomic groups. There must however, be a correlation between the high frequency of staining in mammals and in the upper parts of the deposit and the disturbed unit; both of which are dominated by mammal remains.

Abrasion

A total of 534 specimens, representing 87% of the mammal assemblage from Profile Four were abraded (Table 6.57). Four stages of abrasion were observed in mammals, with stage one (37.9%) being the most prevalent (Figure 6.104). Abrasion was most commonly observed in unidentifiable mammals (91.7%), but was also common in large mammals (57.4%), small mammals (50%) and carnivores (42.9%) (Figure 6.105). Stage three abrasion was absent in small mammals, which display a higher prevalence (16.7%) of stage two modification (Figure 6.106). Stage four was observed in large mammals and indeterminate mammals. Indeterminate mammals tended to have higher intensity abrasion and to display a greater prevalence thereof.

Sheen

Sheen was observed on 140 mammal specimens from Profile Four, representing 22.8% of mammal specimens (Table 6.58). Stage one (11.7%) sheen was most common and stage four (0.3%) was rare (Figure 6.107). Sheen was observed in large mammals, carnivores, small mammals and indeterminate mammals. Sheen was most common in small mammals (50%) but unusual in indeterminate mammals (20%) (Figure 6.108). In large mammals, stage one and stage three were the most abundant modifications (14.9%, respectively) (Figure 6.109). In carnivores, stage two (28.6%) was the most

prevalent type of sheen, while in small mammals it was stage three (33.3%). In indeterminate mammals, stage one (11.9%) was most common. Stage four sheen was only observed in large mammals.

Trampling

A total of 190 specimens, representing 30.9% of mammal remains from Profile Four displayed bone surface marks that could be attributed to trampling (Table 6.59). Trampling was observed in indeterminate mammals (31.8%), carnivores (28.6%), large mammals (27.7%) and small mammals (16.7%) (Figure 6.110). The majority of trampling in mammals was stage one (25.6%) in intensity with some stage two (4.9%) and rare stage three (0.5%) (Figure 6.111). Stage two trampling was observed in large mammals and indeterminate mammals; while stage three was exclusive to indeterminate mammals (Figure 6.112).

Carnivore Modifications

Tooth marks

Carnivore tooth marks were observed on 20 (3.3%) mammal remains from Profile Four (Table 6.60). Tooth marks were observed in all sizes of mammals but were most common (61.1%) in size class three specimens (Figure 6.113). Tooth marks were observed in large mammals, carnivores, small mammals and indeterminate mammals; but were most commonly recorded in carnivores (19%) and small mammals (16.7%) (Figure 6.114). Tooth marks were observed on the *R. paralius*, Sivatherium, herpestid, seal, *Pronolagus* and assorted indeterminate mammal remains (Table 6.61). Numerous long bone remains, as well as occasional vertebra and compact bones display tooth marks. Carnivore tooth marks were thus observed on a range of mammals from small to large, which is likely to reflect the action of different sized carnivores. It was not possible at the time of writing to analyse individual tooth mark size, but all were microscopic, not visible or barely visible with the naked eye, suggesting the action of small carnivores.

Digestive corrosion

A total of only 14 (2.3%) mammal remains from Profile Four displayed acid etching attributed to digestive corrosion (Table 6.62). All size classes of mammal, with the exception of megamammals (size class five), displayed acid etching. This modification was most commonly observed in size class three (33.3%) and size class two (30.8%) remains (Figure 6.115). Digestive corrosion was limited to indeterminate carnivore (19%) and mammal remains (1.9%) (Table 6.63). Digestive corrosion in large mammals (size class three and four) is likely the result of action or ingestion by larger carnivores.

Root Etching

A 32.2% of mammal remains from Profile Four display root etching (Table 6.64). The prevalence of root etching in mammal remains is higher than the relative percentage of this modification observed in the assemblage as a whole (26.1%), suggesting a higher susceptibility to root etching in mammal remains. It should however be noted that root etching was more common in the upper parts of the deposit (where mammals were more prevalent) than in the lower parts of the deposit. Root etching in mammals was predominantly stage one (20.8%), although stages two (8.3%) and three (3.1%) were also observed (Figure 6.116). Root etching was most prevalent in carnivores and indeterminate mammals (33.3%, respectively) and was relatively rare (16.7%) in small mammals (Figure 6.117). Small mammals displayed only stage one root etching (Figure 6.118). Stage two root etching was infrequent in large mammals (4.3%) and carnivores (4.8%) but common in indeterminate mammals (8.9%).

Insect Modifications

Mammals were the only taxonomic group from Profile Four to display modifications indicative of insect activity. Insect modifications were observed on 26 (4.2%) mammal specimens from Profile Four (Table 6.65). These remains displayed surface etching, as described by Backwell and colleagues (2012). Three stages of insect modification were observed in mammals. Insect modification was predominantly moderate in intensity with stage two occurring most frequently (53.8%) (Figure 6.119). Insect modifications were limited to spits four (7.3%) and five (1.3%) and appear to be related to disturbed areas of the deposit. Recent insect activity (burrowing) could be observed in the sediments during excavation of the deposit. Size class two, three, four and five displayed insect modifications, which were

absent from size class one mammals. Insect modifications were relatively rare in size class two (15.4%) compared to the larger mammals (>40%), perhaps indicating a greater susceptibility in the larger remains (Figure 6.120). Insect modifications in mammal remains were limited to indeterminate species (Table 6.66).

6.5 CHELONIA TAXONOMY AND TAPHONOMY

6.5.1 Taxonomic Composition of chelonia

A total of 886 chelonia specimens were recovered from Profile Four, making up 55.8% of the fossil bone assemblage (Table 6.67). The majority (43.5%) of chelonia remains from Profile Four were derived from size class two individuals (Figure 6.121). Size class four, on the other hand, had the poorest representation in the deposit. Chelonia remains were recovered throughout the deposit (Table 6.68). In general the prevalence of chelonia remains increases with spit depth, with spit six (92.7%) producing the largest relative proportion of chelonia remains (Figure 6.122). There is also a particularly high proportion of chelonia remains in the bonebed layers.

6.5.2 Anatomical Composition of chelonia

Of the 886 chelonia specimens recovered from Profile Four, 332 (37.5%) specimens were appendicular or axial skeletal elements and the remaining 554 specimens were assorted shell remains. Shell remains were subdivided into carapace (30.1%), plastron (6.4%) and indeterminate (Carapace/plastron) shell remains (26%) (Figure 6.123).

Appendicular and axial skeletal remains

Over a third (37.5%) of all chelonia remains recovered from Profile Four were derived from the appendicular or axial skeleton (Table 6.69). Figure 6.124 outlines the relative frequency of chelonia appendicular elements recovered from Profile Four. The most common appendicular elements were phalanges (20.8%). Long bones were frequent, particularly the humerus (12.3%), femur (9.6%), radius (6.3%) and tibia (6.3%) as well as innominate remains like the ilium (7.2%). Axial remains were relatively rare. Appendicular or axial elements were derived from all size classes of chelonia (Figure 6.125); but the majority were derived from size class two (53.3%) or three (40.1%) individuals. Figure 6.126 shows body size class representation of skeletal elements. Size class one remains included cranium, humerus, ilium, phalange and vertebra; while size class four elements consisted of corocoid, humerus, radius, ulna, tibia, fibula, distal phalange and long bone fragment. Appendicular remains were recovered at all depths and there is a general trend of increasing chelonia appendicular elements with increasing depth (Table 6.70,

Figure 6.127). However, chelonia appendicular remains are relatively rare in spit one (0.6%), spit six (5.1%), and spit ten (3.6%). This trend follows a general increase in the frequency of chelonia with spit depth. An analysis of MNI based on appendicular and axial remains produced an estimate of 6 individuals based on humeral elements (Table 6.71).

Shell remains

Carapace

Of the 554 shell specimens recovered in Profile Four, 267 specimens representing 30.1% of all chelonia remains were derived from the carapace (Table 6.72). The majority (16.5%) of carapace remains could not be identified to true element (Figure 6.128). Accurate attributions could be made for some remains (ex. Marginal 10) but many others were only identifiable to group (marginal/costal/neural). Marginals were the most common carapace group (59.9%), followed by neurals (12.4%) and costals (11.2%) (Figure 6.129). Marginals are thicker and denser than other carapace elements and are thus more likely to survive. In addition marginals are easier to recognise, especially once fragmented. These characters probably account for the abundance of this element. Most carapace remains were derived from small sized individuals, size class one (43.1%) and two (31.5%) (Figure 6.130). Marginals, costals and neurals were derived from all size classes of chelonia (Figure 7.131). Carapace remains were recovered from all spits but were particularly prevalent in spit nine (21.3%), spit three (15.4%) and spit seven (14.6%) (Table 6.73). Carapace remains were rare in spit one (3.3%) and very rare in spit ten (1.1%) (Figure 6.132). Carapace remains from spit ten were limited to a couple of neurals (6.1%), while spit one lacked costal remains (Figure 6.133). Costals were most common at lower levels of the deposit, particularly spits five to seven and spit nine. Marginal remains suggest an MNI of 4 chelonia shells (Table 6.74).

Plastron

A total of 57 (6.4%) specimens derived from chelonia plastra were recovered from Profile Four (Table 6.72). Plastron remains in the Profile Four assemblage included the xiphiplastron, hypoplastron, hyoplastron, entoplastron and epiplastron (Figure 6.134). The majority (56.1%) of plastron remains were not identifiable below plastron and the epiplastron (19.3%) and hypoplastron (12.3%) were the most commonly recovered plastron remains. Unlike the carapace, the majority (36.8%) of plastron remains

were recovered from size class four chelonia (Figure 6.135). Indeterminate plastron remains were recovered from all size classes of chelonia but the majority (56.3%) were derived from size class four individuals (Figure 6.136). The epiplastron also displayed all sizes of chelonia but was dominated (54.5%) by size class two remains. Entoplastron remains were derived from large (size class three and four) chelonia; while hyoplastron remains were derived from size class one and three. All xiphiplastron remains were derived from size class two chelonia and hypoplastron remains originated from size classes one, three and four. Plastron remains were recovered from all levels (Table 6.75) but were most common (24.6%) in spit nine, due to the associated plastron (Figure 6.137); while spits six, eight and ten show a distinct lack of plastron remains. Xiphiplastron remains were only recovered in spit nine, while entoplastron remains were recovered in spits three and four (Figure 6.138). Epiplastron elements indicate an MNI of five for plastron remains (Table 6.76). Thus there is a minimum of six chelonia represented in Profile Four, based on humeral remains.

Indeterminate shell remains

A total of 26% of all chelonia remains from Profile Four were indeterminate (Plastron/carapace) shell pieces (Table 6.72). Indeterminate shell remains were primarily derived from size class two and one individuals (Figure 6.139). Spit eight and nine produced the largest assemblage of indeterminate shell remains, which were relatively rare in spit ten (Figure 6.140).

6.5.3 Bone Size Frequency Distribution and Fragmentation Pattern of chelonia

Maximum length

On average, maximum diameter of chelonia remains from Profile Four measured 17.5 mm (Table 6.77). There is however a substantial difference in mean diameter between body size classes. The smallest chelonia specimen recovered was 4 mm in length, while the largest was 77 mm. In the histogram of the combined chelonia sample, the majority of remains are 10 mm to 50 mm in length with peaks at 15 mm and 10 mm (Figure 6.141). A number of larger outliers are observable. In the chelonia size class one sample maximum length was limited to between 10 mm and 20 mm, with most remains displaying smaller sizes (Figure 6.142). Size class two remains display maximum length between 5 mm and 40 mm with occasional larger outliers, of up to 65 mm (Figure 6.143). Size class two remains display peaks

around 15 mm, 10 mm and 20 mm. Maximum lengths in size class three chelonia remains were clustered between 10 mm and 50 mm with peaks between 15 mm and 30 mm (Figure 6.144). Occasional larger specimens were observed in size class three remains. Large chelonia (size class four) display a range of sizes from 10 mm and 55 mm but with most remains clustered between 25 mm to 35 mm (Figure 6.145).

Completeness

A total of 129 specimens, representing 14.6% of the chelonia assemblage from Profile Four were recovered complete (Table 6.78). A total of 98 (76%) of these remains were appendicular or axial, 28 (21.7%) were carapace and only 3 (2.3%) were plastron elements. In the appendicular skeleton completeness was mostly observed in phalanges (69.8%), although tarsals/carpals, vertebra and a femur and tibia elements were also recovered complete. Completeness was observed in neurals, costals and marginals as well as the epiplastron. The majority of complete remains were derived from size class two chelonia (Figure 6.146). Size class four produced very few (3.9%) complete remains. Complete chelonia remains were recovered from all layers except spit one (Table 6.79). Completeness in chelonia remains is generally low in the upper parts of the deposit but increases with spit depth (Figure 6.147). Complete plastron elements were only recovered from spit nine, which also produced the majority (42.9%) of the carapace remains (Figure 6.148). The majority (26.5%) of the appendicular remains were derived from spit eight.

Breakage Pattern

Table 6.80 displays the breakage categories observed in chelonia appendicular and axial remains from Profile Four. Phalange remains were all recovered complete. Other long bones were mostly represented by shaft (22.3%) fragments or proximal (19.6%) remains. Scapula remains were most commonly represented by the dorsal parts, while in the coracoid the shaft was more commonly recovered. The majority of vertebral remains were represented by the centrum. Cranium and mandible remains were predominantly fragmentary.

Fracture Shape - Outline

Appendicular skeleton

Fracture outline could be assessed for 228 (34.3%) chelonia long bones out of a possible 664 (Table 6.81). They displayed spiral, transverse (16.2%), splintered (2.6%), eroded (4.8%) and irregular (0.4%) fracture outlines, although the vast majority (75.9%) were spiral breaks (Figure 6.149) indicative of the bones being broken whilst still "fresh" with collagen still in the bone matrix. Transverse breaks were also prominent while splintered, eroded and irregular were rare. Larger (size class three and four) chelonia displayed higher relative prevalence (41.7%, 42.3%; respectively) of long bone ends on which fracture outlines could be diagnosed (Figure 6.150). Splintered and irregular breaks were limited to size class three chelonia. Eroded breaks were observed in size class two and four chelonia, while transverse and spiral breaks were observed in all sizes of chelonia. Fracture outlines were more prevalent in the upper parts of the deposit and spiral breaks were observed at all levels (Table 6.82). Transverse breaks were common in spits two, three and four and were also observed in spits five, seven, eight, nine and ten (Figure 6.151). Splintered breaks were observed in spits two, five, eight and nine. Eroded breaks occurred in spits four to nine and irregular breaks were limited to spit nine. Thus, the majority of chelonia appendicular remains were broken while fresh, but breaks indicative of fracturing in dry or weathered bones were also observed. Fractured edges rarely appeared eroded from sedimentary movement.

Chelonia shell

A total of 554 (50%) fracture outlines on shell remains were analysed in this study out of a possible 1108 (Table 6.83). Fracture outlines observed in chelonia shell remains from Profile Four include spiral, transverse, splintered, eroded and irregular breaks (Figure 6.152). The majority of fracture outlines were spiral (66.1%) breaks; transverse (30%) breaks were common while splintered (0.9%), eroded (2%) and irregular (1.1%) breaks were infrequent. Identifiable fracture outlines were most prevalent in larger, size class three (54.1%) and four (53.4%), chelonia shell remains (Figure 6.153). Fracture outlines in size class four chelonia were limited to spiral and transverse breaks. Irregular breaks were limited to size class three remains. There was a high frequency of fracture outlines in spit one, thereafter the relative percentage of fracture outlines was consistent irrespective of spit (Table6.84). Splintered breaks were observed in spits one, six and nine, while irregular breaks were observed in spits one, four and nine

(Figure 6.154). Eroded breaks were observed in spits two, three and four and spits seven, eight, nine and ten. Fracture outlines in chelonia shell remains compare favourably with the appendicular sample, although more breaks could be analysed in the shell assemblage than the appendicular. The shell assemblage also displayed a greater relative frequency of transverse breaks.

Fracture shape - Angle

Appendicular skeleton

Of the 664 possible long bone ends, a total of 243 (36.6%) fracture angles were classified (Table 6.85). Oblique, right and mixed fracture angles were observed in chelonia appendicular remains (Figure 6.155). Oblique (35.8%) and mixed (35%) fractures occur with equal abundance, while right angles (29.2%) were less common. Fracture angles were least prevalent in size class two remains, which were dominated (13.6%) by oblique angles (Figure 6.156). In all other sizes of chelonia long bones, mixed angles were the most common. Fracture angles were generally more prevalent in the upper part of the deposit, with spit three producing the highest percentage (53.6%) of fracture angles (Table 6.86). Spit one produced only mixed angle breaks, while spit six lacked right angles (Figure 6.157). Fracture angle in chelonia appendicular remains provided conflicting results; fresh breaks (oblique) were slightly more common than dry (right) breaks but a large number of remains displayed mixed breaks.

Chelonia shell

Fracture angles on chelonia shell remains were recorded for 558 (50.4%) specimens out of a possible 1108 shell ends in Profile Four (Table 6.87). The most commonly occurring fracture angle type in chelonia shell remains was right angles (49.3%), followed by mixed (32.6%) with occasional oblique (18.1%) breaks (Figure 6.158). This would suggest a greater degree of breakage occurred when bones were dry, but this is by no means conclusive. Size class four chelonia shell specimens display the highest prevalence for fracture angles (Figure 6.159). The relative frequency of oblique, right and mixed breaks was consistent between size classes. Fracture angle prevalence was high in spit one and low in spits nine and ten (Table 6.88). Spit ten, in addition, displayed a particularly low prevalence of mixed breaks (Figure 6.160). Fracture angles in chelonia shell remains differed from those of appendicular remains. More fracture angles in chelonia shell could be categorised than in the appendicular sample. Right angle

fractures were most common in the shell sample but were uncommon in the appendicular sample. It must be noted however, that fracture angles have been generally inconclusive at Langebaanweg. Thus chelonia shell remains do preserve fracture shape, and in the absence of long bones can be used to measure the timing of bone fracturing. But these remains do differ slightly from long bones and caution must be utilised in dealing with these remains until such time as we have a better understanding of why these samples differ.

6.5.4 Surface Modifications of chelonia

Bone Weathering

Weathering was observed on 133 (15%) chelonia remains from Profile Four (Table 6.89). Weathering in chelonia remains was limited to stage one (7.8%) or stage two (3.6%) modification. Weathering was most commonly observed on the plastron (29.8%), carapace (15.2%), indeterminate shell remains (14.3%) and appendicular or axial skeleton (11.4%) (Figure 6.161). The plastron displays a high relative frequency (29.8%) of weathering compared to the other skeletal parts, despite showing particularly low levels of stage two modification. A total of 11.4% (38) of the chelonia appendicular and axial skeleton were affected by weathering (Table 6.90). Weathering was observed in scapula, humerus, radius, ulna, ilium, ischium, femur, phalange, vertebra elements, as well as long bone fragments. Weathering was most commonly observed in long bone fragments (33.3%), femur 31.3(%) and scapula elements (30%) (Figure 6.162). Stage two weathering was observed in all appendicular remains except the ulna, ilium and ischium. In the case of the vertebra, stage two was the only weathering observed. In chelonia shell remains the relative frequency of weathering increased with body size class (Table 6.91, Figure 6.163). Similarly, the relative frequency of stage two weathering increased with body size class. This indicates larger chelonia were probably sub-aerially exposed for longer periods than smaller chelonia.

Burning

A total of 67 chelonia remains display burning damage, representing 7.6% of the chelonia assemblage from Profile Four (Table 6.92). Stages one (2%), two (3.7%), three (1.1%), four (0.6%) and five (0.1%) burning were observed in chelonia; with stage two most common and higher intensity burning relatively rare (Figure 6.164). Burning was observed in appendicular and axial skeletal remains, carapace elements

and indeterminate shell remains, but was absent from plastron elements (Figure 6.165). Indeterminate shell remains display the highest (10.9%) relative prevalence of burning and were dominated by stage two modification (Figure 6.166). Stage four burning was observed in carapace and indeterminate shell remains and stage five was only recorded in the appendicular skeleton. A total of 8.1% of the appendicular and axial skeleton in chelonia displayed burning (Table 6.93). Appendicular and axial chelonia remains displayed stage one, two, three and five burning, but not stage four. Burning was observed in the forelimb, hindlimb, autopodium and even in the pelvic girdle and vertebra (Figure 6.178). Burning modification in the latter elements would suggest the modification occurred after death and dismemberment, while remains were exposed on the surface. Burning was most prevalent in the humerus (22%), tibia (14.3%) and radius elements (14.3%). Stage five burning was limited to humeral remains (Figure 6.168). Stage three was observed in humerus, ilium, femur and tibia elements. Burning was observed in all size classes of chelonia shell (Table 6.94), but was most prevalent in size class two (15.9%) and three (19.4%) and rare in size class four (1.7%) remains. Size class four shell remains displayed only stage one burning (Figure 6.169). Stage four and five burning were observed in size class one and two remains. The vast majority (90%) of burning was observed on both sides of shell remains rather than being limited to the inner (5%) or outer (5%) surface (Table 6.95) also indicating bones were disarticulated before burning.

Staining

A total of 37.8% (335) of chelonia remains from Profile Four display post-depositional staining (Table 6.96). Stages one, two and three staining were observed in chelonia remains, while stage four staining was absent (Figure 6.170). The majority of staining was light (stage one, 27.2%), and stage three staining was rare (1.8%). Staining was observed in the appendicular and axial skeleton, the carapace and indeterminate shell remains, but was not recorded in the plastron elements (Figure 6.171). It was most prevalent in the carapace (49.1%) and indeterminate shell (44.3%) remains. The appendicular and axial skeleton, carapace and indeterminate shell remains all display staining from stage one to stage three in intensity. The relative percentage of stage two staining was low (5.1%), and stage three high (3.3%) in the appendicular and axial skeleton.

A total of 102 specimens, representing 30.7% of the appendicular and axial skeleton displayed staining (Table 6.97). Staining was observed in forelimb, hindlimb, shoulder girdle and pelvic girdle, autopodial

elements, vertebra and even mandible elements (Figure 6.123). Staining prevalence was high (>=50%) in many remains, including mandible, ischium and tarsal/carpals, but prevalence was greatest in pubis (75%) and scapula remains (70%). Stage three staining was observed in mandible, humerus, femur, phalanges and vertebra (Figure 6.173). Few elements displayed both stage two and three staining, it was usually stage one with either stage two or stage three. Elements that displayed both stages include femur, phalange and humerus. Staining was observed in all sizes of chelonia shell (Table 6.98) and generally the prevalence thereof increased with body size, so that size class one shell remains had a low (38.9%) relative frequency of staining (Figure 6.174). Stage three staining was absent in size class one shell remains. Staining is highly common in chelonia (although less abundant than in mammal remains) but is mostly low in intensity. Staining is a post-depositional process and it is unclear why it should be more prevalent in larger sized remains. Nor is there any discernable reason why staining should be absent from plastron remains. The sample size of plastron elements is small and this may be skewing the results for this part of the skeleton.

Abrasion

Abrasion was highly prevalent in chelonian elements, occurring on 727 (82.1%) of the remains from Profile Four (Table 6.99). Stage one to four abrasion were recorded in chelonia remains with stage one (41.6%) most common and stage four (2.1%) rarely occurring (Figure 6.175). Abrasion was observed in all chelonia parts, but was most common in indeterminate shell (88.3%) and plastron (82.5%) elements (Figure 6.176). In all chelonia parts, stage one was the most common abrasion modification (Figure 6.177). Stage four abrasion was observed in all chelonia parts but was particularly common in plastron and indeterminate shell remains. A total of 81.9% of appendicular and axial remains display abrasion (Table 6.100). Abrasion was observed in all chelonia appendicular or axial elements except the cranium, but was most prevalent in ischium, middle phalange and in long bone fragments (Figure 6.178). The mandible and tarsal/carpals displayed a low (50%) relative frequency of abrasion compared to all other remains. Stage one was the most commonly observed abrasion type and only two elements (middle phalange, tarsal/carpal) did not show stage one abrasion (Figure 6.179). Stage four abrasion was limited to scapula, humerus, femur, tibia and long bone fragments. Abrasion was observed (at a high frequency) in all size classes of chelonia shell remains (Table 6.101), although size class three remains display the lowest (69.4%) relative prevalence of abrasion (Figure 6.180). Stage one abrasion dominated size class one and two shell remains (Figure 6.181). More intense levels of abrasion (stage three and four)

occurred with greater relative frequency in larger size classes (three and four) of shell remains. Larger, more robust bones are more resistant to destruction and have the potential to withstand greater levels of destructive modification like abrasion, which may be why abrasion intensity and frequency increases with body size class.

Sheen

Sheen or polishing was observed on 192 chelonia specimens, representing 21.7% of the Profile Four chelonia assemblage (Table 6.102). Sheen was most prevalent on appendicular and axial remains (26.8%) and on indeterminate shell (22.2%) remains, but was also observed on carapace and plastron elements (Figure 6.182). The majority (14.9%) of chelonia remains display stage one sheen (Figure 6.183). Stage two (4.4%) and three (2.4%) sheen were also observed in chelonia remains, but stage four was absent. Stage three sheen was observed in the appendicular and axial skeleton, carapace and indeterminate shell remains (Figure 6.184). Sheen in the chelonia appendicular and axial skeleton was observed in the forelimb, hindlimb, pelvic girdle, shoulder girdle, mandible, vertebra and some phalanges (Table 6.103, Figure 6.185). The prevalence of sheen was highest in mandible, pubis and scapula elements. All appendicular and axial remains displayed stage one sheen. Stage three was observed on scapula, humerus, radius, ilium, ischium, femur and fibula elements. Sheen was observed in shell remains from size class one, three, two and four (Table 6.104) and was most prevalent (16.3%, 20.7%; respectively) in the latter two size groups (Figure 6.186). Stage three sheen was observed on remains from size classes two, three and four. Appendicular, and to a lesser extent, axial elements are the first parts of a chelonia skeleton to become separated during the disarticulation phase of decomposition.

Trampling

A total of 28.2% (250) of chelonia remains from Profile Four display trampling marks (Table 6.105). The majority of trampling in chelonia remains was stage one (24.3%) in intensity, although stage two (3.8%) and rare stage three (0.1%) were also observed (Figure 6.187). Trampling was highly prevalent in plastron (45.6%) remains, but was also observed in carapace (27.7%), indeterminate shell (31.7%) and appendicular and axial (23.2%) elements. Stage three trampling was limited to a single carapace

element. Trampling was observed in numerous (77, Table 6.106) chelonia appendicular and axial remains including corocoid, scapula, humerus, radius, ulna, ilium, ischium, pubis, femur, tibia, fibula, phalange and vertebra (Figure 6.188). Trampling was particularly prevalent in scapula (50%), radius (47.6%) and ilium (41.7%) and was rare in phalange remains (5.7% and 1.4%, respectively). All chelonia appendicular and axial remains display stage one trampling and stage two was observed on scapula, humerus, radius, ilium, femur, tibia, and long bone fragments (Figure 6.189). Trampling was observed on shell remains from all size classes of chelonia (Table 6.107). In general, the prevalence of trampling marks increases with body size class (Figure 6.190). Stages one and two were observed in all sizes of chelonia shell, however stage three was limited to a single size class four specimen. The relative proportion of stage two modified remains was, in addition, substantially higher in the size class four remains.

Carnivore Modifications

Tooth marks

A total of 35 chelonia specimens displayed tooth marks, representing 4% of the chelonid assemblage from Profile Four (Table 6.108). Tooth marks were observed in the appendicular and axial skeleton, the carapace, plastron and indeterminate shell remains (Figure 6.191). Tooth marks were most common in the plastron (7%), followed by the carapace (4.9%) and appendicular and axial (4.5%) skeleton, and relatively rare in indeterminate shell (1.3%) remains. Tooth marks were observed on 4.5% of appendicular and axial remains including mandible, scapula, humerus, radius, ilium, ischium, femur, tibia, phalange, vertebra and long bone fragments (Table 6.109). Tooth marks were most prevalent in the ischium (12.5%), scapula (20%) and mandible (50%). Tooth marks were observed in all size classes of chelonia (Table 6.110), but were most prevalent in size class three (18.4%) remains. Tooth marks were relatively common in size class four (8.6%) and two (4.3%) and were rare in size class one (1.6%) specimens (Figure 6.192). These results indicate a small proportion of the Langebaanweg chelonia were predated. The predominance for tooth marks on shell remains may reflect efforts by the carnivores to open the shell. Limb elements may then have been swallowed whole or close to whole and are thus unmarked.

Digestion

Digestion was likewise rare in the chelonia assemblage, occurring on only 32 (3.6%) of chelonid remains (Table 6.111). Digestions was most commonly observed on the appendicular and axial skeleton (7.8%), although it also occurs on carapace, plastron and indeterminate shell remains (Figure 6.193). This appears to indicate that while limbs were ingested, most of the shell was probably discarded once all soft parts were removed. Appendicular remains affected by digestion include coracoid, humerus, radius, ilium, pubis, femur, tibia, fibula, tarsal/carpals, phalange and vertebra (Table 6.112). Digestion was most prevalent in tarsal/carpals (50%), pubis (25%) and coracoid (20%) elements (Figure 6.194). Size class three (14.3%) chelonia remains were most extensively affected by digestion, although the modification was observed in all sizes of chelonia (Table 6.113, Figure 6.195). Size class one (1.6%) displayed a low relative percentage of digestive corrosion. It could be expected that size class one chelonia would be heavily predated, although the evidence here does not support that hypothesis. This is most likely a factor of small sample size in the size class one chelonian from Profile Four.

Root etching

A total of 23.7% (210) of chelonia remains from Profile Four displayed root etching (Table 6.114). The majority of chelonia remains display stage one (16.9%) root etching although stage two (6.1%) and rare stage three (0.7%) were also observed (Figure 6.196). Root etching was observed in the appendicular and axial skeleton, carapace, plastron and indeterminate shell remains (Figure 6.197). Root etching was most common in indeterminate shell (33.9%) and carapace (28.8%) remains. Stage one and two root etching were observed on appendicular and axial skeleton, carapace, plastron and indeterminate shell remains, while stage three was limited to the appendicular and axial skeleton and the carapace (Figure 6.198). Plastron remains display a particularly low prevalence (1.8%) of stage two modification. A 13.6% of appendicular chelonia remains displayed root etching (Table 6.115). These include elements of the forelimb, hindlimb, shoulder and pelvic girdle and autopodium (Figure 6.199). Note the absence of root etching on axial remains. Root etching was most prevalent in the ilium (33.3%), scapula (30%), ischium (25%) and pubis (25%). Stage three root etching was observed on the femur, ilium and humerus (Figure 6.200). Stage two was observed on coracoid, humerus, ulna, ilium, ischium, femur, tibia and phalange elements. Root etching was observed in all size classes of chelonia shell (Table 6.116), but was most

prevalent in size class three (39.8%) remains (Figure 6.201). Stage three root etching was limited to size class three remains.

6.6 AVIAN TAXONOMY AND TAPHONOMY

6.6.1 Taxonomic Composition of Aves

A total of 49 avian specimens were recovered from Profile Four, representing only 3.1% of the total assemblage (Table 6.117). Size class one, two, three and four aves were recovered in Profile Four, although the majority (51%) of remains were derived from size class three individuals (Figure 6.202). Remains from three avian families were identified in Profile Four, these include Ciconiidae (2%), Phasianidae (8.2%) and Sphenicidae (2%); the majority (87.8%) of avian remains could not be identified to family level and were left as aves indeterminate (Figure 6.203). Aves remains were recovered from all spits, except spit one (Table 6.118). Aves were rare in spits two (2.1%) and six (4.3%), and the lower parts of the deposit (below spit six) seems to have less avian remains than the upper parts (Figure 6.204). The exception being spit eight (23.4%) which displayed the highest prevalence of avian remains. Ciconiidae remains were recovered from spit ten, Sphenicidae from spit eight and Phasianidae remains were recovered in spits four (50%), seven (25%) and nine (25%). Ciconiidae were represented by a single specimen from a large (size class three) wading bird. A number of Ciconiidae species have been described from Langebaanweg previously including *Ciconia kahli*, *Geronticus apelex* and *Threskiornis* aff *aethiopicus* (Olson 1985b; Haarhoff 1988; Manegold *et al*. 2013). There is a strong likelihood that the Ciconiidae recovered from Profile Four represents one of these species, but it was not possible at this time to investigate this further. Phasianidae remains are common at Langebaanweg with over 500 specimens of *Francolinus* sp. recorded (Manegold *et al* 2013), along with at least two other species (*Dendroperdix* aff. *Sephaena* and cf. *Coturnix* sp.) (Rich 1980; Hendey 1981; Crowe 1992; Manegold *et al.* 2013). In Profile Four, four specimens were assigned to the family Phasianidae. Future research by specialists will however be needed to identify the species of these remains. A single penguin (Sphenicidae) specimen was recovered from Profile Four. At least four species of penguin have been recorded from Langebaanweg (*Inguza predemersus*, *Dege hendeyi*, *Nucleornis insolitus*, *Palaeospheniscus*? *Huxleyorum*) and more research will be needed to assign this specimen to one of these species (Simpson 1971;Simpson 1973; Simpson 1979a; Simpson 1979b; Olson 1983; Olson 1985a; Ksepka & Thomas 2012). Bones from a single individual each of Ciconiidae and Sphenicidae were recovered in Profile Four (Table 6.119). The Phasianidae, on the other hand, were represented by at least two individuals. In the indeterminate aves sample a MNI of three was calculated based on coracoid remains. This would indicate a total avian MNI of seven for Profile Four, but it must be remembered that

any of the indeterminate aves remains may be derived from one of the other avian families. Thus an MNI of four is considered, in this case, to be the most accurate estimation.

6.6.2 Anatomical Composition of Aves

Table 6.120 displays the anatomical composition of avian remains from Profile Four. Ciconiidae were represented by a size class three tibia; while the Sphenicid was represented by a size class four ulna. All Phasianidae remains were derived from size class three individuals and include coracoid, humerus and ulna remains; this material was derived from different depths and is unlikely to represent a single individual. Skeletal elements observed in the indeterminate aves sample include coracoid, scapula, humerus, radius, ulna, innominate, tibiotarsus, tarsometatarsus, tarsal/carpal, synsacrum, cervical vertebra, thoracic vertebra, vertebra and long bone fragments (Figure 6.205). The most commonly occurring avian elements were the tibiotarsus and tarsometatarsus (14.3%, respectively); the coracoid, humerus and long bone fragments were also frequent (8.2%, respectively). These are among the most robust of avian bones. Size class one indeterminate aves remains were represented by coracoid, cervical vertebra and vertebra (Figure 6.206). Size class two by coracoid, humerus, innominate, tibiotarsus, thoracic vertebrae and vertebra elements. Size class four remains included radius, ulna, tibiotarsus, tarsometatarsus, tarsal/carpal, and long bone fragments. Size class three was extensive. Avian elements were found at most depths and there does not appear to be any noticeable patterns in element distribution by spit (Table 6.121).

6.6.3 Fragmentation Profile of Aves

Maximum length

The mean maximum radius of avian specimens from Profile Four was 18.4 mm (Table 6.122). The largest avian specimen measured 44 mm, while the smallest recorded was 9 mm. The bulk of the Profile Four aves specimens were clustered between 10 mm and 35 mm, with a peak at 15 mm (Figure 6.207). Larger specimens (between 35 mm and 45 mm) were also observed.

Fusion

Fusion could be characterised on a total of 25 specimens, representing 51% of the Profile Four avian fauna. All of the specimens were coded as adults, no remains from juveniles or subadults were recovered. Indicating (as observed in the mammal assemblage) a catastrophic mortality profile (Klein 1982).

Completeness

Only three (6.1%) avian specimens were recovered complete (Table 6.123). These were the Sphenicid ulna, Ciconiid tibia and a large (size class four) tarsal/carpal from an indeterminate bird. The Sphenicid was recovered from spit eight while the remaining complete specimens were recovered from spit ten. The low number of complete bones, along with the small average size of specimens indicates a high degree of fracturing in avian remains from Profile Four.

Breakage Profile

Breakage categories in avian remains from Profile Four are displayed in Table 6.124. Long bones were represented by complete specimens as well as proximal parts, distal parts or shaft fragments. Distal ends were the most commonly (48%) occurring breakage category in avian long bones. The majority of coracoid, scapula and innominmate remains were represented by dorsal (77.8%) parts as opposed to shaft (22.2%) remains; ventral parts were not observed. Vertebral remains were either complete (14.3%), fragmentary (71.4%) or represented by parts of the centrum (14.3%).

Fracture Outline

Fracture outlines were categorised on 39 (52.7%) avian long bone ends from Profile Four (Table 6.125). Fracture outlines observed in avian remains include spiral, transverse and eroded breaks. Spiral breaks make up the vast majority (87.2%) of fracture outlines and eroded breaks were rare (2.6%) (Figure 6.208). Size class two and three displayed relatively high prevalence of fracture outlines (57.1%, 55.3%; respectively). Transverse breaks were observed on size class three and four aves, while eroded breaks

were limited to size class two remains (Figure 6.209). Fracture outlines could be characterised from all spits, excluding in spit one, from which no avian remains were gathered (Table 6.26). In general, more fracture outlines could be characterised in the upper parts of the deposit than the lower, with spit 6 producing the highest (75%) prevalence thereof (Figure 6.210). Transverse fracture outlines were observed in spits four and five, while eroded breaks were limited to spit six. Thus, the majority of avian bones were fractured while fresh, although dry breaks and rare erosion of breaks also occurred.

Fracture Angle

Fracture angle was characterised on 42 (56.8%) avian specimens from Profile Four (Table 6.127). The majority of these remains display mixed (50%) breaks although oblique (28.6%) and right (21.4%) angled breaks were also observed (Figure 6.211). Size class two (57.1%) and three remains (60.5%) display the greatest prevalence of fracture angles, and were the only remains with oblique fractures (Figure 6.212). Size class one avian remains displayed only right angled fractures, which were observed in all other size classes. Mixed breaks were observed in size class two, three and four. Spit five (70%) and six (75%) display the highest prevalence of fracture outlines (Figure 6.213). Oblique fractures were observed in spits three, four, five, seven, eight and ten. Right angles fractures were observed in spits two to six, eight and nine. Finally mixed fractures were observed in all levles except spit two, and were highly prevalent, particularly in the lower parts of the deposit. Fracture angle patterns in aves were thus inconclusive.

6.6.4 Surface Modifications of Aves

Weathering

A total of 3 specimens, representing 6.1% of the avian assemblage displayed weathering, all of it limited to stage one. Weathering in aves was observed in spits four, seven and ten; on remains derived from size class one, three and four individuals. These specimens were all indeterminate aves; and elements modified include ulna, humerus and cervical vertebra. There was thus, very little sub-aerial exposure of avian bones, much less than observed in mammals or chelonia.

Burning

Burning in aves was limited to 4 specimens, representing 8.2% of the avian assemblage. Stages three (25%), four (15%) and five (50%) burning were observed in aves. Size class one, three and four (50%) aves displayed burning and these remains were derived from spits three, eight (50%) and nine. The majority (75%) of burning was observed on long bone fragments although a single coracoid was also modified. Burning was infrequent in bird remains but displayed a greater intensity than observed in mammals or chelonia.

Staining

Staining was observed in 22 or 44.9% of avian remains from Profile Four (Table 6.128). Stage three (18.4%) staining was the most common form, although stage two (12.2%) and one (10.2%) were also prevalent; stage four (4.1%) was rare (Figure 6.214). Staining was most prevalent in size class two avian remains, but was observed in all sizes (Figure 6.215). Size class one aves displayed only stage one staining (Figure 6.216). In size classes two and four, staining was limited to stages two and three. Size class three aves displayed all stages of staining, although stage one was most common. The high frequency of staining in aves is probably correlated to the frequency of this modification in the upper parts of the deposit where aves were most common. The high intensity of staining in aves (compared to mammals and chelonia) suggests these remains were more susceptible to this type of modification.

Abrasion

Abrasion was high in avian remains with 67.3% (33) of specimens displaying this modification (Table6.129). Aves remains displayed abrasion up to a stage three intensity, although the majority of specimens were modified to a stage one (36.7%) or two (28.6%) (Figure 6.217). Abrasion was absent in size class one aves. Generally, abrasion frequency increased with body size class, to the point where 90.9% of size class four remains displayed abrasion (Figure 6.218). Stages one and two abrasion were observed in all size classes (size class two, three and four); while stage three abrasion was limited to a single (4%) size class three specimen (Figure 6.219). Abrasion, while still common in aves, was less frequent than observed in mammals and chelonia. Additionally, abrasion was more prevalent on larger avian remains.

Sheen

A total of 27 specimens, representing 55.1% of the avian assemblage displayed sheen or polish modification (Table 6.130). Sheen was most prevalent in size class one (66.7%) specimens, but was also recorded at lower frequencies in size class two (60%), three (60%) and four (36.4%) (Figure 6.220). Stage one (20.4%), two (14.3%) and three (20.4%) sheen was observed in aves (Figure 6.221). Stage one sheen was observed in size classes one, two and three; while stages two and three sheen were observed in size classes two, three and four (Figure 6.222). Size class one aves displayed only stage one sheen. Aves display particularly high frequency of sheen and generally the intensity of sheen increased with body size class. This suggests that the aves bones from Profile Four underwent hydrodynamic processes.

Trampling

Trampling was observed in 16 (32.7%) avian specimens from Profile Four (Table 6.131). Avian remains display stage one (18.4%) and stage two (14.3%) trampling, while stage three was absent. The vast majority (90%) of avian remains which displayed trampling marks were derived from size class two, although size classes three (20%) and four (18.2%) were also affected (Figure 6.223). Stage two trampling was observed in size classes two and three but not size class four. Size class two avian remains were dominated (60%) by stage two trampling.

Carnivore Modifications

Tooth marks

Tooth marks were common in avian bones, with total of 19 specimens, representing 18.4% of avian remains modified (Table 6.132). Tooth marks were observed on the Ciconiid tibia, and the Phasianid coracoid and ulna. Additionally, tooth marks were recorded on indeterminate aves elements including coracoid, tibiotarsus, tarsometatarsus and cervical vertebra. This indicates that many of the aves from Langebaanweg were predated.

Digestive corrosion

Digestive corrosion, on the other hand, affected 5 (10.2%) avian specimens (Table 6.133). Digested aves bones include the Ciconiid tibia, the Phasianid coracoid and ulna, cervical vertebra and vertebra from indeterminate aves. Digestion and tooth marks appear simultaneously on a number of avian bones. Digestion was always of a low intensity.

Root Etching

Root etching affected 7 (14.3%) avian remains from Profile Four (Table 6.134).The majority of root etching in avian remains was stage one (8.2%) in intensity, although stage two (4.1%) and three (2%) root etching were also observed (Figure 6.224). There was a high relative frequency (33.3%) of root etched remains in size class one; while in size class three (8%) root etching was uncommon (Figure 6.225). Stage two root etching was recorded on size classes three and four aves, while stage three was limited to size class two avian bones (Figure 6.226). It is unclear why root etching should be less prevalent in aves than mammals or chelonia.

6.7 PISCES TAXONOMY AND TAPHONOMY

6.7.1 Taxonomic Composition of Pisces

A total of 32 specimens attributable to Pisces were recovered from Profile Four, representing 2% of the total assemblage. These remains were equally distributed between small (size class one) and medium (size class two) specimens. Fish remains were recovered from spits two, four, five, seven, eight, nine and ten (Table 6.135). The majority of fish specimens were recovered from spits eight (25%) and nine (37.5%) (Figure 6.227). This would suggest that fish were more common in the bone bed layers.

6.7.2 Anatomical composition of Pisces

Piscatorial elements from Profile Four include maxilla (3.1%), mandible (3.1%) and numerous vertebra elements (93.8%) (Table 6.136). The maxilla and mandible were derived from size class one fish, respectively; while the vertebral remains were evenly divided between the two body sizes. The mandible and maxilla were both recovered in spit nine; which also produced the bulk (37.5%) of the vertebra remains (Table 6.137). Numerous piscine elements have been recovered from Langebaanweg, but only the cartilaginous fish (sharks, skates, rays) have received expert attention. Fish from the families Sparidae (mussel-crackers) and Tachysuridae (catfish) have been previously identified in the deposit. It is likely that there a much greater diversity of ray-finned fish, but the subject requires the attention of an expert. At this point it is not even possible to identify whether the fish remains from Profile Four are marine or freshwater taxa, which is unfortunate as this information would be beneficial in exploring the origins of marine mammals and birds preserved in the site.

6.7.3 Bone Size Frequency Distribution and Fragmentation Profile of Pisces

Fusion, breakage category and fracture shape (outline and angle) could not be assessed in piscine remains due to the lack of long bones and the fragmentary nature of the recovered specimens.

Maximum Length

Piscine bones were small, with a mean diameter of remains from Profile Four of just 7.4 mm (Table 6.138). The maximum recorded length of any fish bones was 17 mm and most remains cluster around 10 mm in length (Figure 6.228).

Completeness and Breakage

A total of 46.9% of fish remains, all vertebra elements, were recovered complete. All other remains were fragmented. Of these complete remains 53.3% were derived from size class one, the remainder from size class two. Complete fish remains were recovered from spits four (6.7%), five (20%), seven (6.7%), eight (33.3%), nine (26.7%) and ten (6.7%). All (2) fish remains from spit two were fragmented.

6.6.4 Surface Modifications of Pisces

Piscine bones did not display any carnivore modifications including both tooth marks and digestion. Nor did they show any root etching modification.

Weathering

A total of 3 piscine specimens, representing 9.4% of the fish assemblage from Profile Four displayed weathering. All weathering in pisces remains was stage one in intensity and weathering only affected larger (size class two) specimens. Weathered fish remains were derived from spit five and nine (66.7%). Fish remains can only become weathered if they have been sub-aerially exposed. This could only occur if the water source (be it a pond or river) dried up and fish were left stranded on the surface. Lithology does not appear to support period drying of the deposit. Alternatively, fish individuals can be removed from the source by a predator and their bones left exposed on the surface after feeding can become weathered (or even burnt, see below); however fish remains show no indication of carnivore modifications. A lack of digestive etching or carnivore tooth marks cannot be taken as proof of absence however. Bones thus exposed on the surface, could at a later date become incorporated into the deposit

through surface runoff. If this is the case then we cannot assume that the piscine remains from Profile Four reflect a resident population.

Burning

A single specimen, representing 3.1% of piscine specimens from Profile 4 displayed burning. This size class one bone was modified to stage three intensity.

Staining

Staining was observed in 12 (37.5%) piscine specimens from Profile Four (Table 6.139). The majority (50%) of these specimens were derived from size class two. Fish remains from spit four, eight, nine and ten displayed staining (Figure 6.229). Staining in fish remains was more prevalent in spit four than in lower spits.

Abrasion

A total of 26 (81.3%) piscine specimens from Profile Four display abrasion (Table 6.140). Abrasion was evenly distributed across remains from both size class one and size class two. The majority of abrasion in piscine bones was stage one (59.4%) in intensity, although stage two (12.5%) and three (9.4%) were also observed occasionally (Figure6.230). All three stages of abrasion were observed in both size class one and two, although the more intense modifications were relatively more frequent in size class one (Figure 6.231). The high prevalence of abrasion in fish remains indicates that they underwent transport or movement in an aquatic system after death. However, intensity was low indicating transport was short or there was low energy in the system.

Sheen

Sheen or polishing was observed in 2 (6.3%) piscine specimens from Profile Four. Sheen in fish remains was limited to stage one and was observed in both size class one and size class two. Sheen, like abrasion, is indicative of movement, but it is interesting that there is much less sheen or polishing than abrasion.

Trampling

A single fish specimen, representing 3.1% of piscine remains from Profile Four displayed trampling marks. This size class two bone displayed stage two modification.

6.8 REPTILE TAXONOMY AND TAPHONOMY

6.8.1 Taxonomic Composition of Reptilia

A total of 8 reptilian specimens, representing less than 1% of the Profile Four assemblage were recovered (Table 6.141). Reptiles in this context excludes chelonia which are analysed separately (see Chapter Five – Methods). Six (75%) of the reptile specimens recovered were consistent with lizard remains, while the remaining two (25%) bones appear to be snake remains. The majority (88%) of the reptile bones were small, although a single (13%) larger specimen (here classified as a size class two) from a snake was also recovered. Reptile remains were recovered from spits one, two, five and eight. The majority of reptile bones were recovered from spit two (50%) and spit one (13%) produced a relatively small sample (Figure 6.232). There are a minimum of two snakes in Profile Four, based on size. The MNI for lizards was also two. There is a high likelihood that a lot more reptilian material was incorporated into the microfaunal assemblage and these values here should be taken as a preliminary indication of taphonomic preservation in this taxonomic group.

6.8.2 Anatomical composition of Reptilia

Lizard remains were represented by humerus (12.5%), mandible (12.5%) and vertebra elements (40%) (Table 6.142). The lizard vertebra were found associated and there are lizard mandibular fragments in the related microfauna sample. Snake remains were limited to vertebra (25%). The humerus and mandible were recovered from spits one and two respectively (Table 6.143). Vertebral specimens were recovered from spits two (50%), five (33.3%) and eight (16.7%).

6.8.3 Fragmentation Profile of Reptilia

Fusion and fracture shape (outline and angle) could not be analysed for reptiles, as the only long bone was recovered complete.

Maximum Length

The mean diameter of reptilian remains from Profile Four was 10.8 mm (Table 6.144). All reptile bones hover around the same (small) size range with the smallest specimen measuring 9 mm and the largest 12 mm.

Completeness and Breakage Profile

A total of 7 (87.5%) reptilian bones were recovered complete (Table 6.145). This includes the humerus and all vertebra remains, including the large (size class two) specimen. Incomplete elements could simply be coded as fragmentary. Reptiles thus had the highest relative percentage of complete specimens of all taxonomic groups recovered from Profile Four. The high level of completeness of very small bones like reptiles and fish suggests that these remains underwent less transport or destructive forces than mammal and chelonian remains

6.8.4 Surface Modifications of Pisces

Surface modifications like weathering, trampling, and root etching were not observed in reptile remains from Profile Four. Carnivore modifications, including both tooth marks and digestive corrosion were absent in reptiles from Profile Four.

Burning

A single (12.5%) reptile specimen displayed burning. This specimen was the large vertebra and was burnt to a stage three intensity.

Staining

Staining was extensive in reptile remains, occurring on all but one (87.5%) specimen. Staining in reptile remains was limited to stage one or two, with stage one occurring more frequently (57.1%).

Abrasion

A total of 7 specimens, representing 87.5% of reptilian remains from Profile Four displayed abrasion. The majority of abrasion in reptiles was stage one (85.7%) and a single specimen (14.3%) displayed stage two abrasion. Stronger abrasion (stage three or four) was not observed in reptilian bones.

Sheen and Polishing

A single (12.5%) specimen from the reptile assemblage of Profile Four displayed sheen. Sheen was observed in the lizard mandible, which was modified to a light (stage one) intensity.

6.9 DISCUSSION

6.9.1 Sedimentology

Roberts (2006b) described the MPPM as fine to coarse grained, moderately sorted and a light brownish grey colour (5YR 6/1). The MPPM contains phosphatic and quartzose sands with bimodal size distributions and angular to rounded character (Smith 1971). The minor differences observed between his results and those presented here, can be excused on the basis of minor lateral variations in the deposit. Roberts (2006b) described the MPPM as massive (structurless), with occasional fine laminations, due to variations in phosphate content. Similar relative proportions in grain size distribution were observed by Brumfitt *et al*. (2013) in the bonebed excavations. Brumfitt observed slightly higher (2%) percentages of fine material, with a bimodal distribution in the fine to very fine sands. They found the sand fraction to consist predominantly (60% – 80%) of quartz with dark colour phosphatic grains and minor amounts of bone and shell fragments (Brumfitt *et al*. 2013). Sediments from Profile Four thus compare favourably with previous analyses of the bonebed and of the MPPM.

Sediments in lacustrine (lake) settings can show numerous sedimentary structures, but the most diagnostic characteristics are varves (line laminations) (Boggs 2011). Lacustrine sediments are generally fine-grained, but sands can accumulate along lakeshores in delta environments. While the sediments of Profile Four appear massive to the naked eye, the occurrence of thin horizons of iron-staining suggests there may be faintly developed laminations in the deposit. This is supported by occasional appearances of fine laminations in other areas of the bonebed deposit. Such laminations in Profile Four and the bonebed could indicate deposition in a low energy environment like a lake or pond. Roberts (2006)described the occurrence of fine laminations in parts of the MPPM as being the result of slight variations in phosphate content, which would suggest the laminations are post-depositional. Intensive trampling in the bonebed could, additionally, have destroyed any bedding structures. I don't believe that trampling along can account for complete removal of bedding features throughout the large (80 m^2) bonebed deposit. Large bones from the bonebed layers (spits nine and ten) were complete and undamaged and trampling modifications in the rest of the profile were not excessively common; suggesting that trampling varied in intensity throughout the bonebed.

Little information is available on the lithological characteristics of aquifers and artesian wells. Many of these systems appear to contain water saturated with minerals and are often part of karstic systems (Le Tenser *et al.* 2007). Such systems would be expected to be associated with evaporates, of which there is

little indication at Langebaanweg. For example, the fossil beds at the nearby Pleistocene deposit Elandsfontein display numerous calcareous spring eyes (Braun *et al.* 2013). A possible facsimile of the conditions observed in Profile Four and the bonebed could be in an open lake with little clastic sediment supply. Chemical and biochemical processes are predominant in these systems leading to deposition of chemical sediments such as inorganic carbonate (Boggs 2011). Sediments of the MPPM are cemented by carbonate but this applies to the entire bed, and is not limited to the bonebed deposit and does not appear to occur at the concentrations that might be expected from a system of this nature. It is additionally, unclear to what extent this carbonate cementation is the result of post-depositional processes. Brumfitt *et al.*'s (2013) main argument for an aquifer in the bonebed seems to be a low energy environment lacking in mud. As I will show in this analysis, a lack of muds and silts was common in a number of sedimentary units and localities sampled at Langebaanweg and it is more probably related to depositional conditions at the level of the stratigraphic member.

6.9.2 Taxonomic Comparison

Taxonomic Composition

Profile Four produced twice as many bones (identifiable and un-identifiable) as any of the other profiles measured in this study (Please see Chapters Seven and Eight for details). It must however, be noted that this test pit was more than twice the depth of any other. Chelonia and mammals were the most commonly (55.8% and 38.6%, respectively) occurring taxonomic groups in Profile Four (Table 6.146). This pattern was consistently observed in excavations at Langebaanweg. Profile Four also produced remains from aves, pisces and very rare reptile remains. Bovids were the most commonly recovered mammal group. Profile Four produced remains from the extinct bovids *Raphicerus paralius* and *Mesembri portaxacrae*; these identifications are preliminary until more material, particularly postcranial bones have been recovered for comparison. Both these species have been recorded at Langebaanweg previously (Gentry 1980). Profile Four also produced an abundant and diverse carnivore assemblage including two canids, two felids, a seal, a hyaenid, and mongoose specimens. A number of small mammals were recovered from Profile Four, including leporids, mole-rats and a large rodent. The percentage of remains not identifiable below the family or higher taxonomic level (mammal indeterminate, carnivore indeterminate etc.) was high in all taxonomic groups. Mammal remains from

Profile Four compare favourably with mammals from the other excavations in this analysis with high numbers of unidentifiable remains, and bovids and carnivores predominant. Profile Four displays a remarkable diversity compared to the other test pits excavated. This may be a reflection of superior bone preservation in the bonebed or it could reflect greater mammal diversity in the environment surrounding the bonebed.

All four size groups of chelonia were recovered from Profile Four. Avian remains include marine forms like the penguin (Sphenicidae), terrestrial forms like Phasianidae and wading birds (Ciconiidae). The taxonomic composition of the bonebed with marine, terrestrial and freshwater fauna suggests that the bonebed deposit sampled bones from different environments. The high relative frequency of piscine remains (compared to the other excavations) suggests that Profile Four (and the bonebed) may have been deposited in a perennial or semi-permanent aquatic environment where fish were resident. However, some of these remains display evidence of sub-aerial exposure (weathering, burning). This could indicate occasional drying out of the water source or it suggests that these bones did not originate in the immediate area but were transported into the site. Further investigation into the species composition of pisces remains of the bonebed will help elucidate this question.

Fragmentation Profile

Fragmentation was high in Profile Four, with an average specimen length of only 22.8 mm. This pattern was consistently observed in my excavations at Langebaanweg. Average fragment size in mammals was greater than in other taxonomic groups. This is due to the recovery of large mammal specimens with good preservation in the bonebed. Additionally large mammal specimens were recovered from the disturbed unit, but these bones were poorly preserved. They displayed rolling and abrasion and were fragmentary in nature, the majority were not identifiable below class. The disturbed unit appears to sample bones from large sized mammals that have undergone transport. With the exception of fragmentary mammal bones from the disturbed unit, mammals display better preservation in Profile Four than in Profiles One or Two.

Chelonia remains were mostly represented by shell elements rather than appendicular or axial remains and the majority of chelonia specimens were derived from the carapace, rather than the plastron. This pattern is consistent throughout Langebaanweg. The majority of mammal remains, as well as chelonia appendicular remains were represented by small compact bones of the autopodium. Fracture shape in

mammals, chelonia and aves indicate breakage while bones were fresh, however some fractures indicative of breakage in dry and weathered bones were also observed. Fracture angle provided inconclusive results. Profile One and Two bones concur, fracture outline indicates fresh breakage but fracture angle is inconclusive. In mammals and chelonia fracture angle was equally distributed between oblique (fresh) or right (dry) angled breaks; while fracture angle in aves was mostly mixed. A similar pattern with fracture angle, providing inconclusive and conflicting results, was observed by (Thompson 2010) in remains from the Middle Stone Age localityPinnacle Point, and this method must be treated with caution, at least when analysing material from Langebaanweg.

Surface Modifications

A large number of surface modifications were observed in bones from Profile Four including weathering, staining, abrasion, trampling marks, root etching and carnivore modifications. Mammal remains appeared to be more heavily affected than remains from other taxonomic groups, for reasons unknown. The high prevalence of stage one weathering indicates that many bones were exposed on the surface for a short period (1 - 3 years) (Behrensmeyer 1978) before complete burial. Burning was rare in Profile Four, and both Profiles One and Two display higher relative frequencies of burning. Burning was more commonly observed on chelonia and avian remains. Some authors have hypothesised that this pattern indicates mortality from fire in these taxa (Avery *et al.* 2004). However, burning was observed with equal frequency on the inner sides of shell bones than the outer sides, which suggests shells were already disarticulated prior to burning. Burning in Chelonia will be discussed in more detail in Chapter Nine. The low intensity of burning in Profile Four indicates fast moving or low temperature fires, consistent with veld fires. Animals killed by a fire are unlikely to display burning on their bones, due to the protection afforded by skin and flesh. Bones were however, more likely already exposed on the surface prior to the fire. The presence of burning on piscine bones is particularly interesting, as the bones must have been exposed on a dry surface for them to burn. If we were to assume that the piscine bones were resident in the area of the deposit prior to death and burial then it would suggest that there has been periodic drying of the deposit. Lithology does not support this, systems that suffer season drying usually develop laminations reflecting seasonal changes (Boggs 2011). The other possibility is that the piscine bones were accumulated by a predator, but these remains showing no evidence of predator modifications. Investigating species composition and taphonomic modifications in this under-researched will help address these questions.

Burning may be more prevalent in aves simply due to the relatively fragile structure of their bones, which may make them more susceptible to modification. Similarly, the avian assemblage of Profile Four displays high relative frequencies of sheen, trampling and carnivore modifications. The high relative frequency of carnivore modifications in aves may indicate that many of the birds from Profile Four were predated. However, the frequency of carnivore modifications in other taxonomic groups was small, indicating that carnivores made, at best, a small contribution to the bonebed. In the case of the penguin, tooth marks could have been produced by a marine predator like a pinniped, which are known to predate penguins (Skinner & Chimimba 2005), or penguin carcasses could have been scavenged from the beach by a terrestrial predator. The latter scenario could provide a mechanism by which remains from a marine taxon could have become incorporated into the Profile Four deposit. On the other hand, Cruz (2008) observed that fragile bird bones were usually completely consumed by carnivores and where bones are not destroyed, carnivore modifications were few. Avian remains in other Profiles studied in this analysis displayed a similar pattern to Profile Four; and future investigations into bird taphonomy at Langebaanweg will be necessary in order to understand accumulating processes specific to this taxonomic group.

The high relative frequency of abrasion would suggest that bones from Profile Four have undergone transport or were active in a high energy system. However, abrasion was overall slight in intensity and heavy or sever modifications were rare. This may indicate that the bones experienced some activity and/or movement but in a low energy environment or for a short duration. It should be noted, that all bones excavated from Langebaanweg in this analysis display a high frequency of light abrasion, suggesting this modification affected bones across large areas of the quarry. Trampling occurred on almost a third of remains from Profile Four, but was mostly slight. None of the bones from Profile Four, particularly in the bonebed layer, displayed the heavy green-stick fractures observed in other parts of the bonebed. Trampling was, in fact, more frequently observed in remains from Profile One (more on this in Chapter Nine). Trampling modifications and intensity appear to vary widely across the bonebed deposit. These variations may be related to topography and animal behaviour and a more detailed investigation of taphonomic modifications in the future will be beneficial. The severity of the green-stick fractures on large robust bones, such as a sivathere mandible, would suggest trampling by large bodied animals, like sivatheres. The lighter degree of modification observed in Profile Four could also indicate trampling activity by smaller bodied animals. Trampling could result in the high degree of fragmentation observed in Profile Four. Additionally, bones immersed in water can crack and fracture and Fernández-Jalvo and Andrews (2016) suggest bones from the bonebed may have undergone such modification.

High levels of polishing in chelonian appendicular remains from Profile Four may indicate intrainment of these remains in flowing water. The small and elongate shapes of these bones would have allowed for easy entrainment (Voorhies 1969). Blob (1997) found in an experimental study of hydrodynamic dispersal potentials of soft-shelled turtles that bone shape had a stronger influence on dispersal than bone density. I must emphasise however, that polishing occurred in less than 30% of chelonia remains and was predominantly light. Suggesting that entrainment was short or flow was slow and low in energy.

The high relative frequency of root etching likely reflects a long residence time in an active soil profile before final internment and fossilisation. This would suggest a time gap between deposition of the bonebed and the deposition of the overlying MPPM sands. Brumfitt *et al.* (2013) find apatite and manganese staining in the pore spaces of bones from the bonebed, which suggests that staining occurred during fossilisation. The presence of the apatite might suggest that the bonebed was deposited prior to phosphatisation of the MPPM. It could, alternatively, indicate that the phosphate has been 'reworked'. In other words, conditions changed and previously deposited phosphate was dissolved only to be re-precipitated onto the bones. Further study will be required in order to address these questions.

6.9.3 Comparison between Bonebed and overlying MPPM

Spits nine and ten have, throughout this chapter, been taken to be part of the bonebed deposit. There is no clear change in sedimentology from the overlying MPPM into the bonebed and the bonebed has been identified simply on the appearance of many large complete bones from associated skeletons. A similar large and complete bone, which displayed many of the same preservation characteristics, was observed at the base of spit five. The preservation of this specimen, so far above the main bonebed layer may be an indication that the bonebed is larger than originally thought. Additionally, it is not known how much of the original bonebed may have been removed by mining activity. For this reason, spits one to five will be considered, in this discussion, as part of the undifferentiated MPPM and spits six to ten will be considered part of the bonebed. Sedimentological evidence suggests that there is a gradual change between the environment represented by the undifferentiated MPPM and the bonebed and that they are part of the same system. The differences in bone preservation between these levels, as described below, would suggest that something changed between the MPPM and the bonebed; and for this reason, they are considered as separate deposits. Further, detailed excavations in the future, will be needed in order to fully understand the lateral relationship between these levels. The relative

paucity of bones between spit five and spit ten and the lack of the characteristic well preserved and associated skeletons, indicates that bone distribution in the bonebed was patchy. A finding that concurs with previous excavations in the bonebed.

Taxonomic Composition

The upper parts of the deposit or MPPM produced much greater (58.5%) numbers of bone than the bonebed (Table 6.147). Mammal bones were abundant in the MPPM, but were few in the bonebed which was dominated by chelonia remains. Similarly, reptiles were more common in the MPPM, and piscine bones were common in the bonebed. Avian remains were recovered in both deposits with equal frequency. The occurrence of fish remains in the bonebed supports previous interpretations of the bonebed as part of an aquatic (possibly fluvial) system. Identifying the piscine species present in the bonebed could help identify if there is a marine signal or freshwater signal in the bed and could indicate whether the bonebed was seasonal or perennial. This should improve our understanding of the depositional environment of the bonebed. Typically, chelonia bones dominate all parts of the Langebaanweg deposit, so the very high relative abundance of mammal bones in the upper levels of Profile Four are of interest. Many of these mammal bones occur in the disturbed unit. Material in this unit has undergone post-depositional alluvial transport, which has concentrated bones from another part of the deposit. This is most likely to have occurred after mining activity began. There is no reason why this process might winnow out chelonia remains and only accumulate mammals and it must be thus assumed that the disturbed unit is locally sourced from a deposit that consisted mostly of mammal bones. Further sampling in this area and possibly upstream (to try to identify the source) would be beneficial if the question of the high abundance of mammal bones in (at least some parts of) the MPPM is to be resolved. Avian preservation appears to be independent of the processes affecting differential taxonomic preservation in the MPPM and bonebed. Mammal species recovered in the Profile Four bonebed layer include the bovids *Raphiceru sparalius* and *Mesembriportax acrae*, the *Canis* species, the large rodent and numerous indeterminate carnivore and bovid bones.

A large microfaunal assemblage was recovered from Profile Four, given the relatively coarse mesh size that was used during excavations. Previous excavations in the bonebed have produced vast amounts of microfauna (Matthews 2006). This investigation indicates that microfauna bones were more common in the bonebed than in the MPPM sediments and that large numbers of microfauna are a characteristic of

the bonebed deposit. It has been previously suggested (Smith & Haarhoff 2006) that microfaunal remains in the bonebed were deposited as roost regurgitates from birds of prey. Indeed Matthews (2006) recorded digestive damage on 53% of Muridae remains from the bonebed deposits. The microfauna recovered in this investigation has not yet been studied and future investigation of this material should provide additional data regarding the accumulating mechanisms of microfauna in the bonebed.

Fragmentation patterns

The MPPM and the bonebed differ in their patterns of bone breakage. Average length of bones was greater in the MPPM (26 mm) than the bonebed (18 mm) (Table 6.146). Histograms of the maximum length of specimens in the MPPM and the bonebed show that the majority of the assemblage falls between 10 mm and 40 - 50 mm (respectively) but with many large sized outliers in both parts of the deposit (Figure 6.233, Figure 6.234). In the MPPM, there is a high frequency of remains measuring around 15, 25 and 30 mm in length. In the bonebed, maximum length is skewed towards small sized remains with peaks around 10 mm and 15 mm. The larger average size in the MPPM is most likely being driven by the high numbers of large (unidentifiable) mammal specimens in that part of the deposit. The bonebed produced much higher numbers of complete elements then the MPPM, but most of these remains were derived from chelonia, which displayed a greater frequency of completeness than mammals. A high degree of complete elements in the bonebed was expected given the generally good preservation of the deposit. In general, large numbers of complete remains would be considered indicative of bones having accumulated in a low energy setting with little transport and high rates of sedimentation. Both the MPPM and the bonebed display mostly spiral fracture outlines indicating that most breakage occurred while bones were fresh; however, the relative percentage of fresh breaks was higher in the bonebed (73.2%) than the MPPM (65.3%) (Table 6.149). Transverse and splintered breaks were more common in the MPPM (Figure 6.235). The high prevalence of spiral shaped bone breaks and a low degree of bone weathering in the bonebed indicates that most breakage occurred at or soon after death, and that the bones were completely buried within a year or two. It was previously stated that many of the bones in the disturbed unit of the MPPM appear to have undergone post-depositional transport. Fracture outlines in this case would be expected to show high prevalence of dry (Right angled) or old breaks; the lack of such breaks in this deposit can only be the result of either low energy transport and/or transport over a very short distance. Fracture angle in Profile Four, as in the other test pits

studied in this analysis, has provided inconclusive results. In the MPPM, oblique and right angled fractures occurred with near equal frequency (Figure 6.236). On its own this would suggest that dry and fresh breaks occurred with equal frequency, which conflicts with the fracture outline information. In the bonebed fracture angles were most commonly oblique (35.6%).

Surface Modifications

The MPPM and the bonebed display similar levels of weathering, trampling and sheen. Weathering was slightly more common in the MPPM, but was for the most part light. Trampling marks were slightly more common in the MPPM than the bonebed. Remains from the bonebed displayed slightly more sheen than remains from the MPPM. This could be the result of alluvial action in the bonebed but the differences are so slight that nothing conclusive can really be said. Burning was much more prevalent in the bonebed, than in the MPPM. Burnt bones must have been common in the environment sampled by the bonebed. The botanical record for Langebaanweg provides numerous indications for seasonal burning. Thus I believe that the burnt bones at Langebaanweg are the result of drier conditions with more frequent seasonal burning and do not reflect a once-off fire event. Post-depositional modifications like staining and root etching were more common in the MPPM than the bonebed. Much of these modifications were observed in the disturbed unit and merely act to emphasive the excellent preservation of remains in the bonebed. Future, expanded investigations into the processes through which bones become stainined will greatly improve our understanding of the preservation processes at Langebaanweg. Carnivore modifications (both tooth marks and digestion) were substantially more frequent (although still not common occurrences) in the bonebed than the MPPM. This is interpreted as an indication of greater frequency of predator activity in the area of the bonebed accumulation, compared to the overlying MPPM. The bonebed does not have the characteristics generally associated with a carnivore den. These include the presence of juvenile carnivores, a high relative frequency (approximately 20%) of carnivore individuals, and carnivore surface modifications (Cruz-Uribe 1991; Stiner 1991; Pickering 2002; Kuhn *et al.* 2010). The bonebed assemblage does not show these criteria, nor doe the lithology of Profile Four support the presence of a den or burrow. However, predator accumulation has been previously suggested for microfauna remains (Matthews 2006). It is likely that predators contributed some of the remains to the deposit, but that this was not a regular occurrence and was not the only means by which bones came to be accumulated in the bonebed. Predator activity might be an explanation for isolated bones from marine taxa occurring within the bonebed. In this

scenario, terrestrial predators scavenge bones from marine carcasses on the beach or estuary periphery and transport those bones into the predominantly terrestrial or fluvial bonebed assemblage. Further study will be required in order to investigate these scenarios.

6.9.4 Depositional environment interpretations and conclusions

Profile Four displays a high taxonomic diversity, especially in mammals; although the most commonly occurring taxa were chelonids. Both the undifferentiated MPPM and the bonebed display a mix of taxa from marine, terrestrial and freshwater environments. The undifferentiated MPPM and the bonebed differ in their taxonomic composition and in their preservation style; indicating that they were deposited under different environmental conditions. There is little sedimentological change between the MPPM and the bonebed suggesting that the environmental change was gradual and juxtaposed on the same landscape. Mammals were common in the MPPM, and show a high diversity, with many large specimens, suggesting the presence of large bodied mammals. Bones recovered from the MPPM have undergone post-depositional modifications like root etching and staining. In addition, trampling marks and weathering were slightly more common in the MPPM than in the bonebed.

Remains from the bonebed have extremely good preservation, consistent with deposition in a low energy environment. There were large numbers of complete bones and at least three associated skeletons. Breakage was fresh and weathering slight, suggesting minimal sub aerial exposure and relatively rapid burial. Abrasion is light in remains from the Profile Four bonebed and large bones with trampling modifications occur in previously excavated parts of the bonebed (Smith and Haarhoff 2006). Taken together, this suggest that while bones were buried quickly and suffered little transport, there was some degree of biological activity prior to final burial. A habitat in which this might occur could be on the muddy bank of a river or pond. Hendey's (1980b) initial interpretations of fossil remains in the area now known as the bonebed was for an intermittent fluvial channel. Remains from the Profile Four bonebed show little evidence for this. There is little alluvial damage in the form of polishing, and abrasion was minor; remains from the bonebed layers of Profile Four display little framentation. These conditions would suggest a depositional system more like a pond than the high energy river lag deposit or scour pool, as suggested by Roberts *et al.* (2011) and Smith and Haarhoff (2006). Brumfitt and colleagues (2013) concur that the bonebed was accumulated in a low energy environment and suggest that this, together with the lack of mud, indicates an aquifer-fed waterhole as the causal agent for

accumulation. Literature on ancient aquifers and artesian springs is lacking, but what literature is available indicates that these environments are characterised in the fossil record by the preservation of evaporates (Le Tenser *et al.* 2007; Braun *et al.* 2013). The appearance of marine remains in the bonebed and Profile Four is remarkable, and researchers have suggested occasional wash-in or tidal contributions of marine material to Profile Four (Hendey 1980; Brumfitt *et al.* 2013). Marine specimens occur infrequently and it is possible that the input of these remains may be the work of predators scavenging marine bones and carcasses from the nearby estuary or shoreline. The greater degree of carnivore modified bones in the bonebed layers of Profile Four may be an indication of this.

Thus the Langebaanwegbonebed was deposited in a low energy system. Bones were buried quickly with little surface exposure, but some biological activity in the form of trampling took place before final internment. Numerous burnt bones were incorporated into the bonebed deposit and carnivore activity was more frequent in this layer. Results from the Profile Four excavation have built on previous research into the Langebaanweg bonebed, but further research with a greater sampling of the site is needed to fully understand the depositional mechanisms at work in this deposit.



Figure 6.1. Profile Four at start of excavation. Located within an archaeological survey trench created by the Archaeology Contracts Office (1999) note the black tarpaulin covering the old excavation surface.



Figure 6.2. Closeup of mammal bones from spit one showing heavy 'purple' staining from apatite



Figure 6.3. Disturbed unit and undifferentiated MPPM, Profile Four, spit two. Arrows demarcate the contact beteen the two units, with the disturbed unit in foreground.



Figure 6.4. Disturbed unit, conglomerate texture with fragmented fossils, cobbles and rocks of phosphorite, granite and calcrete. Note the large phosphorite block imbedded in the profile wall (top right). View facing west.



Figure 6.5. Profile Four, spit six. Note uniform sedimentary texture with some colour mottling but few fossils. Large, well preserved thoracic vertebra from spit five pedastled in lower right.



Figure 6.6. Associated tortoise bones from partial skeleton in bonebed layer. Note bone scatter



Figure 6.7. Associated tortoise shell and appendiocular skelton. (a – f) Progressive exposure of skeleton with excations.



Figure 6.8. Associated vertebra from a large (size class four) bovid. A total of seven associated specimens were recovered and attributed to the extinct species *Mesembriportax acrae*.

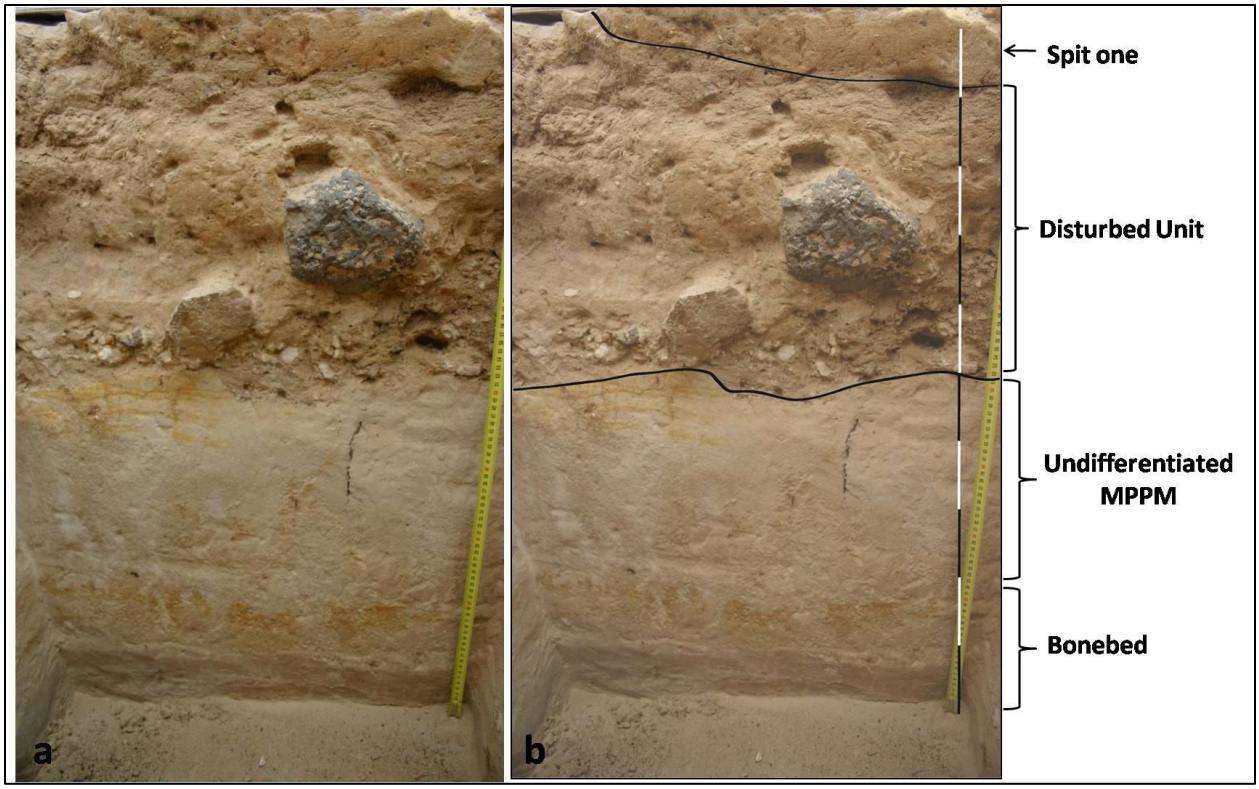


Figure 6.9. Profile wall for Profile Four, (a) original, (b) annotated.

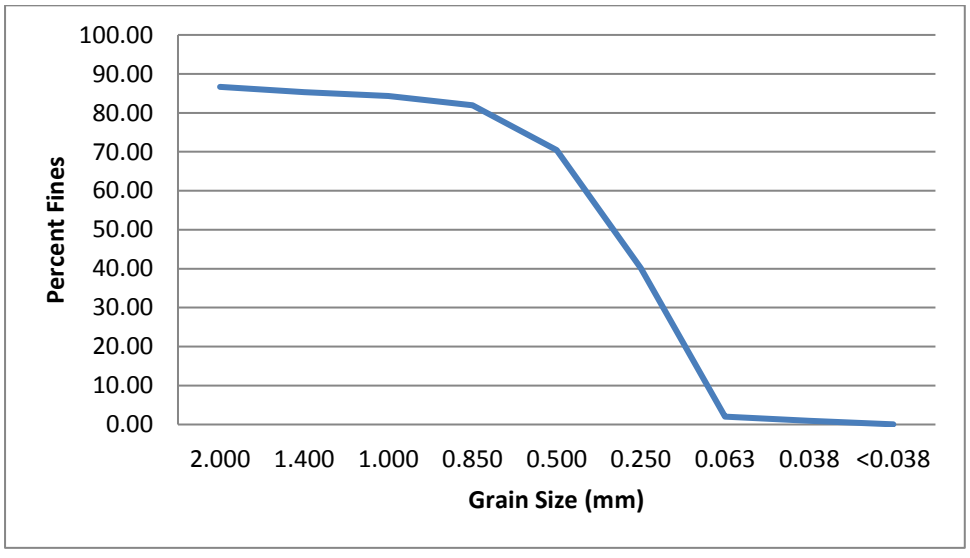


Figure 6.10. Cumulative percentage curve of grain size in the undifferentiated MPPM sample

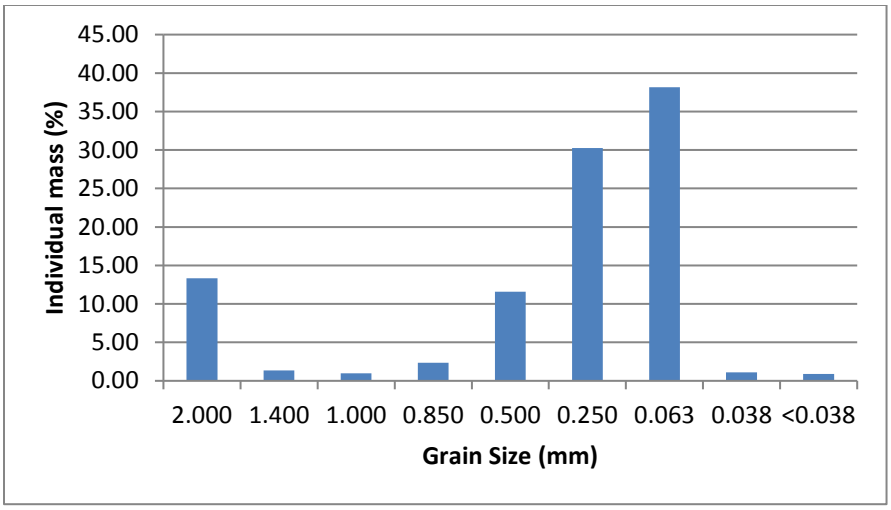


Figure 6.11. Relative frequencies of grain size in undifferentiated MPPM sample

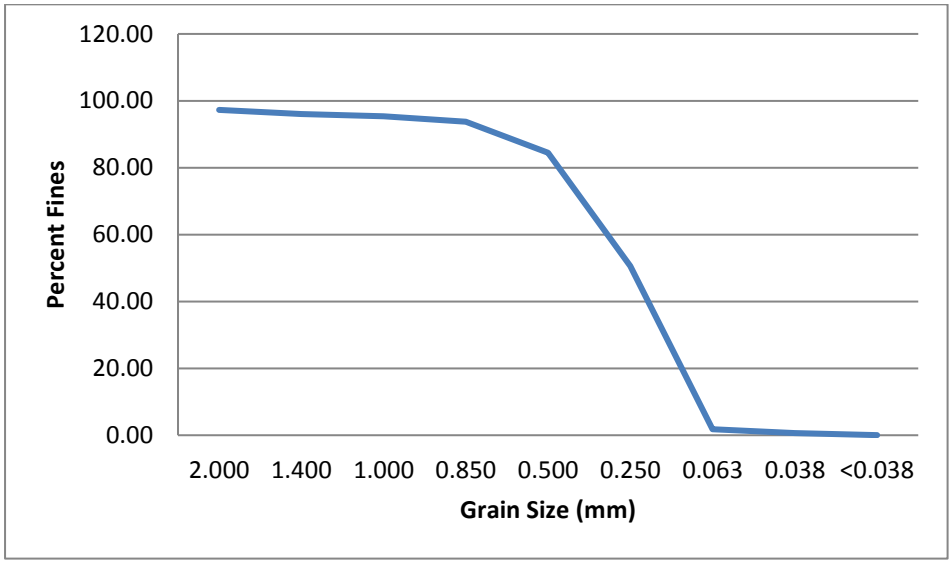


Figure 6.12. Cumulative percentage curve of grain size in Disturbed unit

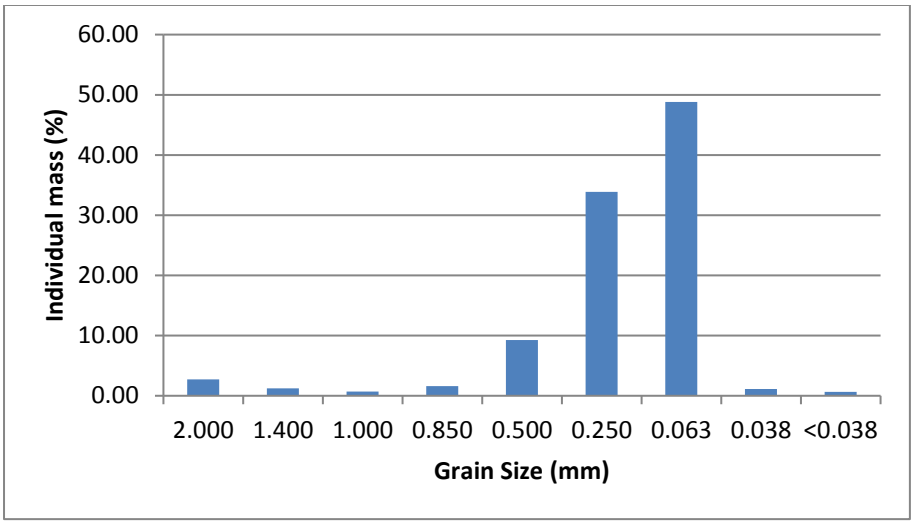


Figure 6.13. Relative frequencies of grain size in Disturbed unit

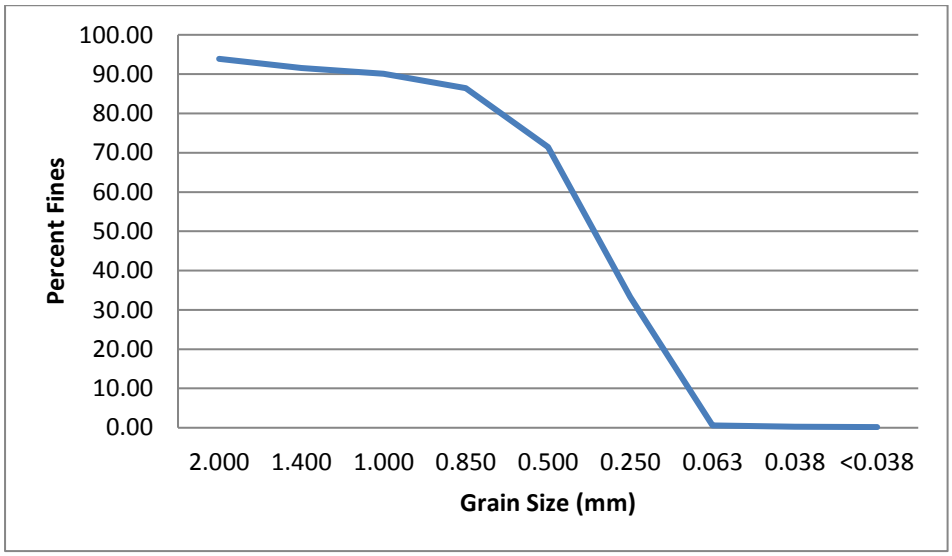


Figure 6.14. Cumulative percentage curve of grain size in Bonebed

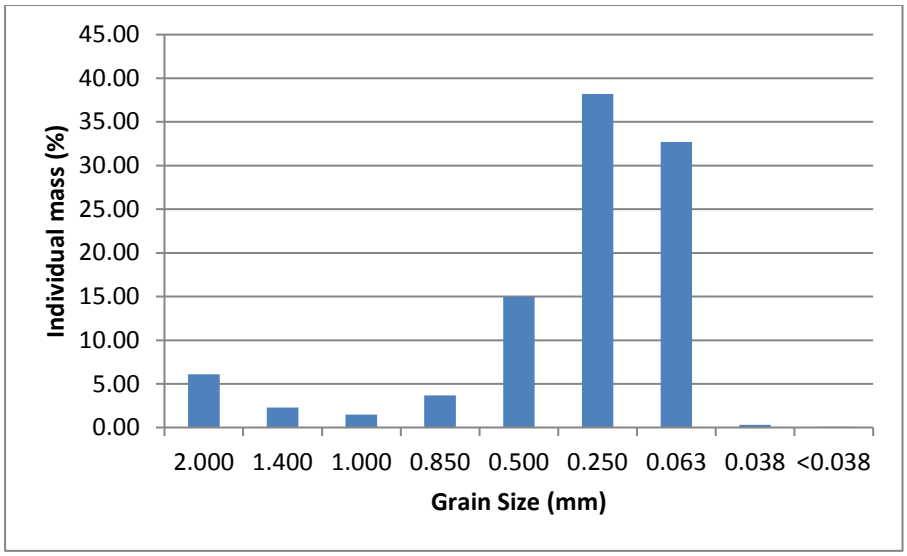


Figure 6.15. Relative frequencies of grain size in Bonebed

Table 6.1. Relative frequency of identifiable bones, unidentifiable bones and microfauna in Profile one, Profile Two and Profile Four. Presented as NISP

	Identified	Identifiable (%)	Unidentified	Microfauna	Microfauna (%)	Total Bones
Profile 1	1332	13	7267	1647	16.1	10246
Profile 2	202	4.9	3874	18	0.4	4094
Profile 4	1589	7.8	16855	2043	10	20487
Total	**3123**		**27996**	**3708**		**34827**

Table 6.2. Profile Four specimen frequency by spit

	N	%
Spit 1	123	7.7
Spit 2	95	6
Spit 3	171	10.8
Spit 4	313	19.7
Spit 5	228	14.3
Spit 6	55	3.5
Spit 7	157	9.9
Spit 8	183	11.5
Spit 9	213	13.4
Spit 10	51	3.2
Total	**1589**	

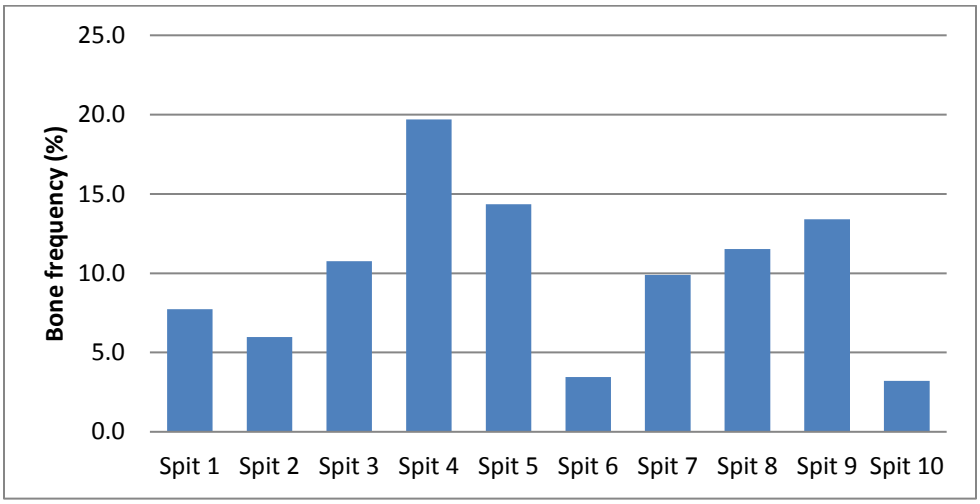


Figure 6.16. Relative frequency (%) of bone specimens by spit in Profile Four

Table 6.3. Relative frequency of microfauna by spit in Profile Four

	N	%
Spit 1	36	1.8
Spit 2	47	2.3
Spit 3	121	5.9
Spit 4	302	14.8
Spit 5	225	11
Spit 6	118	5.8
Spit 7	368	18
Spit 8	288	14.1
Spit 9	439	21.5
Spit 10	99	4.8
Total	**2043**	

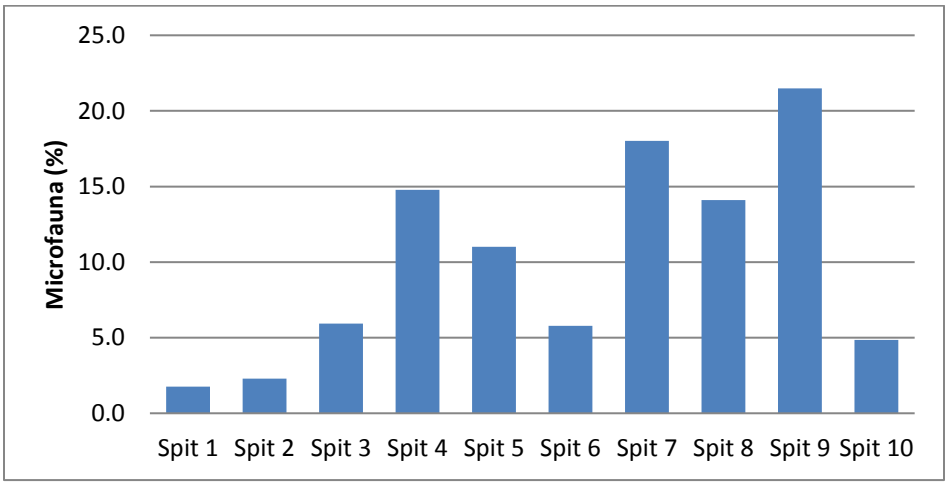


Figure 6.17. Microfauna frequency (%) by spit in Profile Four

Table 6.4. Taxonomic composition of Profile Four by spit

	Mammals		Chelonia		Aves		Pisces		Reptilia		Total	
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**n**	**%**
Spit 1	95	77.2	27	22	-	-	-	-	1	0.8	**123**	**7.7**
Spit 2	42	44.2	46	48.4	1	1.1	2	2.1	4	4.2	**95**	**6**
Spit 3	68	39.8	97	56.7	6	3.5	-	-	-	-	**171**	**10.8**
Spit 4	218	69.6	85	27.2	8	2.6	2	0.6	-	-	**313**	**19.7**
Spit 5	105	46.1	109	47.8	8	3.5	4	1.8	2	0.9	**228**	**14.3**
Spit 6	2	3.6	51	92.7	2	3.6	-	-	-	-	**55**	**3.5**
Spit 7	22	14	129	82.2	5	3.2	1	0.6	-	-	**157**	**9.9**
Spit 8	15	8.2	148	80.9	11	6	8	4.4	1	0.5	**183**	**11.5**
Spit 9	30	14.1	166	77.9	5	2.3	12	5.6	-	-	**213**	**13.4**
Spit 10	17	33.3	28	54.9	3	5.9	3	5.9	-	-	**51**	**3.2**
Total	**614**		**886**		**49**		**32**		**8**		**1589**	

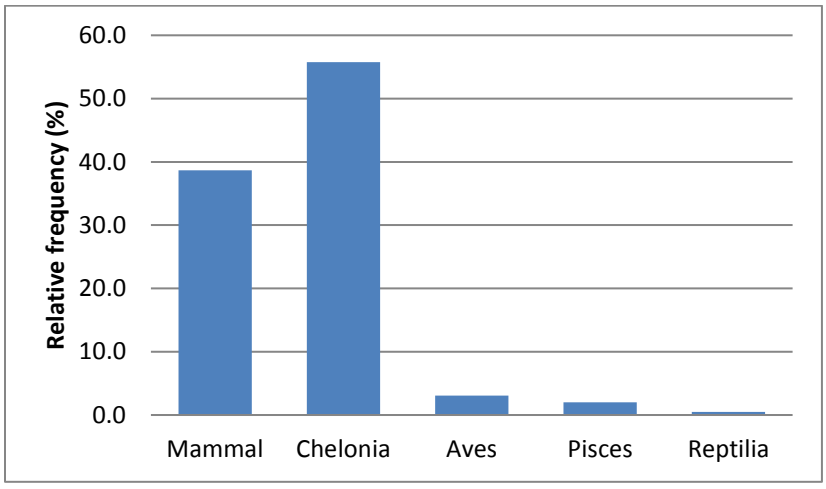


Figure 6.18. Relative frequency (%) of taxonomic groups in Profile Four

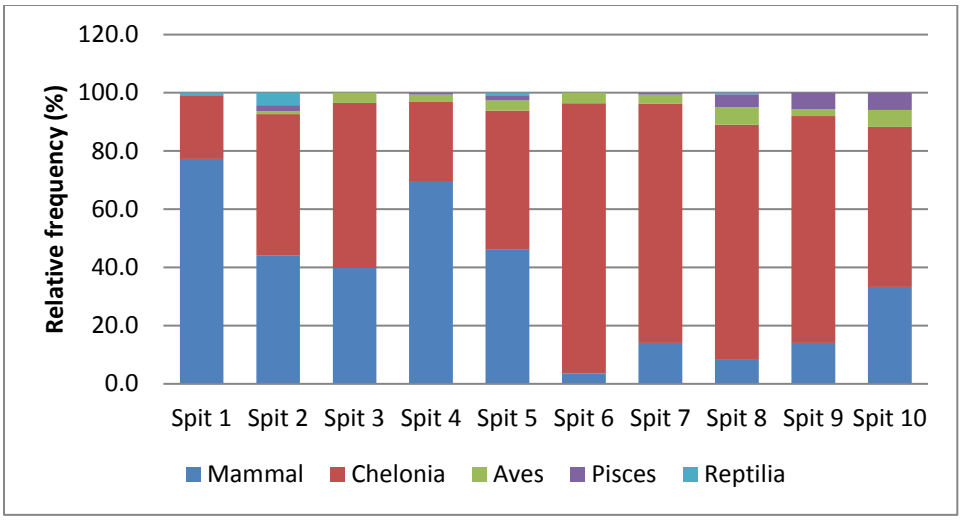


Figure 6.19. Relative frequency of taxonomic groups by spit in Profile Four

Table 6.5. Descriptive statistics of maximum specimen length in combined Profile Four sample

N	1585
Minimum	3
Maximum	117
Mean	22.8
Standard Deviation	14.1

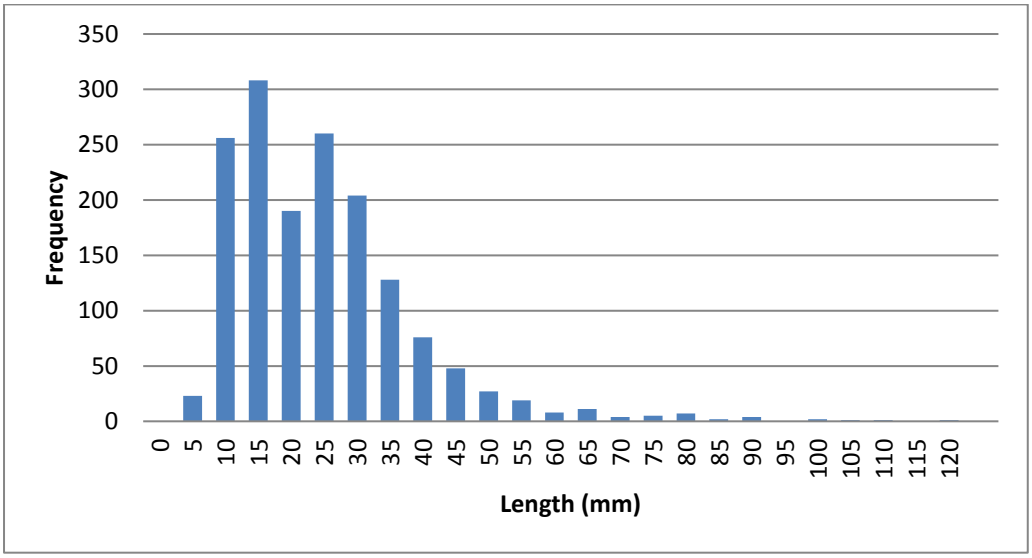


Figure 6.20. Histogram of maximum specimen length in bones from Profile Four

Table 6.6. Bone weathering by taxonomic group in Profile Four

	Mammals		Chelonia		Aves		Pisces		Totals	
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Stage 1	109	17.8	94	10.6	3	6.1	3	9.4	**209**	**13.2**
Stage 2	29	4.7	39	4.4	-	-	-	-	**68**	**4.3**
Stage 3	1	0.2	-	-	-	-	-	-	**1**	**0.1**
Total	**139**	**22.6**	**133**	**15**	**3**	**6.1**	**3**	**9.4**	**278**	**17.5**

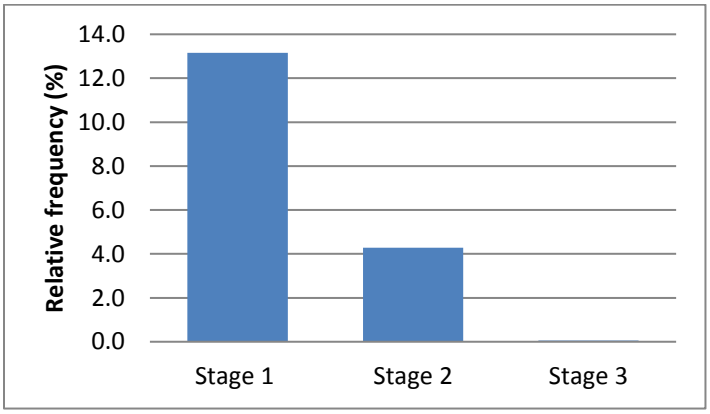


Figure 6.21. Bone weathering intensity in remains from Profile Four

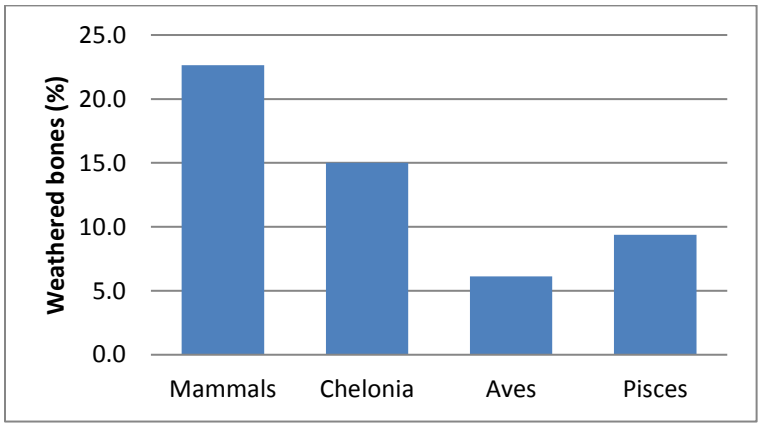


Figure 6.22. Bone weathering frequency by taxonomic group in Profile Four

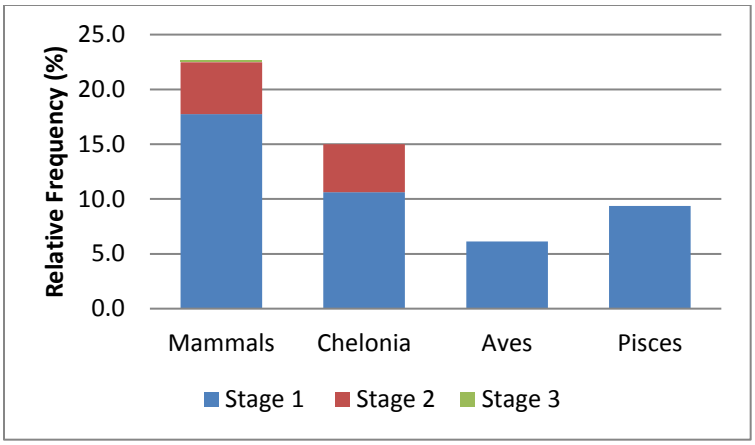


Figure 6.23. Bone weathering intensity by taxonomic group in Profile Four

Table 6.7. Intensity of bone weathering by spit in Profile Four

	Stage 1		Stage 2		Stage 3		Totals	
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Spit 1	23	18.7	7	5.7	-	-	**30**	24.4
Spit 2	9	9.5	5	5.3	-	-	**14**	14.7
Spit 3	19	11.1	3	1.8	-	-	**22**	12.9
Spit 4	51	16.3	16	5.1	-	-	**67**	21.4
Spit 5	26	11.4	12	5.3	1	0.4	**39**	17.1
Spit 6	5	9.1	4	7.3	-	-	**9**	16.4
Spit 7	26	16.6	4	2.5	-	-	**30**	19.1
Spit 8	14	7.7	5	2.7	-	-	**19**	10.4
Spit 9	26	12.2	8	3.8	-	-	**34**	16
Spit 10	10	19.6	4	7.8	-	-	**14**	27.5
Total	**209**	**13.2**	**68**	**4.3**	**1**	**0.1**	**278**	**17.5**

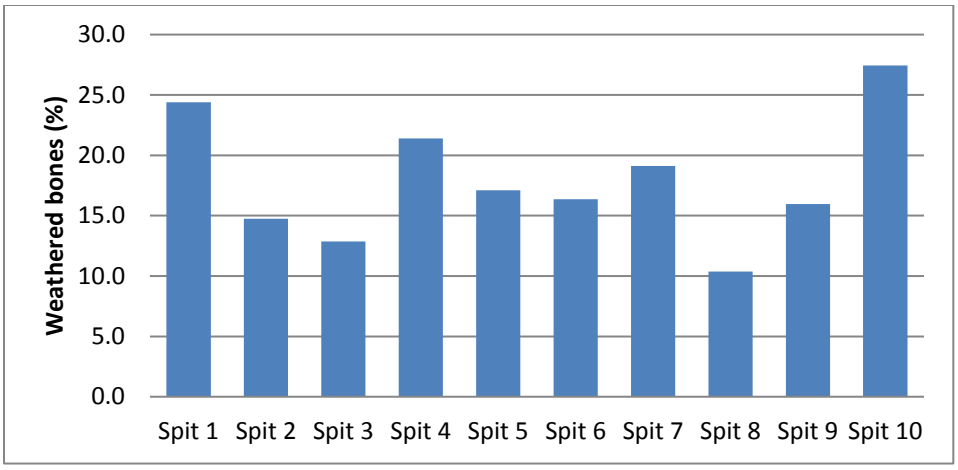


Figure 6.24. Relative frequency of weathering by spit in Profile Four

Table 6.8. Burning by taxonomic group in Profile Four

	Mammals		Chelonia		Aves		Pisces		Reptilia		Totals	
	N	%	N	%	N	%	N	%	N	%	N	%
Stage 1	-	-	18	2	-	-	-	-	-	-	**18**	**1.1**
Stage 2	2	0.3	33	3.7	-	-	-	-	-	-	**35**	**2.2**
Stage 3	6	1	10	1.1	1	2	1	3.1	1	12.5	**19**	**1.2**
Stage 4	2	0.3	5	0.6	1	2	-	-	-	-	**8**	**0.5**
Stage 5	-	-	1	0.1	2	4.1	-	-	-	-	**3**	**0.2**
Stage 6	1	0.2	-	-	-	-	-	-	-	-	**1**	**0.1**
Total	**11**	**1.8**	**67**	**7.6**	**4**	**8.2**	**1**	**3.1**	**1**	**12.5**	**84**	**5.3**

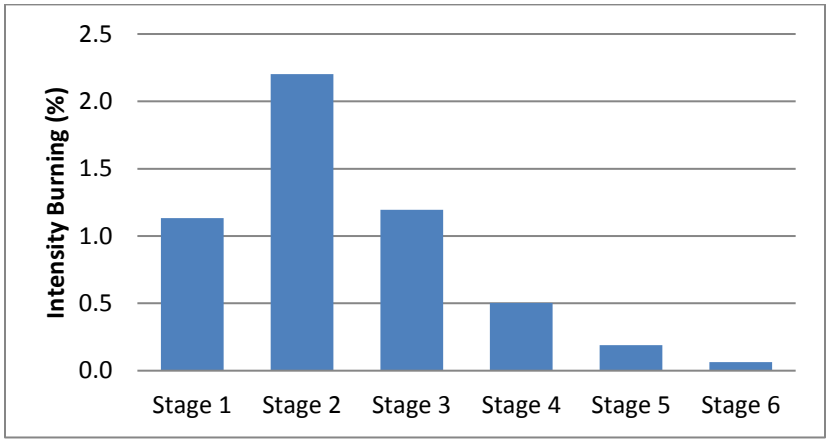


Figure 6.25. Burning intensity in Profile Four

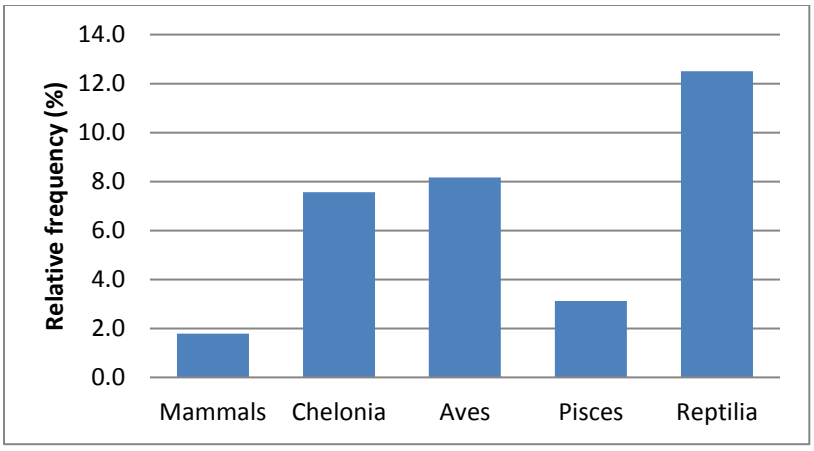


Figure 6.26. Relative frequency of burning by taxonomic group in Profile Four

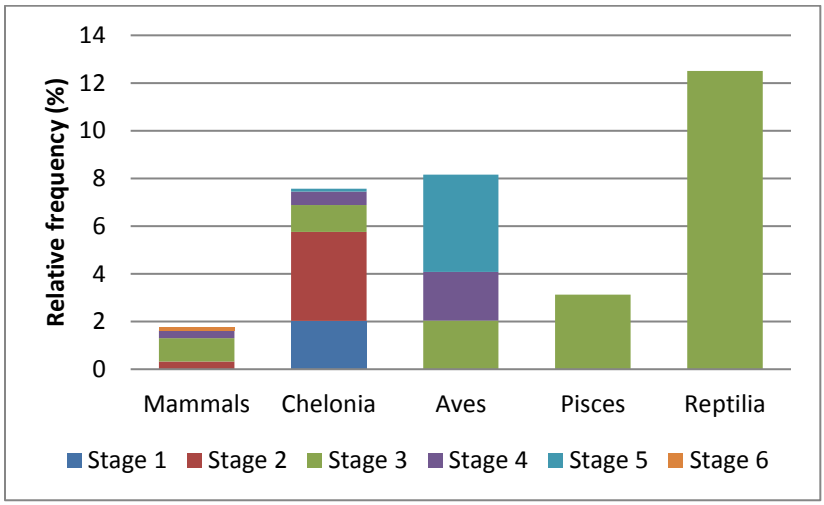


Figure 6.27. Intensity of burning by taxonomic group in Profile Four

Table 6.9. Burning intensity by spit in Profile Four

	Stage 1		Stage 2		Stage 3		Stage 4		Stage 5		Stage 6		Totals	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%
Spit 1	1	0.8	-	-	-	-	-	-	-	-	-	-	**1**	**0.8**
Spit 2	1	1.1	-	-	1	1.1	-	-	-	-	-	-	**2**	**2.1**
Spit 3	2	1.2	1	0.6	-	-	-	-	1	0.6	-	-	**4**	**2.3**
Spit 4	2	0.6	1	0.3	1	0.3	-	-	-	-	-	-	**4**	**1.3**
Spit 5	3	1.3	4	1.8	3	1.3	-	-	-	-	-	-	**10**	**4.4**
Spit 6	1	1.8	1	1.8	1	1.8	1	1.8	-	-	-	-	**4**	**7.3**
Spit 7	2	1.3	9	5.7	5	3.2	1	0.6	1	0.6	-	-	**18**	**11.5**
Spit 8	3	1.6	7	3.8	5	2.7	4	2.2	-	-	1	0.5	**20**	**10.9**
Spit 9	3	1.4	11	5.2	3	1.4	2	0.9	1	0.5	-	-	**20**	**9.4**
Spit 10	-	-	1	2	-	-	-	-	-	-	-	-	**1**	**2**
Total	**18**	**1.1**	**35**	**2.2**	**19**	**1.2**	**8**	**0.5**	**3**	**0.2**	**1**	**0.1**	**84**	**5.3**

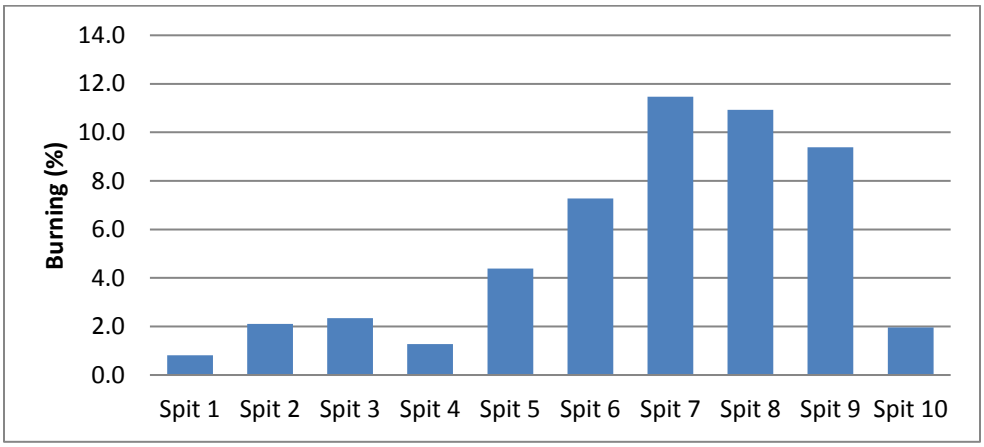


Figure 6.28. Burning intensity by spit in Profile Four

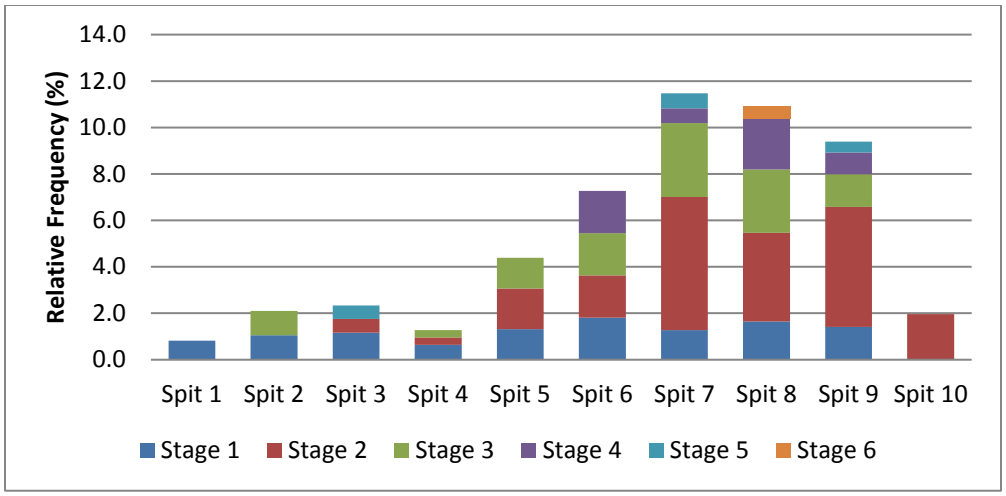


Figure 6.29. Burning intensity by spit in Profile Four

Table 6.10. Staining intensity by taxonomic group in Profile Four

	Mammals		Chelonia		Aves		Pisces		Reptilia		Totals	
	N	%	N	%	N	%	N	%	N	%	N	%
Stage 1	224	36.5	270	30.5	5	10.2	8	25	4	50	**511**	**32.2**
Stage 2	165	26.9	86	9.7	6	12.2	4	12.5	3	37.5	**264**	**16.6**
Stage 3	98	16	17	1.9	9	18.4	-	-	-	-	**124**	**7.8**
Stage 4	1	0.2	-	-	2	4.1	-	-	-	-	**3**	**0.2**
Total	**488**	**79.5**	**373**	**42.1**	**22**	**44.9**	**12**	**37.5**	**7**	**87.5**	**902**	**56.8**

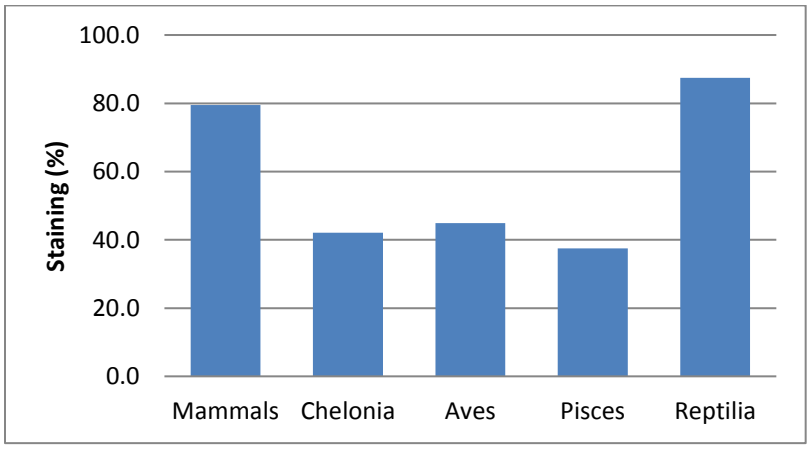


Figure 6.30. Staining intensity by taxonomic group in Profile Four

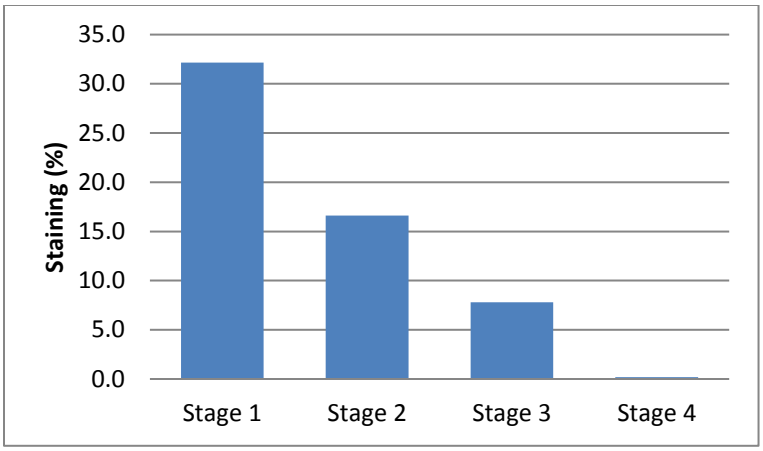


Figure 6.31. Staining intensity in Profile Four

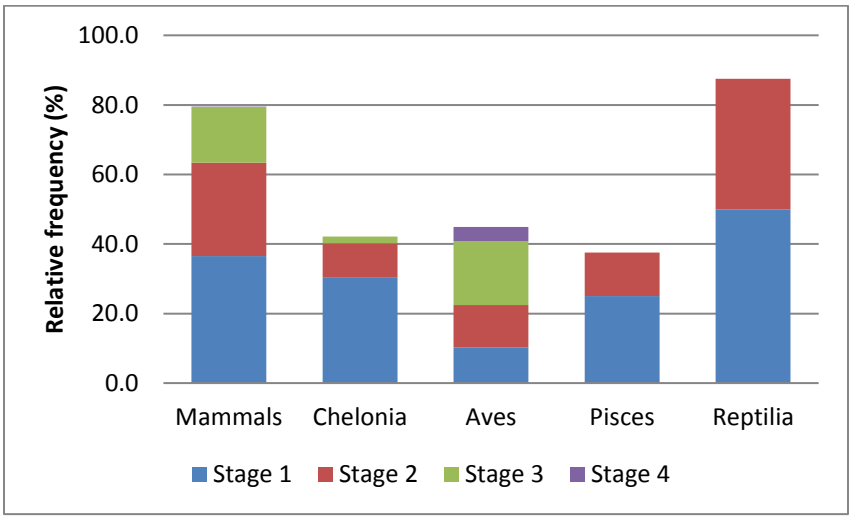


Figure 6.32. Staining intensity by taxonomic group in Profile Four

Table 6.11. Staining intensity by spit in Profile Four

	Stage 1		Stage 2		Stage 3		Stage 4		Totals	
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Spit 1	45	36.6	35	28.5	25	20.3	-	-	**105**	85.4
Spit 2	50	52.6	25	26.3	6	6.3	-	-	**81**	85.3
Spit 3	74	43.3	34	19.9	17	9.9	-	-	**125**	73.1
Spit 4	110	35.1	76	24.3	50	16	1	0.3	**237**	75.7
Spit 5	75	32.9	40	17.5	16	7	-	-	**131**	57.5
Spit 6	8	14.5	5	9.1	-	-	-	-	**13**	23.6
Spit 7	17	10.8	11	7	1	0.6	-	-	**29**	18.5
Spit 8	32	17.5	13	7.1	5	2.7	2	1.1	**52**	28.4
Spit 9	74	34.7	22	10.3	4	1.9	-	-	**100**	46.9
Spit 10	26	51	3	5.9	-	-	-	-	**29**	56.9
Total	**511**	**32.2**	**264**	**16.6**	**124**	**7.8**	**3**	**0.2**	**902**	**56.8**

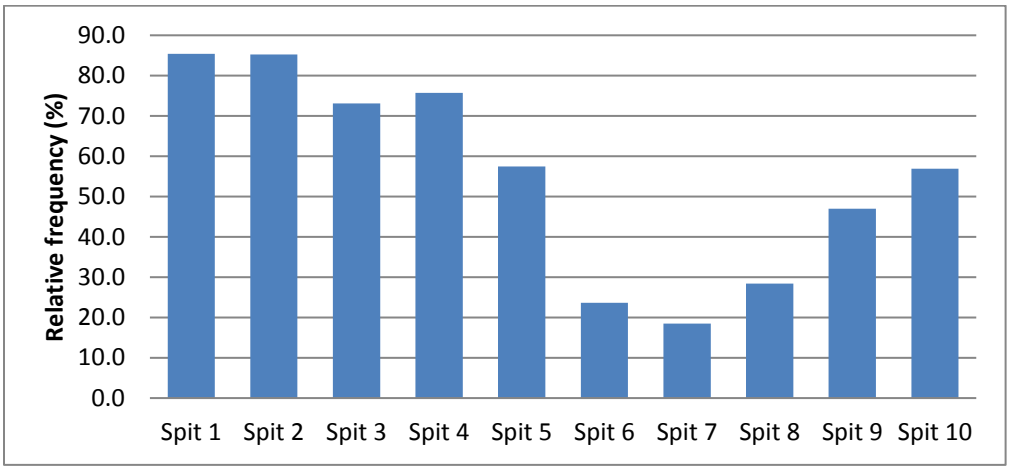


Figure 6.33. Relative frequency of staining by spit in Profile Four

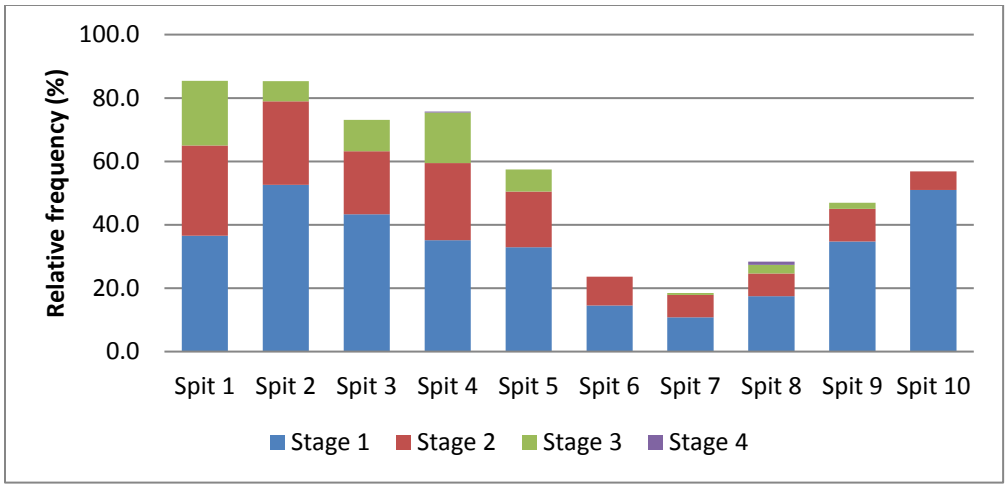


Figure 6.34. Staining intensity by spit in Profile Four

Table 6.12. Staining colour and staining intensity in Profile Four

	Brown		Purple		Black		Orange		Total	
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Stage 1	316	57.1	38	23.8	131	91.6	21	75	**506**	**57.2**
Stage 2	174	31.5	67	41.9	8	5.6	5	17.9	**254**	**28.7**
Stage 3	60	10.8	55	34.4	4	2.8	2	7.1	**121**	**13.7**
Stage 4	3	0.5	-	-	-	-	-	-	**3**	**0.3**
Total	**553**	**62.6**	**160**	**18.1**	**143**	**16.2**	**28**	**3.2**	**884**	

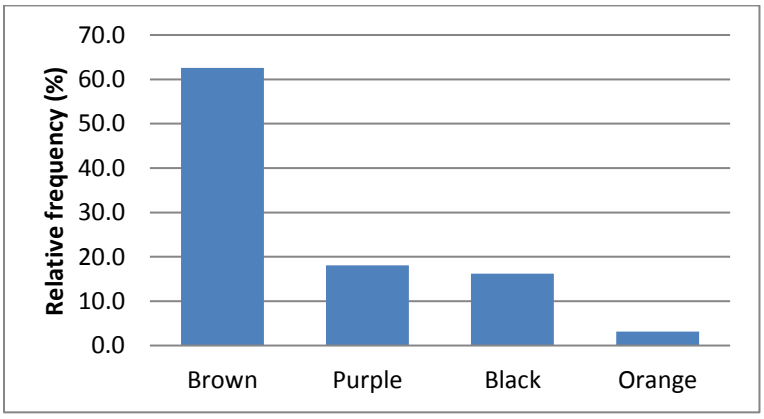


Figure 6.35. Relative frequency of staining colour in Profile Four

Table 6.13. Abrasion intensity by taxonomic group in Profile Four

	Mammals		Chelonia		Aves		Pisces		Reptilia		Totals	
	N	%	N	%	N	%	N	%	N	%	N	%
Stage 1	233	37.9	369	41.6	18	36.7	19	59.4	6	75	**645**	**40.6**
Stage 2	137	22.3	212	23.9	14	28.6	4	12.5	1	12.5	**368**	**23.2**
Stage 3	108	17.6	127	14.3	1	2	3	9.4	-	-	**239**	**15.0**
Stage 4	56	9.1	19	2.1	-	-	-	-	-	-	**75**	**4.7**
Total	**534**	**87**	**727**	**82.1**	**33**	**67.3**	**26**	**81.3**	**7**	**87.5**	**1327**	**83.5**

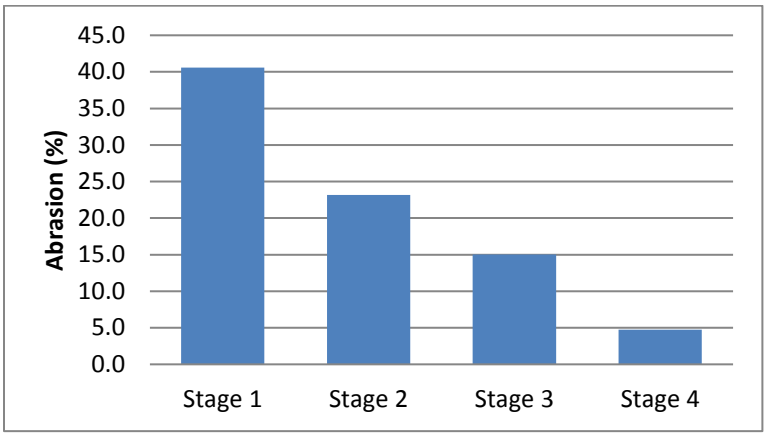


Figure 6.36. Abrasion intensity in Profile Four

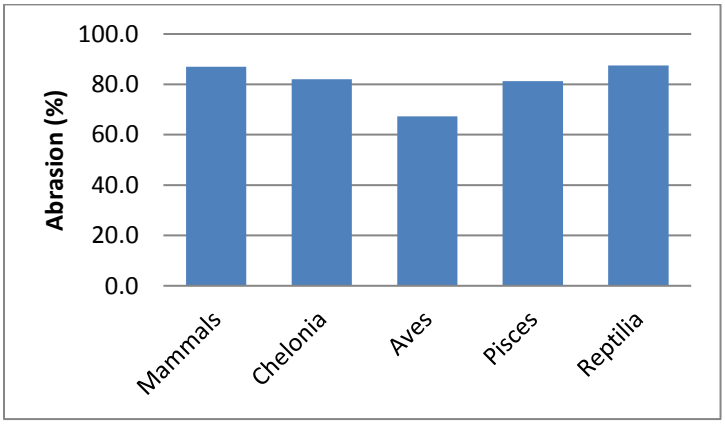


Figure 6.37. Relaitve frequency of abrasion by taxonomic group in Profile Four

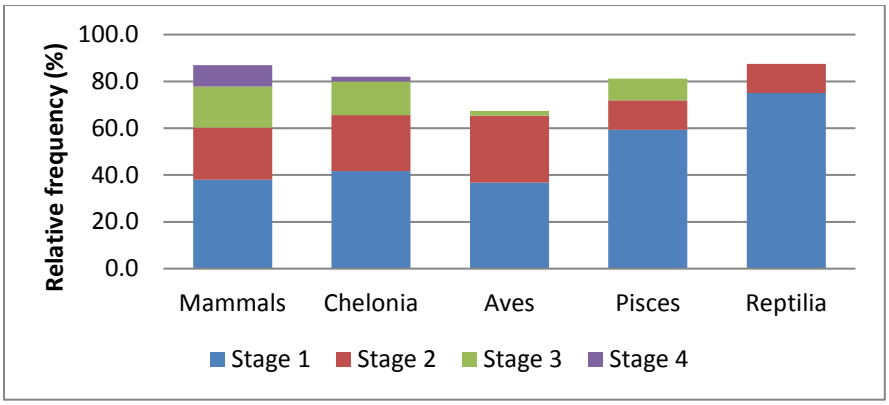


Figure 6.38. Abrasion intensity by taxonomic group in Profile Four

Table 6.14. Abrasion intensity by spit in Profile Four

	Stage 1		Stage 2		Stage 3		Stage 4		Totals	
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Spit 1	39	31.7	35	28.5	27	22	9	7.3	**110**	89.4
Spit 2	42	44.2	24	25.3	17	17.9	9	9.5	**92**	96.8
Spit 3	58	33.9	39	22.8	42	24.6	11	6.4	**150**	87.7
Spit 4	116	37.1	94	30	51	16.3	22	7	**283**	90.4
Spit 5	89	39	60	26.3	38	16.7	19	8.3	**206**	90.4
Spit 6	27	49.1	13	23.6	8	14.5	-	-	**48**	87.3
Spit 7	69	43.9	32	20.4	15	9.6	1	0.6	**117**	74.5
Spit 8	85	46.4	43	23.5	23	12.6	-	-	**151**	82.5
Spit 9	104	48.8	23	10.8	16	7.5	1	0.5	**144**	67.6
Spit 10	16	31.4	5	9.8	2	3.9	3	5.9	**26**	51
Total	**645**	**40.6**	**368**	**23.2**	**239**	**15**	**75**	**4.7**	**1327**	**83.5**

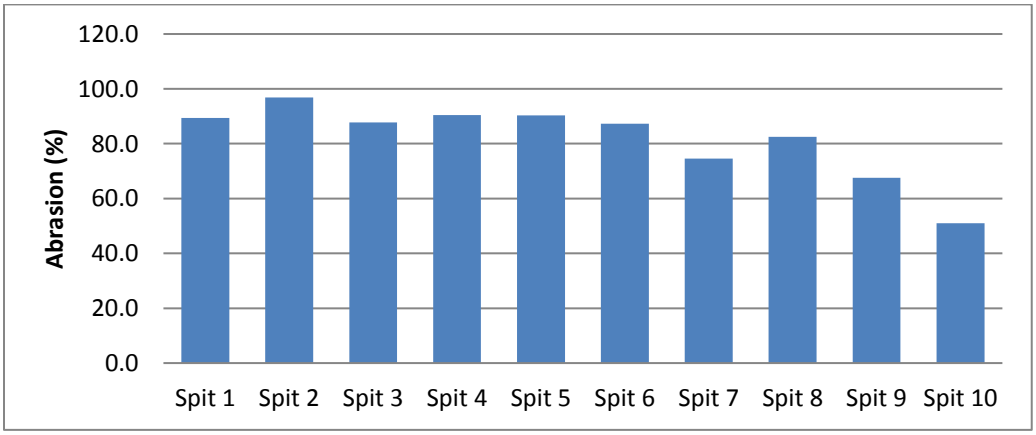


Figure 6.39. Relative frequency of abrasion by spit in Profile Four

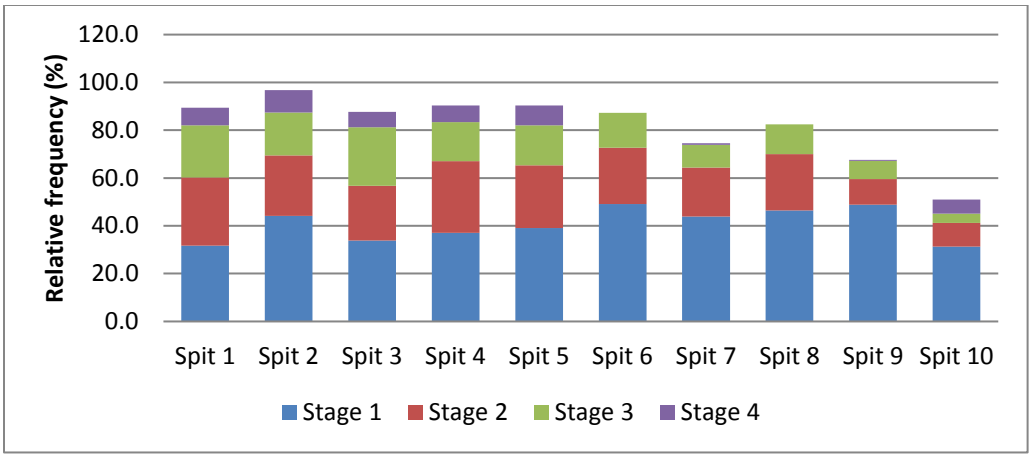


Figure 6.40. Abrasion intensity by spit in Profile Four

Table 6.15. Sheen intensity by taxonomic group in Profile Four

	Mammals		Chelonia		Aves		Pisces		Reptilia		Totals	
	N	%	N	%	N	%	N	%	N	%	N	%
Stage 1	72	11.7	132	14.9	10	20.4	2	6.3	1	12.5	**217**	**13.7**
Stage 2	41	6.7	44	5.0	7	14.3	-	-	-	-	**92**	**5.8**
Stage 3	25	4.1	21	2.4	10	20.4	-	-	-	-	**56**	**3.5**
Stage 4	2	0.3	-	-	-	-	-	-	-	-	**2**	**0.1**
Total	**140**	**22.8**	**197**	**22.2**	**27**	**55.1**	**2**	**6.3**	**1**	**12.5**	**367**	**23.1**

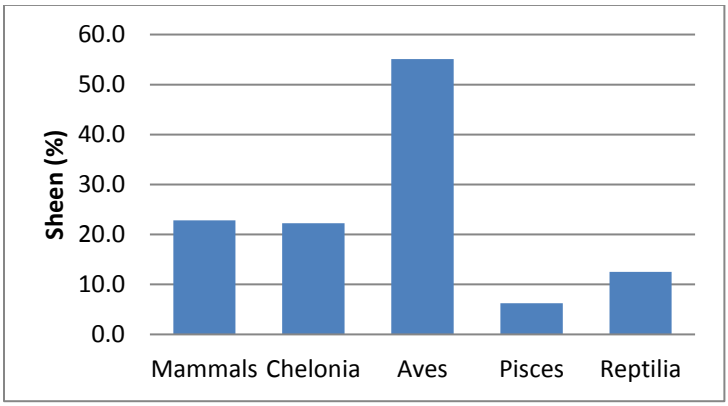


Figure 6.41. Relative frequency of sheen by taxonomic group in Profile Four

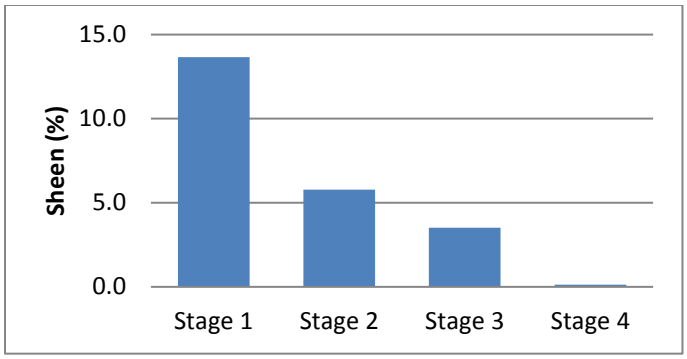


Figure 6.42. Sheen intensity in Profile Four

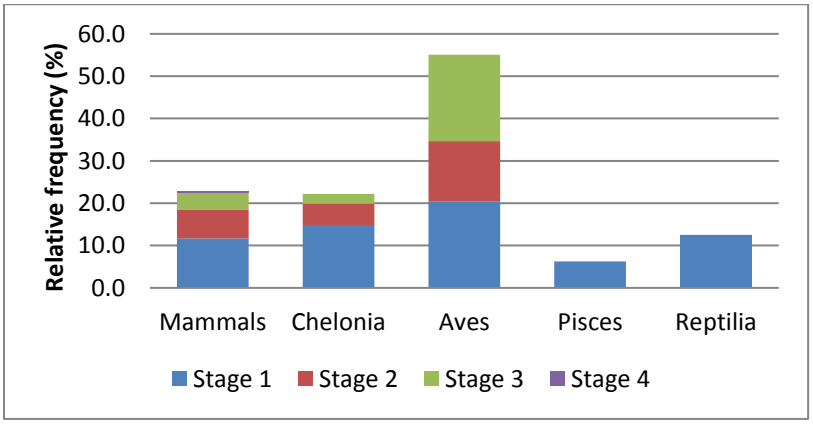


Figure 6.43. Sheen intensity by taxonomic group in Profile Four

Table 6.16. Sheen intensity by spit in Profile Four

	Stage 1		Stage 2		Stage 3		Stage 4		Totals	
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Spit 1	17	13.8	3	2.4	6	4.9	-	-	**26**	**21.1**
Spit 2	11	11.6	8	8.4	1	1.1	-	-	**20**	**21.1**
Spit 3	23	13.5	11	6.4	10	5.8	-	-	**44**	**25.7**
Spit 4	30	9.6	20	6.4	10	3.2	2	0.6	**62**	**19.8**
Spit 5	24	10.5	15	6.6	3	1.3	-	-	**42**	**18.4**
Spit 6	11	20	3	5.5	1	1.8	-	-	**15**	**27.3**
Spit 7	24	15.3	6	3.8	5	3.2	-	-	**35**	**22.3**
Spit 8	25	13.7	12	6.6	14	7.7	-	-	**51**	**27.9**
Spit 9	46	21.6	13	6.1	6	2.8	-	-	**65**	**30.5**
Spit 10	6	11.8	1	2	-	-	-	-	**7**	**13.7**
Total	**217**	**13.7**	**92**	**5.8**	**56**	**3.5**	**2**	**0.1**	**367**	**23.1**

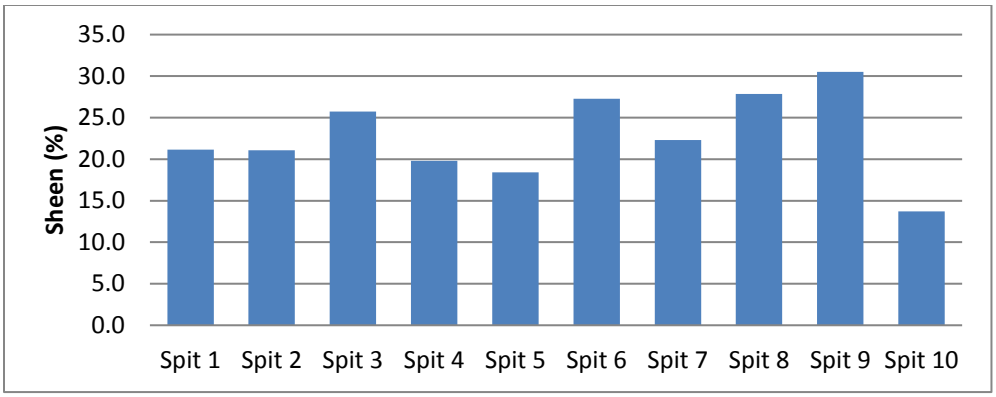


Figure 6.44. Relative frequency of sheen by depth in Profile Four

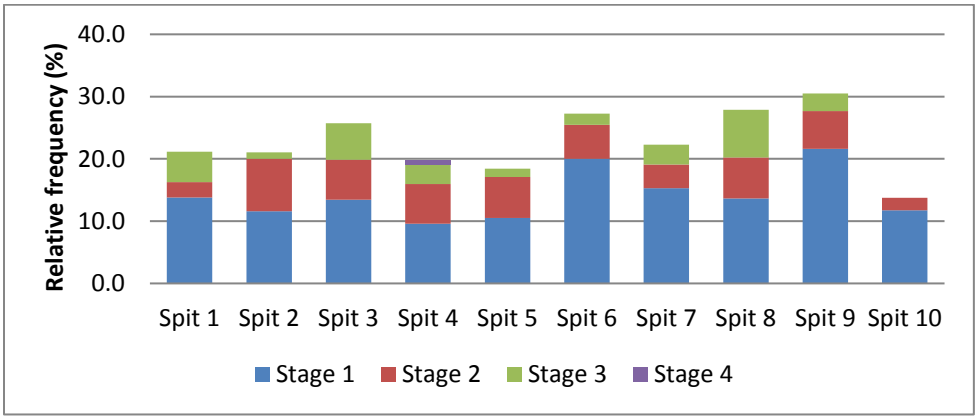


Figure 6.45. Sheen intensity by taxonomic group in Profile Four

Table 6.17. Trampling intensity by taxonomic group in Profile Four

	Mammals		Chelonia		Aves		Pisces		Totals	
	N	%	N	%	N	%	N	%	N	%
Stage 1	157	25.6	215	24.3	9	18.4	-	-	**381**	**24**
Stage 2	30	4.9	34	3.8	7	14.3	1	3.1	**72**	**4.5**
Stage 3	3	0.5	1	0.1	-	-	-	-	**4**	**0.3**
Total	**190**	**30.9**	**250**	**28.2**	**16**	**32.7**	**1**	**3.1**	**457**	**28.8**

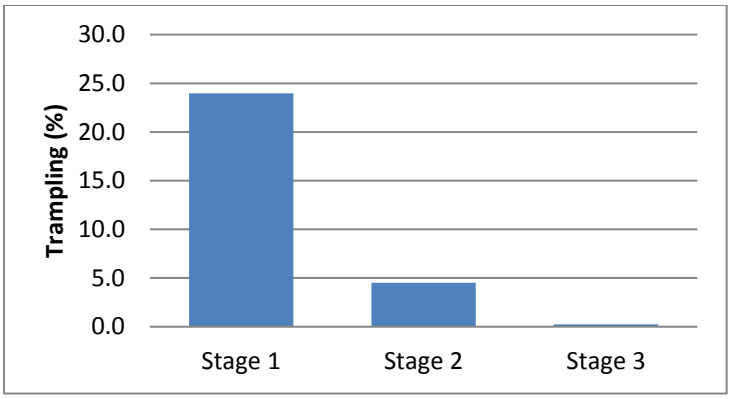


Figure 6.46. Trampling intensity in remains from Profile Four

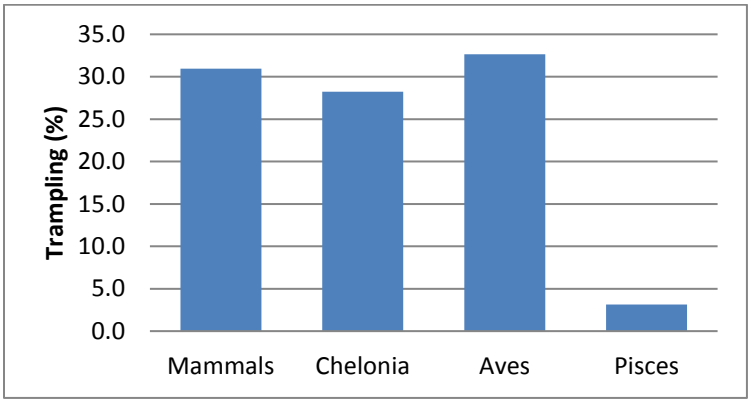


Figure 6.47. Relative frequency of trampling by taxonomic group in Profile Four

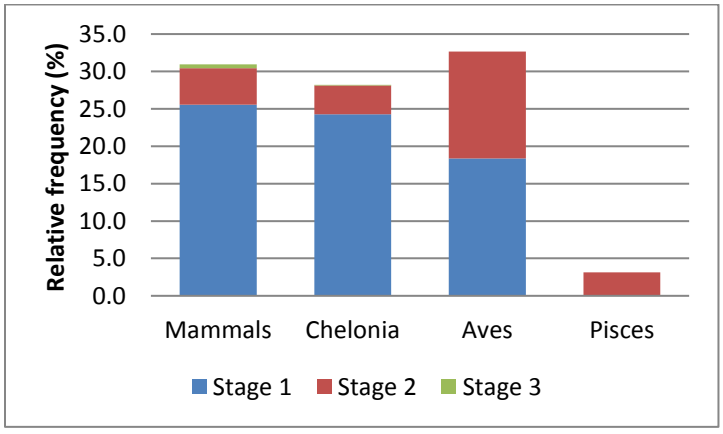


Figure 6.48. Trampling intensity by taxonomic group in Profile Four

Table 6.18. Trampling intensity by spit in Profile Four

	Stage 1		Stage 2		Stage 3		Totals	
	N	%	N	%	N	%	N	%
Spit 1	22	17.9	3	2.4	-	-	**25**	20.3
Spit 2	20	21.1	7	7.4	-	-	**27**	28.4
Spit 3	35	20.5	3	1.8	1	0.6	**39**	22.8
Spit 4	89	28.4	16	5.1	1	0.3	**106**	33.9
Spit 5	66	28.9	10	4.4	1	0.4	**77**	33.8
Spit 6	11	20	1	1.8	-	-	**12**	21.8
Spit 7	27	17.2	2	1.3	-	-	**29**	18.5
Spit 8	33	18	18	9.8	1	0.5	**52**	28.4
Spit 9	64	30	8	3.8	-	-	**72**	33.8
Spit 10	14	27.5	4	7.8	-	-	**18**	35.3
Total	**381**	**24**	**72**	**4.5**	**4**	**0.3**	**457**	**28.8**

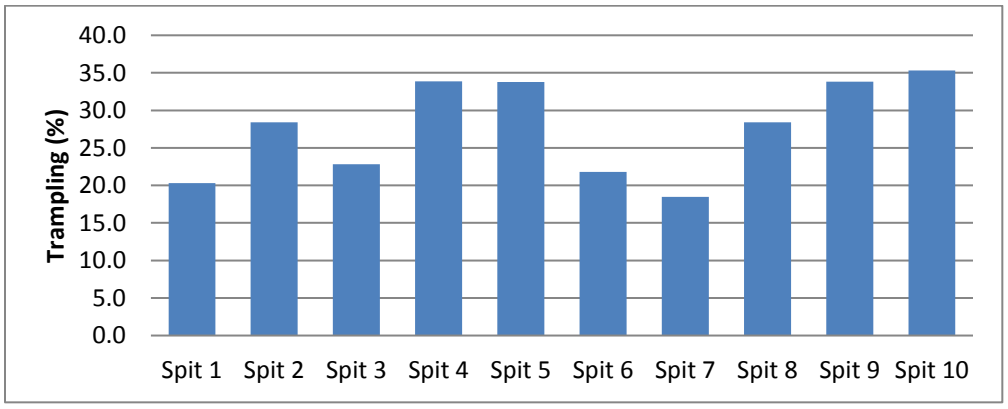


Figure 6.49. Relative frequency of trampling by spit from Profile Four

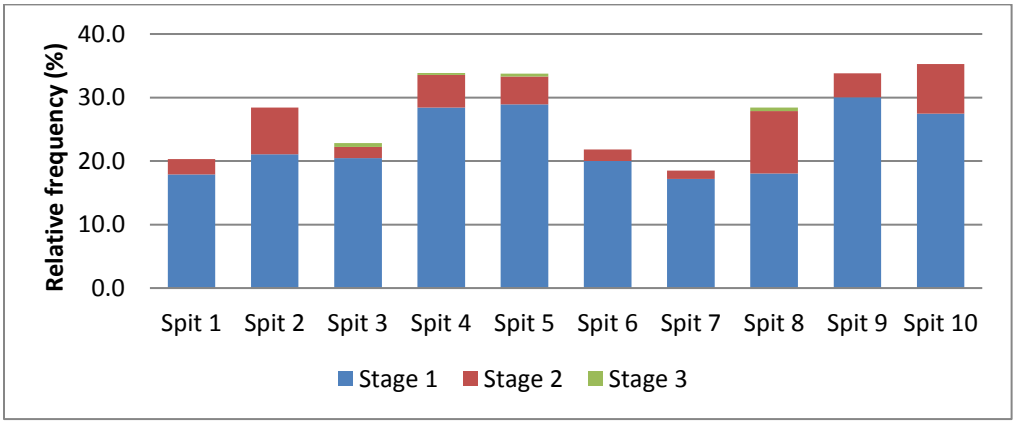


Figure 6.50. Trampling intensity by spit in Profile Four

Table 6.19. Trampling mark types in Profile Four

	Pit		Score		Scratch		Total	
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Stage 1	122	79.2	273	82.7	22	55	**417**	**79.6**
Stage 2	31	20.1	54	16.4	15	37.5	**100**	**19.1**
Stage 3	1	0.6	3	0.9	3	7.5	**7**	**1.3**
Total	**154**	**29.4**	**330**	**63**	**40**	**7.6**	**524**	

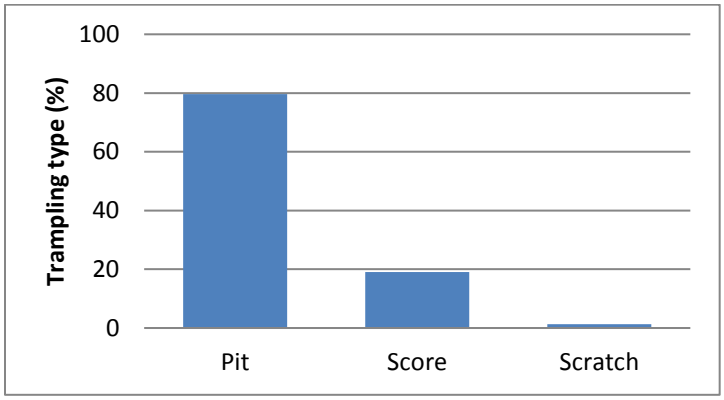


Figure 6.51. Relative frequency of trampling type in Profile Four

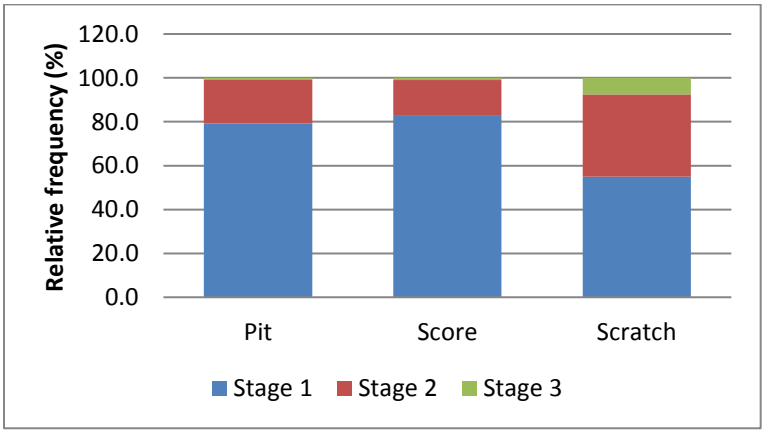


Figure 6.52. Trampling mark type and intensity in profile Four

Table 6.20. Tooth marked bones by taxonomic group in Profile Four

	Mammals		Chelonia		Aves		Totals	
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Stage 1	17	2.8	32	3.6	9	18.4	**58**	**3.7**
Stage 2	2	0.3	3	0.3	-	-	**5**	**0.3**
Stage 3	1	0.2	-	-	-	-	**1**	**0.1**
Total	**20**	**3.3**	**35**	**4.0**	**9**	**18.4**	**64**	**4**

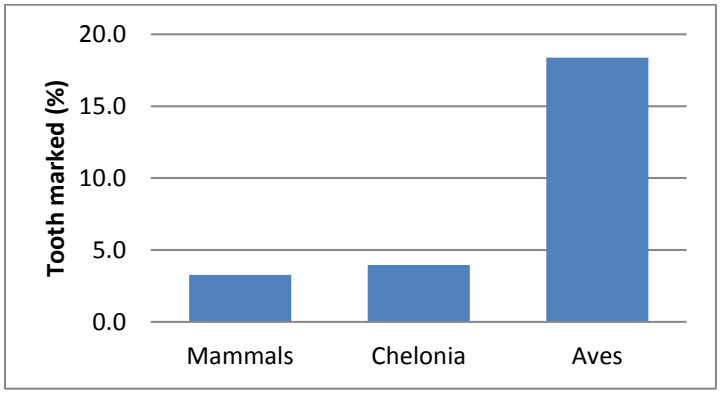


Figure 6.53. Tooth marked bones by taxonomic group in Profile Four

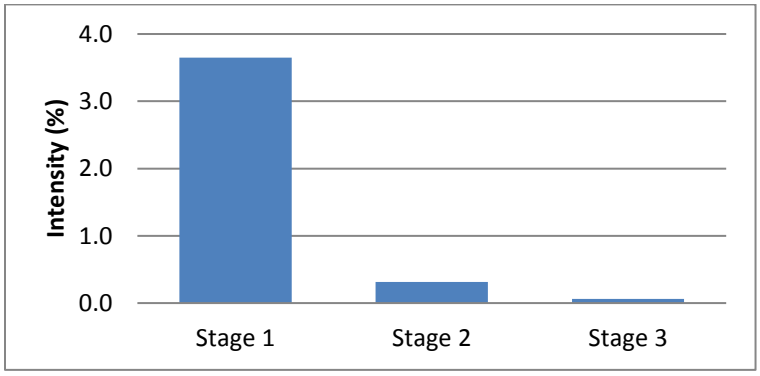


Figure 6.54. Intensity of tooth marking on bones in Profile Four

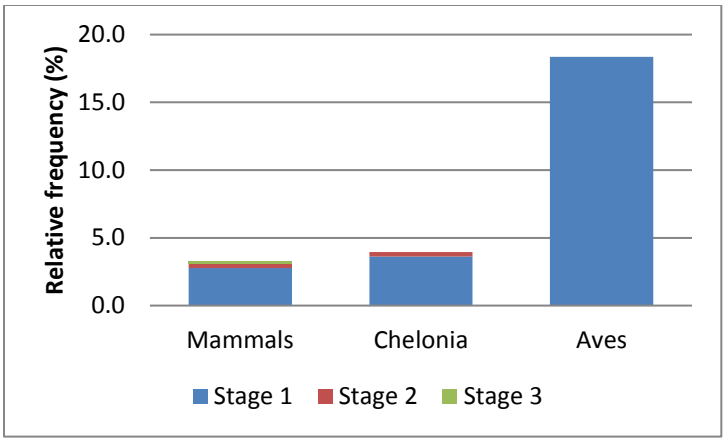


Figure 6.55. Intensity of tooth marking by taxonomic group on bones from Profile Four

Table 6.21. Relative frequency of tooth marked bones by spit in Profile Four

	N	%
Spit 1	2	1.6
Spit 3	5	2.9
Spit 4	12	3.8
Spit 5	6	2.6
Spit 6	1	1.8
Spit 7	7	4.5
Spit 8	6	3.3
Spit 9	14	6.6
Spit 10	11	21.6
Total	64	4

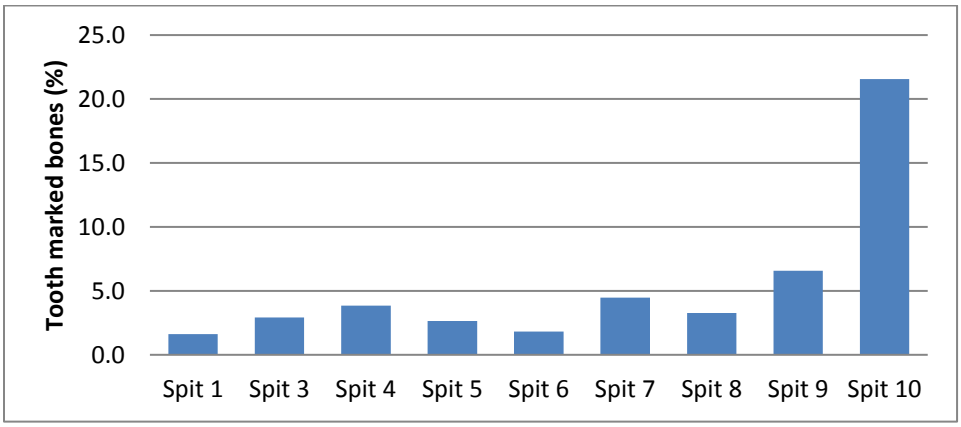


Figure 6.56. Relative frequency of tooth marked bones by spit in Profile Four

Table 6.22. Tooth mark type in Profile Four

	N	%
Pit	35	38
Puncture	11	12
Score	38	41.3
Notch	8	8.7
Total	**92**	

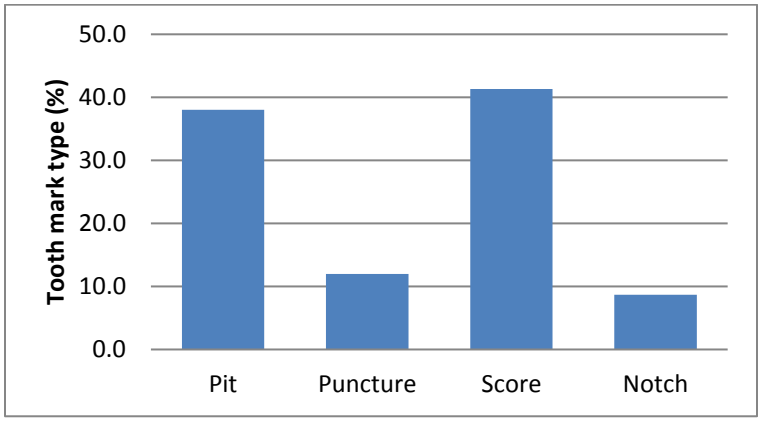


Figure 6.57. Relative frequency of tooth mark type in Profile Four

Table 6.23. Digestive corrosion by taxonomic group in Profile Four

	Mammals		Chelonia		Aves		Totals	
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Stage 1	6	1	26	2.9	2	4.1	**34**	**2.1**
Stage 2	5	0.8	3	0.3	-	-	**8**	**0.5**
Stage 3	3	0.5	3	0.3	3	6.1	**9**	**0.6**
Total	**14**	**2.3**	**32**	**3.6**	**5**	**10.2**	**51**	**3**

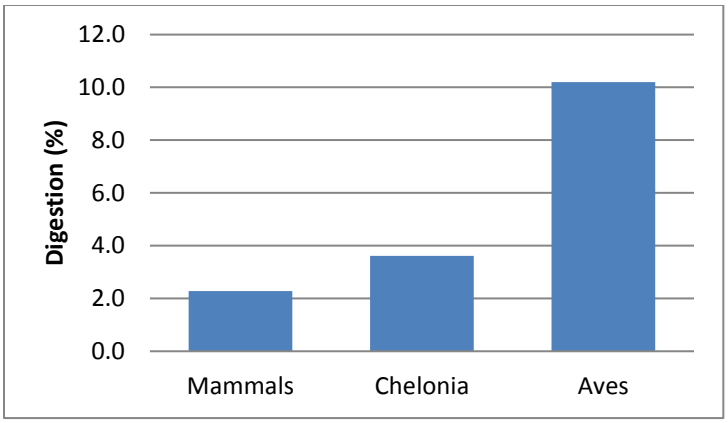


Figure 6.58. Relative frequency of digestive corrosion in Profile Four

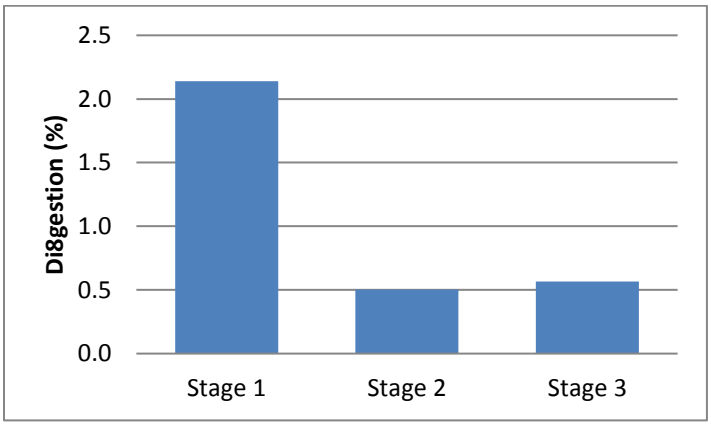


Figure 6.59. Digestive corrosion intensity in Profile Four

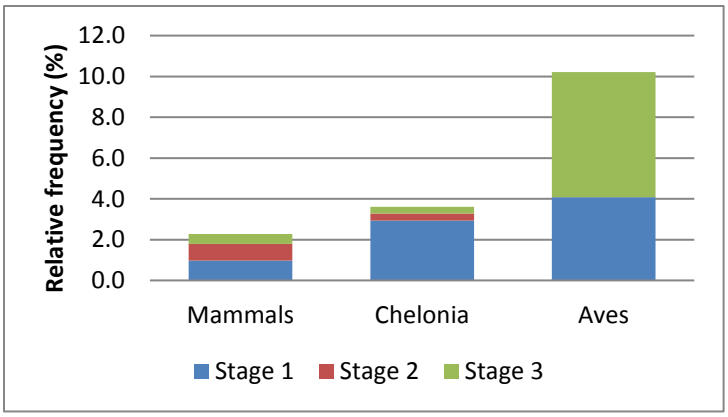


Figure 6.60. Digestion corrosion intensity by taxonomic group in Profile Four

Table 6.24. Relative frequency of digestive corrosion by spit in Profile Four

	N	%
Spit 1	1	0.8
Spit 2	1	1.1
Spit 3	2	1.2
Spit 4	6	1.9
Spit 5	4	1.8
Spit 7	13	8.3
Spit 8	8	4.4
Spit 9	7	3.3
Spit 10	9	17.6
Total	51	3.2

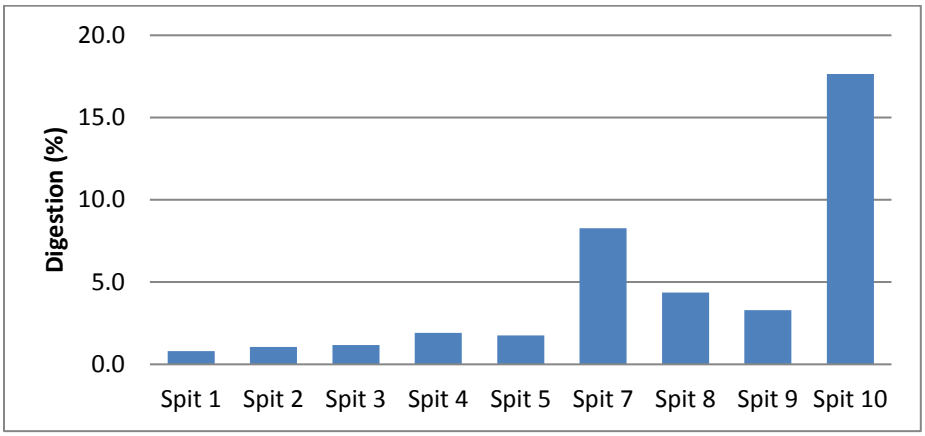


Figure 6.61. Relative frequency of digestive corrosion by spit in Profile Four

Table 6.25. Digestive corrosion type in Profile Four

	N	%
Surface etching	21	32.8
Corrosive pitting	41	64.1
Foramen excavation	2	3.1
Total	**64**	

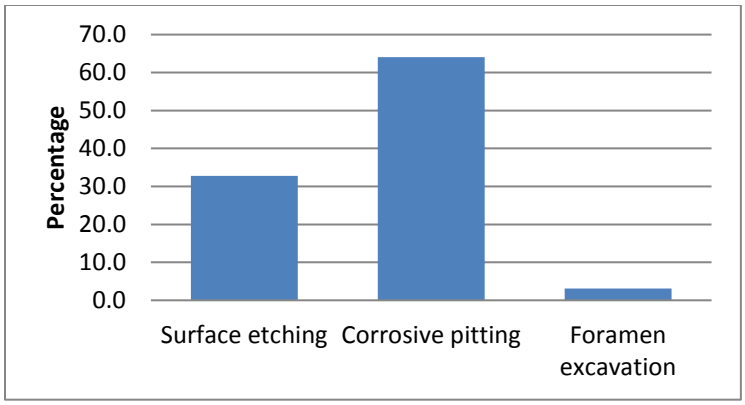


Figure 6.62. Digestive corrosion type in Profile Four

Table 6.26. Root etching by taxonomic group in Profile Four

	Mammals		Chelonia		Aves		Totals	
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Stage 1	128	20.8	150	16.9	4	8.2	**282**	**17.7**
Stage 2	51	8.3	54	6.1	2	4.1	**107**	**6.7**
Stage 3	19	3.1	6	0.7	1	2	**26**	**1.6**
Total	**198**	**32.2**	**210**	**23.7**	**7**	**14.3**	**415**	**26.1**

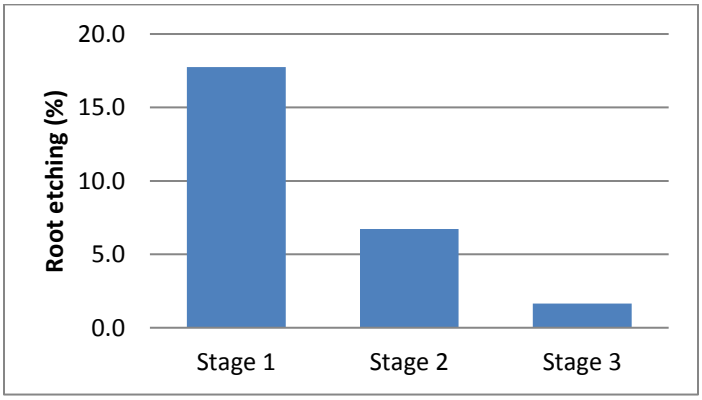


Figure 6.63. Root etching intensity in Profile Four

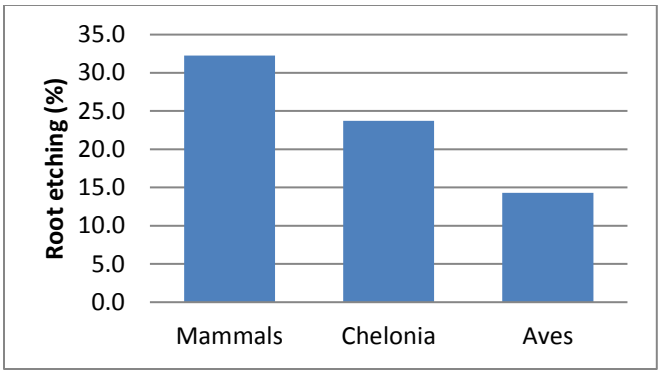


Figure 6.64. Relative frequency of root etching by taxonomic group in Profile Four

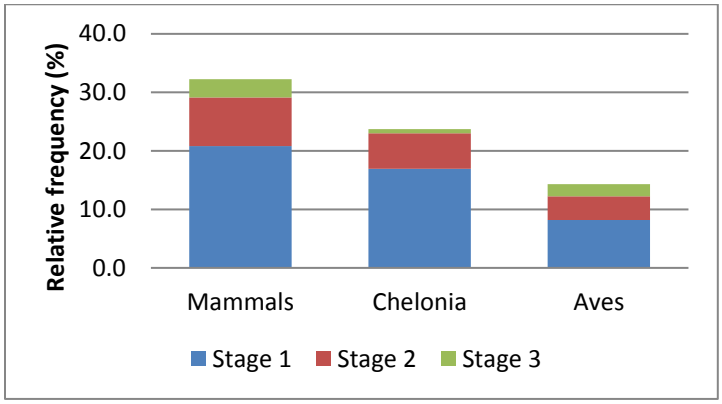


Figure 6.65. Root etching Intensity by taxonomic group in Profile Four

Table 6.27. Root etching intensity by spit in Profile Four

	Stage 1		Stage 2		Stage 3		Totals	
	N	%	N	%	N	%	N	%
Spit 1	27	22	10	8.1	2	1.6	39	31.7
Spit 2	16	16.8	11	11.6	4	4.2	31	32.6
Spit 3	26	15.2	11	6.4	4	2.3	41	24
Spit 4	82	26.2	24	7.7	9	2.9	115	36.7
Spit 5	41	18	13	5.7	4	1.8	58	25.4
Spit 6	13	23.6	7	12.7	-	-	20	36.4
Spit 7	20	12.7	8	5.1	1	0.6	29	18.5
Spit 8	27	14.8	11	6	1	0.5	39	21.3
Spit 9	28	13.1	9	4.2	1	0.5	38	17.8
Spit 10	2	3.9	3	5.9	-	-	5	9.8
Total	282	17.7	107	6.7	26	1.6	415	26.1

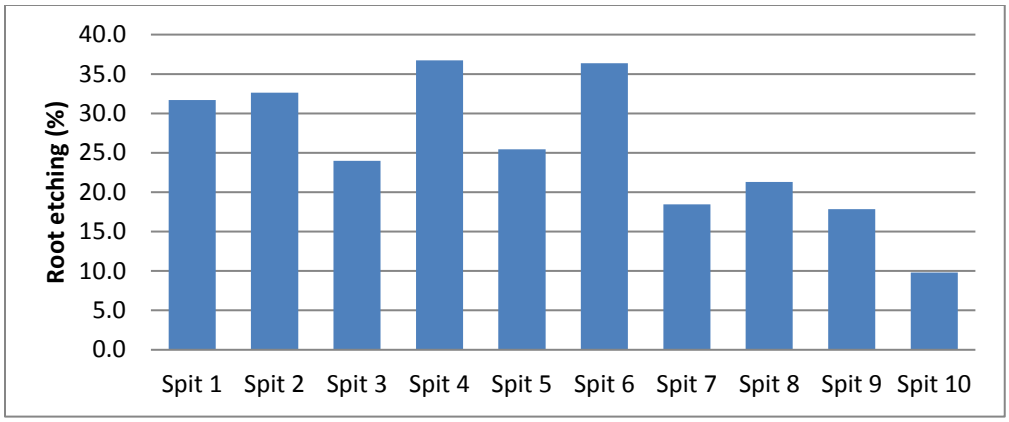


Figure 6.66. Relative frequency root etching by spit in Profile Four

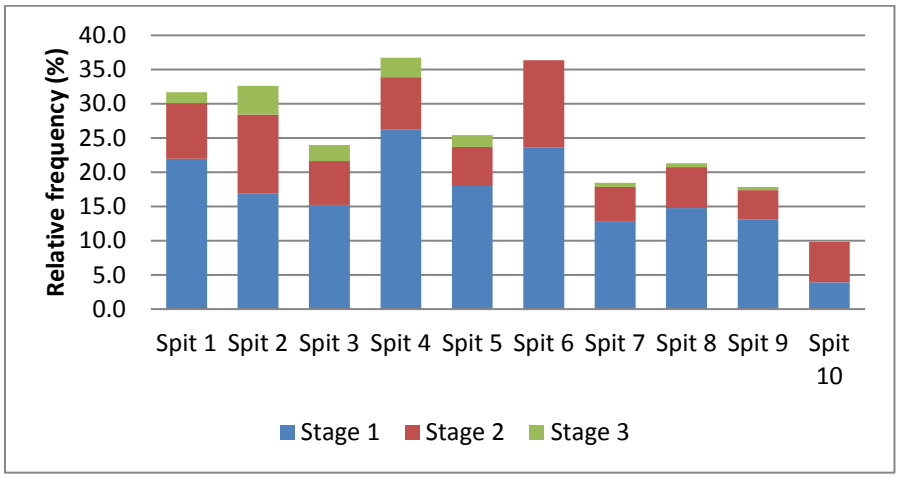


Figure 6.67. Root etching intensity by spit in Profile Four

Table 6.28. Mammal species observed in Profile Four

		Size Class 1		Size Class 2		Size Class 3		Size Class 4		Size Class 5		Total	
		N	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Bovidae	*Raphicerus paralius*	1	100	-	-	-	-	-	-	-	-	**1**	**0.2**
	?*Mesembriportax acrae*	-	-	-	-	-	-	7	100	-	-	**7**	**1.1**
	Bovidae indet.	2	5.7	6	17.1	4	11.4	19	54.3	3	8.6	**34**	**5.5**
Equidae	Equidae	-	-	-	-	-	-	1	100	-	-	**1**	**0.2**
Giraffidae	*Sivatherium hendeyi*	-	-	-	-	-	-	1	25	3	75	**4**	**0.7**
Carnivora	aff. *Vulpes*	-	-	1	100	-	-	-	-	-	-	**1**	**0.2**
	aff. *Canis*	-	-	1	100	-	-	-	-	-	-	**1**	**0.2**
Felidae	Felidae	-	-	1	100	-	-	-	-	-	-	**1**	**0.2**
	aff. Felidae	-	-	-	-	1	100	-	-	-	-	**1**	**0.2**
Hyaenidae	c.f. *Ikelohyaena abronia*	-	-	-	-	1	100	-	-	-	-	**1**	**0.2**
Phocidae	Phocidae	-	-	-	-	2	100	-	-	-	-	**2**	**0.3**
Herpestidae	Herpestidae	3	100	-	-	-	-	-	-	-	-	**3**	**0.5**
Carnivore	Carnivore indet.	1	9.1	3	27.3	6	54.5	1	9.1	-	-	**11**	**1.8**
Leporidae	Pronolagus sp.	-	-	1	100	-	-	-	-	-	-	**1**	**0.2**
	aff. *Lepus*	2	100	-	-	-	-	-	-	-	-	**2**	**0.3**
Bathyergidae	Bathyergidae	2	100	-	-	-	-	-	-	-	-	**2**	**0.3**
Rodentia	Rodentia	1	100	-	-	-	-	-	-	-	-	**1**	**0.2**
Mammal	Mammal indet.	30	5.6	111	20.6	188	34.8	190	35.2	21	3.9	**540**	**87.9**
	Total	**42**	**6.8**	**124**	**20.2**	**202**	**32.9**	**219**	**35.7**	**27**	**4.4**	**614**	

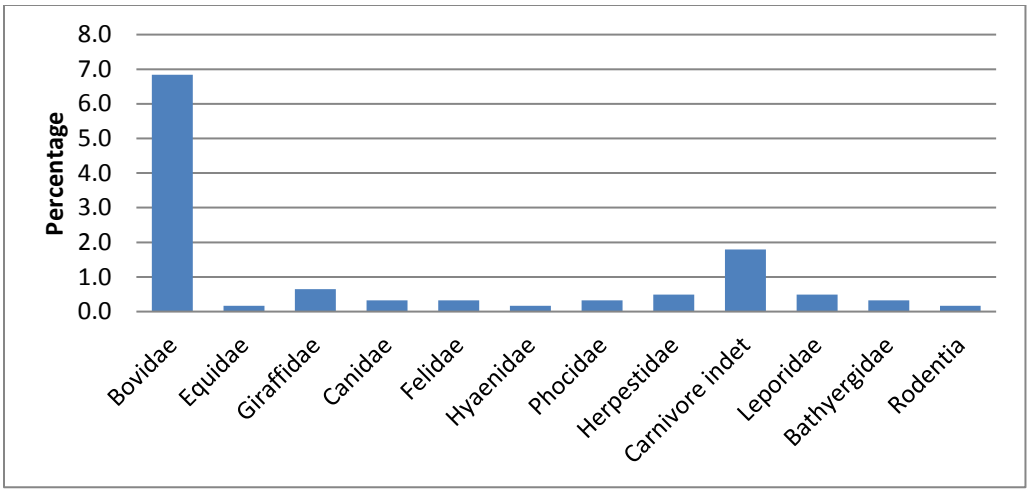


Figure 6.68. Relative frequency of mammal families in Profile Four

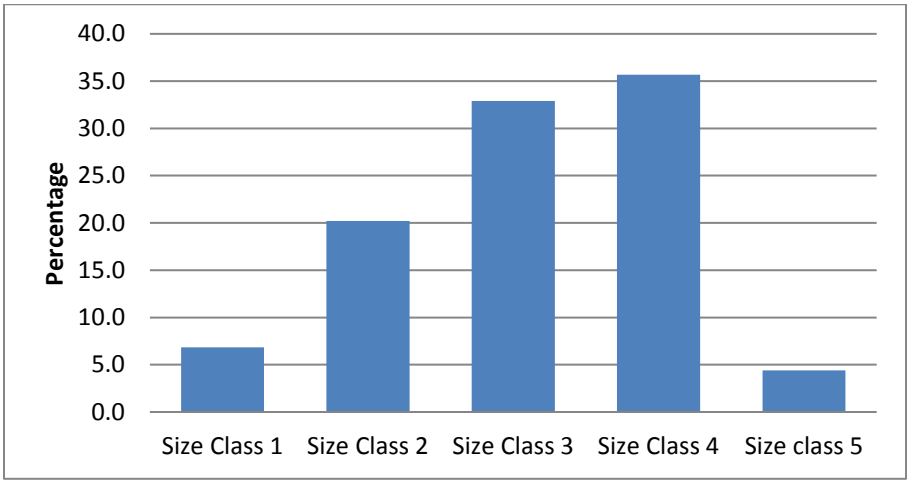


Figure 6.69. Relative frequency of body size classes in mammal remains from Profile Four

Table 6.29. Relative percentage of mammal bones by spit in Profile Four

	N	%
Spit 1	95	15.5
Spit 2	42	6.8
Spit 3	68	11.1
Spit 4	218	35.5
Spit 5	105	17.1
Spit 6	2	0.3
Spit 7	22	3.6
Spit 8	15	2.4
Spit 9	30	4.9
Spit 10	17	2.8
Total	**614**	

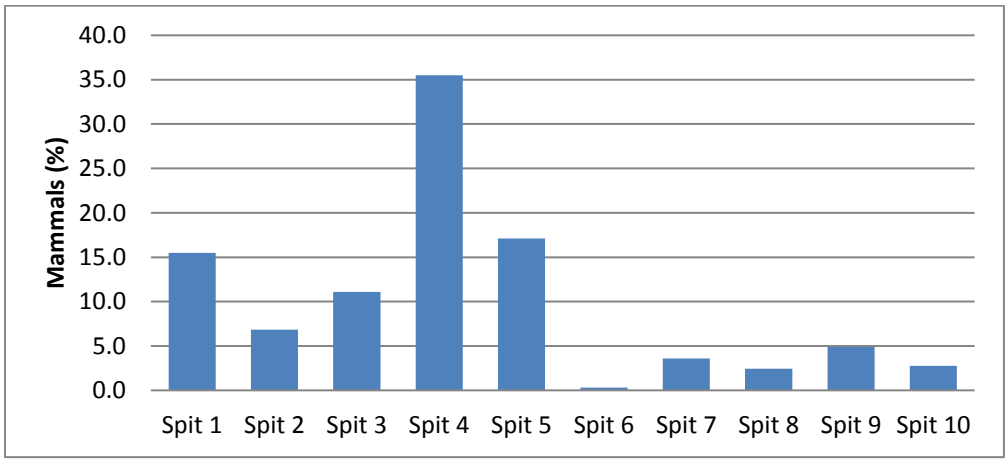


Figure 6.70. Relative frequency of mammals by spit in Profile Four

Table 6.30. Mammal species by spit in Profile Four

		Spit1		Spit2		Spit3		Spit4		Spit5		Spit6		Spit7		Spit8		Spit9		Spit10		Total	
		N	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Bovidae	*Raphicerus paralius*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	100	**1**	**0.2**
	?Mesembriportax acrae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	14.3	6	85.7	**7**	**1.1**
	Bovidae indet.	7	20.6	2	5.9	4	11.8	10	29.4	5	14.7	1	2.9	-	-	-	-	3	8.8	2	5.9	**34**	**5.5**
Equidae	Equidae	-	-	-	-	-	-	1	100	-	-	-	-	-	-	-	-	-	-	-	-	**1**	**0.2**
Giraffidae	*Sivatherium hendeyi*	1	25	-	-	-	-	3	75	-	-	-	-	-	-	-	-	-	-	-	-	**4**	**0.7**
Canidae	aff. *Vulpes*	1	100	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**1**	**0.2**
	aff. *Canis*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	100	-	-	-	-	**1**	**0.2**
Felidae	Felidae	1	100	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**1**	**0.2**
	aff. Felidae	-	-	-	-	1	100	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**1**	**0.2**
Hyaenidae	c.f. *Ikelohyaena abronia*	-	-	1	100	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**1**	**0.2**
Phocidae	Phocidae	-	-	-	-	-	-	2	100	-	-	-	-	-	-	-	-	-	-	-	-	**2**	**0.3**
Herpestidae	Herpestidae	-	-	-	-	-	-	1	33.3	2	66.6	-	-	-	-	-	-	-	-	-	-	**3**	**0.5**
	Carnivore indet.	-	-	-	-	-	-	6	54.5	1	9.1	-	-	1	9.1	2	18.2	1	9.1	-	-	**11**	**1.8**
Leporidae	Pronolagus sp.	-	-	-	-	1	100	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**1**	**0.2**
	aff. *Lepus*	-	-	-	-	-	-	2	100	-	-	-	-	-	-	-	-	-	-	-	-	**2**	**0.3**
Bathyergidae	Bathyergidae	1	50	-	-	1	50	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**2**	**0.3**
Rodentia	Rodentia	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	100	-	-	**1**	**0.2**
Mammal	Mammal indet.	84	15.6	39	7.2	61	11.3	193	35.7	97	18	1	0.2	21	3.9	12	2.2	24	4.4	8	1.5	**540**	**87.9**
	Total	**95**	**15.5**	**42**	**6.8**	**68**	**11.1**	**218**	**35.5**	**105**	**17.1**	**2**	**0.3**	**22**	**3.6**	**15**	**2.4**	**30**	**4.9**	**17**	**2.8**	**614**	

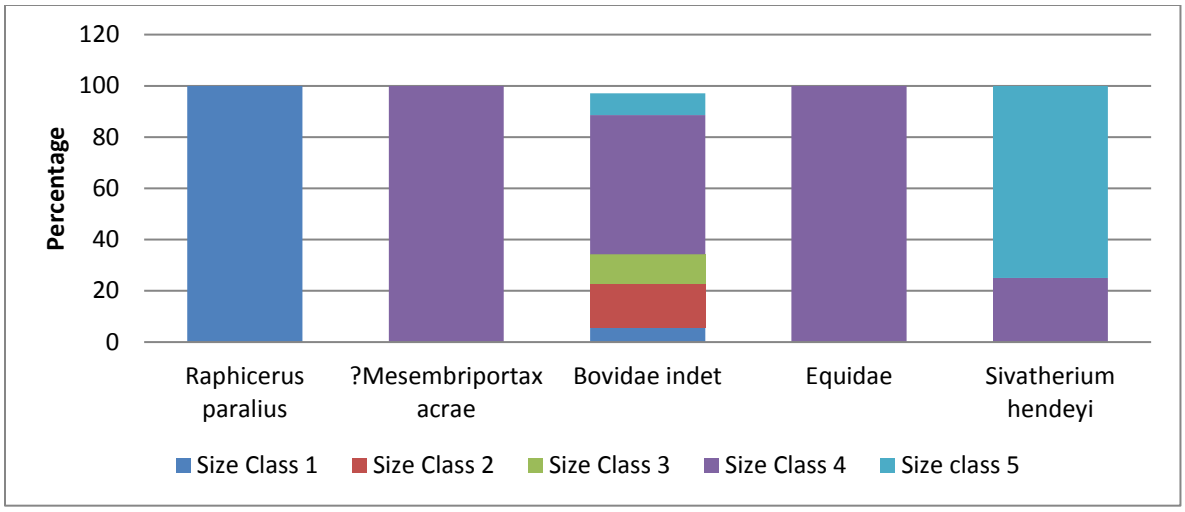


Figure 6.71. Relative frequency of body size class in large mammal groups

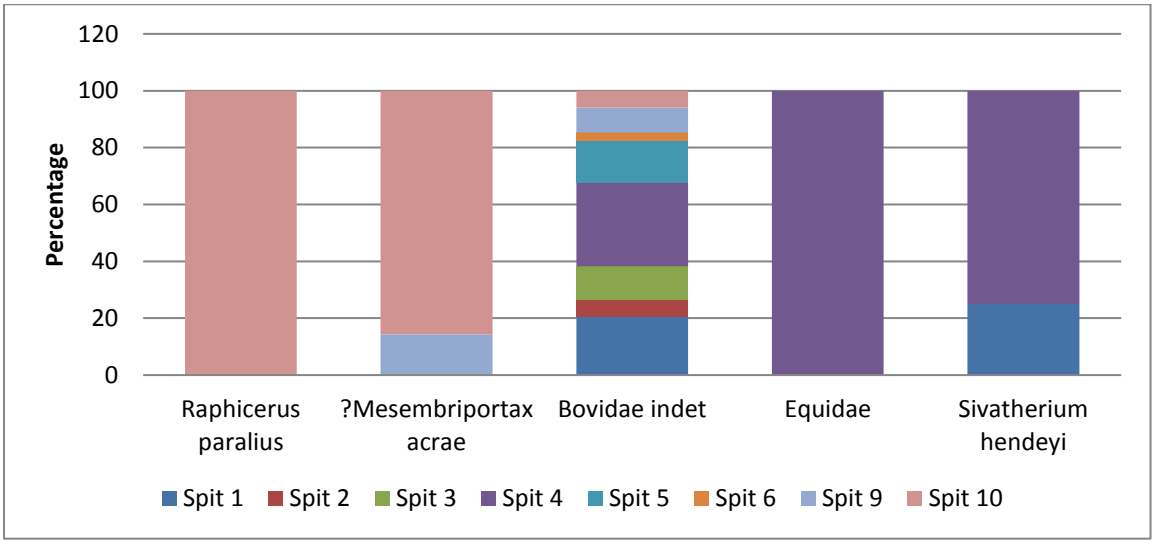


Figure 6.72. Large mammal distribution by spit in Profile Four

Table 6.31. Skeletal element frequencies in large mammals from Profile Four

	Taxon	Element	NISP	MNE	MAU	%MAU	MNI
Bovidae	*Raphicerus paralius*	Ulna	1	1	1	50	1
	?*Mesembriportax acrae*	Vertebra	7	7	1	50	1
	Bovidae indet.	Premolar deciduous	1	1	1	50	1
		Premolar	1	1	1	50	1
		Incisor	1	1	1	50	1
		Molar	5	2	2	100	2
		Tooth indet	1	1	1	50	1
		Horncore	1	1	1	50	1
		Humerus	2	2	2	100	2
		Femur	2	1	1	50	1
		Metapodial	5	2	2	100	2
		Astragalus	1	1	1	50	1
		Patella	1	1	1	50	1
		Proximal phalange	2	2	1	50	1
		Distal phalange	3	3	1	50	1
		Phalange	1	1	1	50	1
		Rib	4	2	2	100	2
		Thoracic vertebra	2	2	2	100	2
		Vertebra	1	1	1	50	1
Equidae	Equidae	Long bone fragment	1	1	1	50	1
Giraffidae	*Sivatherium hendeyi*	Incisor	1	1	1	50	1
		Molar	1	1	1	50	1
	Giraffidae indet.	Tooth indet	2	2	2	100	2
		Total	**47**				**2**

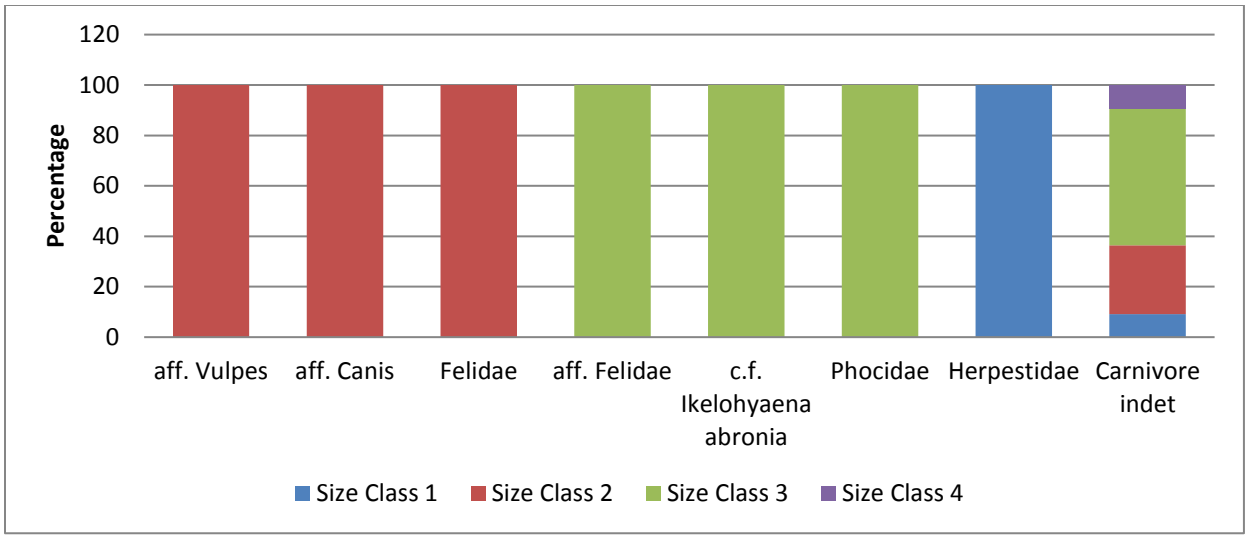


Figure 6.73. Body size class distribution in carnivore remains from Profile Four

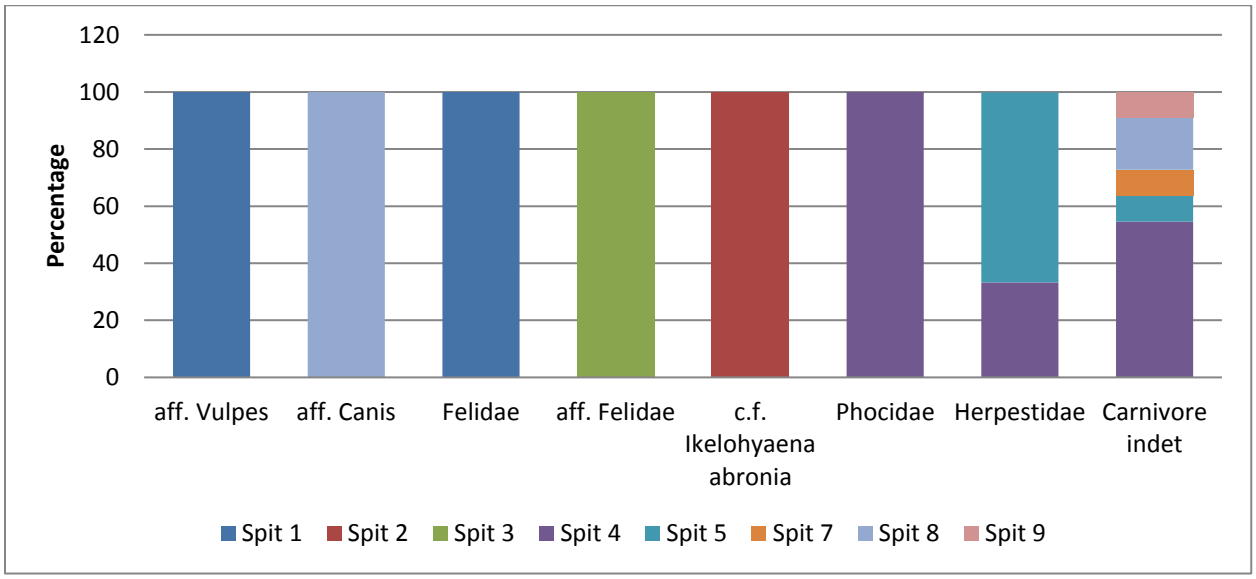


Figure 6.74. Relative frequency of carnivore remains by spit in Profile Four

Table 6.32. Skeletal element frequencies in carnivores from Profile Four

Taxon	Element	NISP	MNE	MAU	%MAU	MNI
aff. *Vulpes*	Proximal phalange	1	1	1	50	1
aff. *Canis*	Tibia	1	1	1	50	1
Felidae	Rib	1	1	1	50	1
aff. Felidae	Radius	1	1	1	50	1
Hyaenidae	Maxilla	1	1	1	50	1
Phocidae	Tibia	1	1	1	50	1
	Tarsal/carpal	1	1	1	50	1
Herpestidae	Mandible	1	1	1	50	1
	Proximal phalange	1	1	1	50	1
	Canine	1	1	1	50	1
Carnivore indet.	Incisor	1	1	1	50	1
	Maxilla	1	1	1	50	1
	Radius	1	1	1	50	1
	Metapodial	1	1	1	50	1
	Calcaneous	1	1	1	50	1
	Proximal phalange	2	2	1	50	2
	Middle phalange	3	3	1	50	2
	Caudal vertebra	1	1	1	50	1
	Total	**21**				**7**

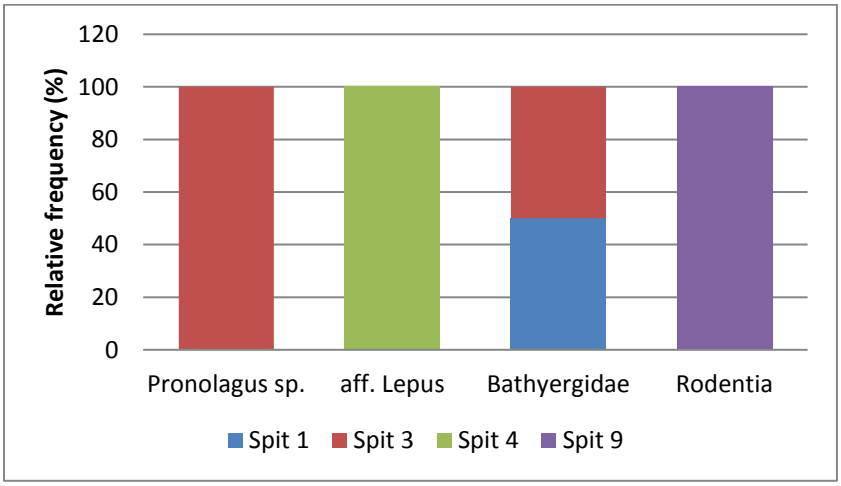


Figure 6.75. Relative frequency of small mammal remains by spit in Profile Four

Table 6.33. Skeletal element frequencies in small mammals from Profile Four

	Taxon	Element	NISP	MNE	MAU	%MAU	MNI
Leporidae	*Pronolagus* sp.	Femur	1	1	1	50	1
	aff. *Lepus*	Tarsal/carpal	1	1	1	50	1
		Proximal phalange	1	1	1	50	1
Bathyergidae	Bathyergidae	Mandible	2	2	2	100	2
Rodentia	Rodentia	Humerus	1	1	1	50	1
		Total	**6**				**5**

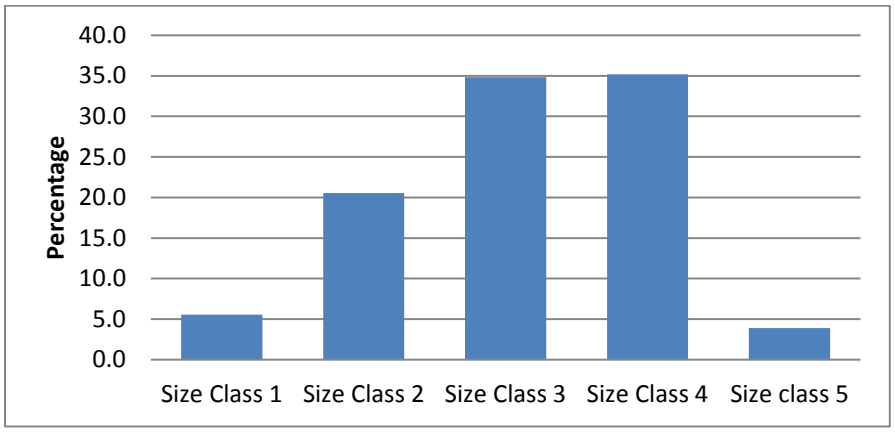


Figure 6.76. Body size class in indeterminate mammal remains from Profile Four

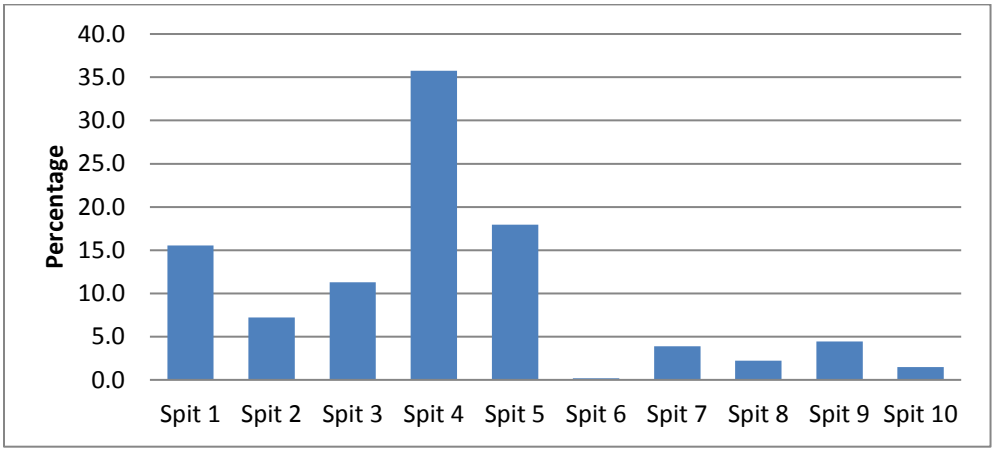


Figure 6.78. Relative frequency of indeterminate mammals by spit in Profile Four

Table 6.34. Skeletal element frequencies in indeterminate mammal remains from Profile Four

Taxon	Element	NISP	MNE	MAU	%MAU	MNI
Mammal indet.	Cranium	2	1	1	25	1
	Auditory Bulla	1	1	1	25	1
	Scapula	2	2	1	25	2
	Humerus	1	1	1	25	1
	Radius	9	3	2	50	3
	Ulna	2	1	1	25	1
	Femur	3	2	2	50	2
	Tibia	7	5	3	75	3
	Metapodial	11	6	3	75	3
	Proximal phalange	3	3	1	25	2
	Middle phalange	1	1	1	25	1
	Distal phalange	2	2	2	50	2
	Phalange	4	2	2	50	2
	Astragalus	1	1	1	25	1
	Calcaneous	2	2	1	25	1
	Sesamoid	4	4	2	50	2
	Tarsal/carpal	9	9	4	100	4
	Thorcic vertebra	4	4	3	75	3
	Lumbar vertebra	1	1	1	25	1
	Caudal vertebra	6	4	3	75	3
	Vertebra	38	7	4	100	4
	Rib	20	4	4	100	4
	Tooth indet.	18	2	2	50	2
	Long bone fragment	389	4	4	100	4
	Total	540				**4**

Table 6.35. Anatomical composition and body size class of large mammals from Profile Four including bovids, equids and giraffids

		Size Class 1		Size Class 2		Size Class 3		Size Class 4		Size Class 5		Total	
Taxon	**Element**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Raphicerus paralius	Ulna	1	100	-	-	-	-	-	-	-	-	**1**	**2.1**
?*Mesembriportax acrae*	Thoracic vertebra	-	-	-	-	-	-	1	100	-	-	**1**	**2.1**
	Lumbar vertebra	-	-	-	-	-	-	6	100	-	-	**6**	**12.8**
Bovidae indet.	Premolar deciduous	-	-	-	-	-	-	1	100	-	-	**1**	**2.1**
	Premolar	-	-	-	-	1	100	-	-	-	-	**1**	**2.1**
	Incisor	-	-	-	-	-	-	1	100	-	-	**1**	**2.1**
	Molar	-	-	-	-	-	-	4	80	1	20	**5**	**10.6**
	Tooth indet.	-	-	-	-	-	-	1	100	-	-	**1**	**2.1**
	Horncore	-	-	-	-	-	-	1	100	-	-	**1**	**2.1**
	Humerus	-	-	1	50	1	50	-	-	-	-	**2**	**4.3**
	Femur	-	-	2	100	-	-	-	-	-	-	**2**	**4.3**
	Metapodial	1	20	-	-	-	-	4	80	-	-	**5**	**10.6**
	Astragalus	-	-	-	-	1	100	-	-	-	-	**1**	**2.1**
	Patella	-	-	-	-	-	-	1	100	-	-	**1**	**2.1**
	Proximal phalange	-	-	1	50	1	50	-	-	-	-	**2**	**4.3**
	Distal phalange	1	33.3	1	33.3	-	-	1	33.3	-	-	**3**	**6.4**
	Phalange	-	-	-	-	-	-	1	100	-	-	**1**	**2.1**
	Rib	-	-	-	-	-	-	2	50	2	50	**4**	**8.5**
	Thoracic vertebra	-	-	1	50	-	-	1	50	-	-	**2**	**4.3**
	Vertebra	-	-	-	-	-	-	1	100	-	-	**1**	**2.1**
Equidae	Tibia	-	-	-	-	-	-	1	100	-	-	**1**	**2.1**
Sivatherium hendeyi	Incisor	-	-	-	-	-	-	-	-	1	100	**1**	**2.1**
	Molar	-	-	-	-	-	-	-	-	1	100	**1**	**2.1**
	Tooth indet.	-	-	-	-	-	-	1	50	1	50	**2**	**4.3**
	Total	**3**	**6.4**	**6**	**12.8**	**4**	**8.5**	**28**	**59.6**	**6**	**12.8**	**47**	

Table 6.36. Anatomical composition and spit depth of large mammals from Profile Four including bovids, equids and giraffids

		Spit 1		Spit 2		Spit 3		Spit 4		Spit 5		Spit 6		Spit 9		Spit 10		Total	
Taxon	**Element**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Raphicerus paralius	Ulna	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	100	**1**	**2.1**
?*Mesembriportax acrae*	Thoracic vertebra	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	100	**1**	**2.1**
	Lumbar vertebra	-	-	-	-	-	-	-	-	-	-	-	-	1	16.7	5	83.3	**6**	**12.8**
Bovidae indet.	Premolar deciduous	-	-	-	-	-	-	1	100	-	-	-	-	-	-	-	-	**1**	**2.1**
	Premolar	-	-	-	-	-	-	-	-	1	100	-	-	-	-	-	-	**1**	**2.1**
	Incisor	1	100	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**1**	**2.1**
	Molar	1	20	1	20	2	40	1	20	-	-	-	-	-	-	-	-	**5**	**10.6**
	Tooth indet.	-	-	-	-	-	-	-	-	1	100	-	-	-	-	-	-	**1**	**2.1**
	Horncore	-	-	-	-	-	-	1	100	-	-	-	-	-	-	-	-	**1**	**2.1**
	Humerus	-	-	-	-	-	-	1	50	1	50	-	-	-	-	-	-	**2**	**4.3**
	Femur	1	50	-	-	-	-	1	50	-	-	-	-	-	-	-	-	**2**	**4.3**
	Metapodial	3	60	-	-	-	-	1	20	1	20	-	-	-	-	-	-	**5**	**10.6**
	Astragalus	-	-	-	-	1	100	-	-	-	-	-	-	-	-	-	-	**1**	**2.1**
	Patella	-	-	-	-	-	-	-	-	-	-	-	-	1	100	-	-	**1**	**2.1**
	Proximal phalange	1	50	-	-	-	-	1	50	-	-	-	-	-	-	-	-	**2**	**4.3**
	Distal phalange	-	-	-	-	-	-	2	66.6	-	-	1	33.3	-	-	-	-	**3**	**6.4**
	Phalange	-	-	-	-	-	-	1	100	-	-	-	-	-	-	-	-	**1**	**2.1**
	Rib	-	-	-	-	-	-	-	-	-	-	-	-	2	50	2	50	**4**	**8.5**
	Thoracic vertebra	-	-	1	50	1	50	-	-	-	-	-	-	-	-	-	-	**2**	**4.3**
	Vertebra	-	-	-	-	-	-	-	-	1	100	-	-	-	-	-	-	**1**	**2.1**
Equidae	Tibia	-	-	-	-	-	-	1	100	-	-	-	-	-	-	-	-	**1**	**2.1**
Sivatherium hendeyi	Incisor	-	-	-	-	-	-	1	100	-	-	-	-	-	-	-	-	**1**	**2.1**
	Molar	-	-	-	-	-	-	-	-	1	100	-	-	-	-	-	-	**1**	**2.1**
Giraffidae indet.	Tooth indet.	-	-	-	-	-	-	2	100	-	-	-	-	-	-	-	-	**2**	**4.3**
	Total	**7**	**14.9**	**2**	**4.3**	**4**	**8.5**	**14**	**29.8**	**6**	**12.8**	**1**	**2.1**	**4**	**8.5**	**9**	**19.1**	**47**	

Table 6.37. Anatomical composition and body size class of carnivores from Profile Four

		Size Class 1		Size Class 2		Size Class 3		Size Class 4		Total	
Taxon	**Element**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
aff. *Vulpes*	Proximal phalange	-	-	1	100	-	-	-	-	**1**	**4.8**
aff. *Canis*	Tibia	-	-	1	100	-	-	-	-	**1**	**4.8**
Felidae	Rib	-	-	1	100	-	-	-	-	**1**	**4.8**
aff. Felidae	Radius	-	-	-	-	1	-	-	-	**1**	**4.8**
Hyaenidae	Premolar/mandible	-	-	-	-	1	-	-	-	**1**	**4.8**
Phocidae	Tibia	-	-	-	-	1	100	-	-	**1**	**4.8**
	Tarsal/carpal	-	-	-	-	1	100	-	-	**1**	**4.8**
Herpestidae	Mandible	1	100	-	-	-	-	-	-	**1**	**4.8**
	Proximal phalange	1	-	-	-	-	-	-	-	**1**	**4.8**
	Canine	1	100	-	-	-	-	-	-	**1**	**4.8**
Carnivore indet.	Incisor	-	-	-	-	1	100	-	-	**1**	**4.8**
	Maxilla	-	-	1	50	-	-	-	-	**1**	**4.8**
	Radius	-	-	-	-	1	100	-	-	**1**	**4.8**
	Metapodial	-	-	-	-	-	-	1	100	**1**	**4.8**
	Calcaneous	-	-	-	-	1	100	-	-	**1**	**4.8**
	Proximal phalange	1	66.6	-	-	1	33.3	-	-	**2**	**9.5**
	Middle phalange	-	-	1	33.3	2	66.6	-	-	**3**	**14.3**
	Caudal vertebra	-	-	1	100	-	-	-	-	**1**	**4.8**
	Total	**4**	**19**	**6**	**28.6**	**10**	**47.6**	**1**	**4.8**	**21**	

Table 6.38. Anatomical composition and spit depth of carnivores from Profile Four

		Spit 1		Spit 2		Spit 3		Spit 4		Spit 5		Spit 7		Spit 8		Spit 9		Total	
Taxon	**Element**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
aff. *Vulpes*	Proximal phalange	1	100	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**1**	**4.8**
aff. *Canis*	Tibia	-	-	-	-	-	-	-	-	-	-	-	-	1	100	-	-	**1**	**4.8**
Felidae	Rib	1	100	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**1**	**4.8**
aff. Felidae	Radius	-	-	-	-	1	100	-	-	-	-	-	-	-	-	-	-	**1**	**4.8**
Hyaenidae	Premolar/mandible	-	-	1	100	-	-	-	-	-	-	-	-	-	-	-	-	**1**	**4.8**
Phocidae	Tibia	-	-	-	-	-	-	1	100	-	-	-	-	-	-	-	-	**1**	**4.8**
	Tarsal/carpal	-	-	-	-	-	-	1	100	-	-	-	-	-	-	-	-	**1**	**4.8**
Herpestidae	Mandible	-	-	-	-	-	-	1	100	-	-	-	-	-	-	-	-	**1**	**4.8**
	Proximal phalange	-	-	-	-	-	-	-	-	1	100	-	-	-	-	-	-	**1**	**4.8**
	Canine	-	-	-	-	-	-	-	-	1	100	-	-	-	-	-	-	**1**	**4.8**
Carnivore indet.	Incisor	-	-	-	-	-	-	1	100	-	-	-	-	-	-	-	-	**1**	**4.8**
	Maxilla	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	100	**1**	**4.8**
	Radius	-	-	-	-	-	-	1	100	-	-	-	-	-	-	-	-	**1**	**4.8**
	Metapodial	-	-	-	-	-	-	1	100	-	-	-	-	-	-	-	-	**1**	**4.8**
	Calcaneous	-	-	-	-	-	-	1	100	-	-	-	-	-	-	-	-	**1**	**4.8**
	Proximal phalange	-	-	-	-	-	-	-	-	1	50	1	50	-	-	-	-	**2**	**9.5**
	Middle phalange	-	-	-	-	-	-	2	66.6	-	-	-	-	1	33.3	-	-	**3**	**14.3**
	Caudal vertebra	-	-	-	-	-	-	-	-	-	-	-	-	1	100	-	-	**1**	**4.8**
	Total	**2**	**9.5**	**1**	**4.8**	**1**	**4.8**	**9**	**42.9**	**3**	**14.3**	**1**	**4.8**	**3**	**14.3**	**1**	**4.8**	**21**	

Table 6.39. Anatomical composition and body size class in small mammals from Profile Four

			Size Class 1		Size Class 2		Total	
	Taxon	**Element**	**N**	**%**	**N**	**%**	**N**	**%**
Leporidae	*Pronolagus* sp.	Femur	-	-	1	100	**1**	**16.7**
	aff. *Lepus*	Tarsal/carpal	1	100	-	-	**1**	**16.7**
		Proximal phalange	1	100	-	-	**1**	**16.7**
Bathyergidae	Bathyergidae	Mandible	2	100	-	-	**2**	**33.3**
Rodentia	Rodentia	Humerus	1	100	-	-	**1**	**16.7**
		Total	**5**	**83.3**	**1**	**16.7**	**6**	

Table 6.40. Anatomical composition and spit depth in small mammal remains from Profile Four

			Spit 1		Spit 3		Spit 4		Spit 9		Total	
	Taxon	**Element**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Leporidae	*Pronolagus* sp.	Femur	-	-	1	100	-	-	-	-	**1**	**16.7**
	aff. *Lepus*	Tarsal/carpal	-	-	-	-	1	100	-	-	**1**	**16.7**
		Proximal phalange	-	-	-	-	1	100	-	-	**1**	**16.7**
Bathyergidae	Bathyergidae	Mandible	1	50	1	50	-	-	-	-	**2**	**33.3**
Rodentia	Rodentia	Humerus	-	-	-	-	-	-	1	100	**1**	**16.7**
		Total	**1**	**16.7**	**2**	**33.3**	**2**	**33.3**	**1**	**16.7**	**6**	

Table 6.41. Anatomical composition and body size class in indeterminate mammal remains from Profile Four

		Size Class 1		Size Class 2		Size Class 3		Size Class 4		Size Class 5		Total	
Taxon	**Element**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Mammal indet.	Cranium	-	-	-	-	1	50	1	50	-	-	**2**	**0.4**
	Auditory Bulla	-	-	1	100	-	-	-	-	-	-	**1**	**0.2**
	Scapula	-	-	-	-	-	-	1	50	1	50	**2**	**0.4**
	Humerus	-	-	-	-	1	100	-	-	-	-	**1**	**0.2**
	Radius	-	-	2	22.2	5	55.6	2	22.2	-	-	**9**	**1.7**
	Ulna	-	-	-	-	-	-	2	100	-	-	**2**	**0.4**
	Femur	-	-	2	66.6	1	33.3	-	-	-	-	**3**	**0.6**
	Tibia	2	28.6	-	-	3	42.9	2	28.6	-	-	**7**	**1.3**
	Metapodial	5	45.5	4	36.4	2	18.2	-	-	-	-	**11**	**2**
	Proximal phalange	2	66.6	1	33.3	-	-	-	-	-	-	**3**	**0.6**
	Middle phalange	1	100	-	-	-	-	-	-	-	-	**1**	**0.2**
	Distal phalange	1	50	-	-	-	-	-	-	1	50	**2**	**0.4**
	Phalange	3	75	-	-	-	-	1	25	-	-	**4**	**0.7**
	Astragalus	1	100	-	-	-	-	-	-	-	-	**1**	**0.2**
	Calcaneous	2	100	-	-	-	-	-	-	-	-	**2**	**0.4**
	Sesamoid	1	25	3	75	-	-	-	-	-	-	**4**	**0.7**
	Tarsal/carpal	1	11.1	2	22.2	1	11.1	1	11.1	4	44.4	**9**	**1.7**
	Thorcic vertebra	1	25	-	-	1	25	2	50	-	-	**4**	**0.7**
	Lumbar vertebra	-	-	-	-	-	-	1	100	-	-	**1**	**0.2**
	Caudal vertebra	2	33.3	3	50.0	1	16.7	-	-	-	-	**6**	**1.1**
	Vertebra	2	5.3	4	10.5	6	15.8	25	65.8	1	2.6	**38**	**7**
	Rib	2	10	1	5	4	20	12	60	1	5	**20**	**3.7**
	Tooth indet.	-	-	-	-	-	-	16	88.9	2	11.1	**18**	**3.3**
	Long bone fragment	4	1.0	88	22.6	162	41.6	124	31.9	11	2.8	**389**	**72**
	Total	**30**	**5.6**	**111**	**20.6**	**188**	**34.8**	**190**	**35.2**	**21**	**3.9**	**540**	

Table 6.42. Descriptive statistics of maximum specimen length in mammal remains from Profile Four

	Size Class 1	Size Class 2	Size Class 3	Size Class 4	Size Class 5	Combined
N	42	124	206	213	28	613
Minimum	4	6	4	3	19	3
Maximum	36	54	100	104	117	117
Mean	14.3	24.8	30.5	37.5	48.6	31.5
Standard Deviation	7.13	8.39	10.66	16.11	25.50	15.16

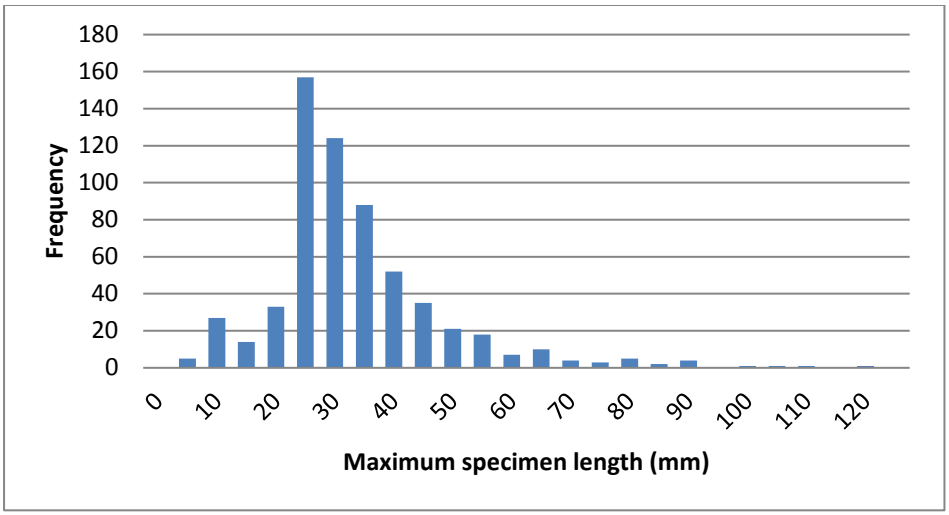


Figure 6.78. Histogram of maximum specimen length of combined mammal remains from Profile Four

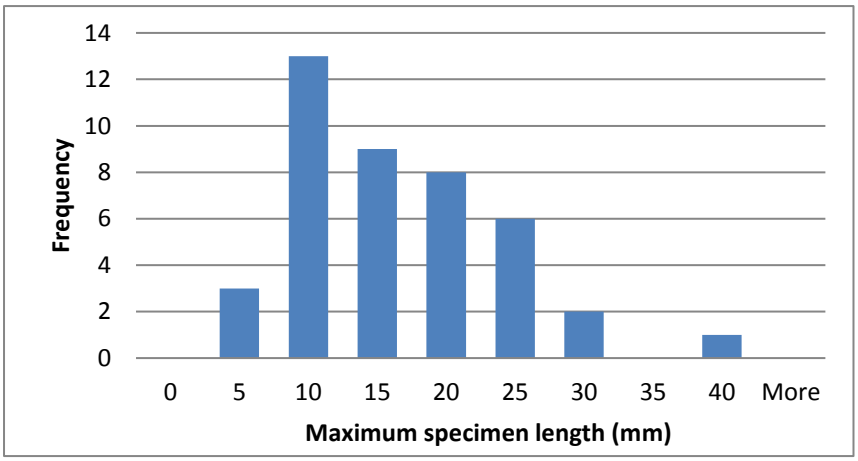


Figure 6.79. Histogram of maximum specimen length of size class one mammal remains from Profile Four

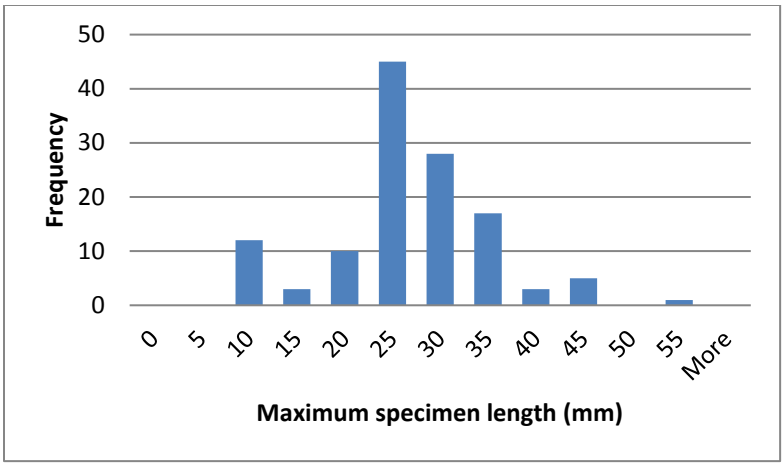


Figure 6.80. Histogram of maximum specimen length of size class two mammal remains from Profile Four

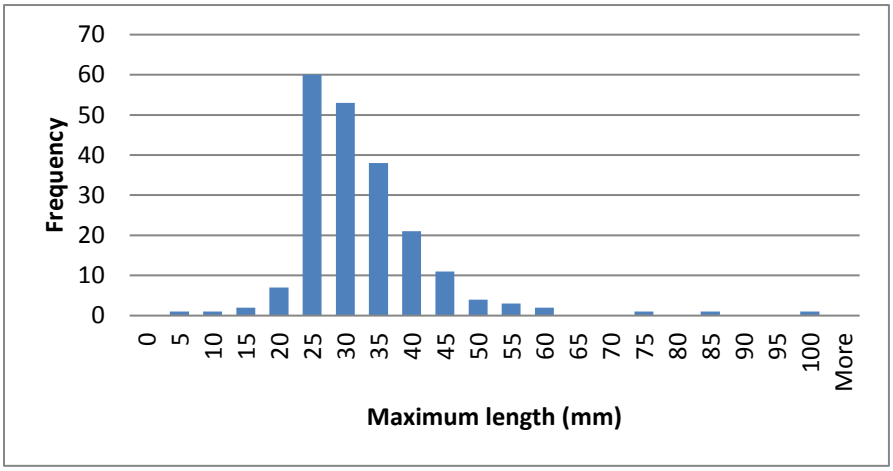


Figure 6.81. Histogram of maximum specimen length of size class three mammal remains from Profile Four

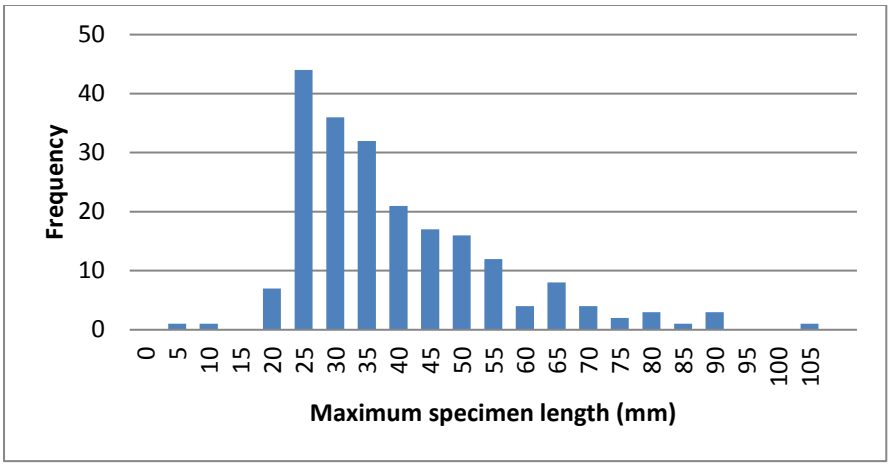


Figure 6.82. Histogram of maximum specimen length of size class four mammal remains from Profile Four

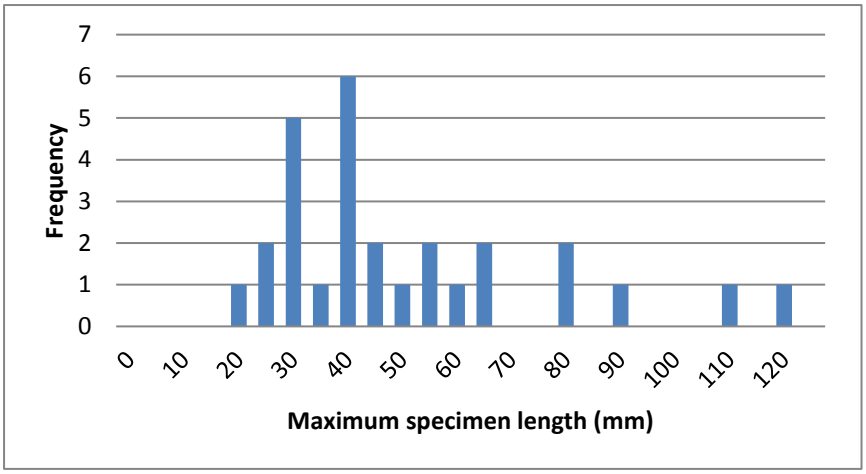


Figure 6.83. Histogram of maximum specimen length of size class five mammal remains from Profile Four

Table 6.43. Age categories and body size class in mammal remains from Profile Four

	Size class 1		Size class 2		Size class 3		Size class 4		Size class 5		Total	
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Adult	18	78.3	16	80	12	60	11	57.9	3	60	**60**	**69**
Subadult	2	8.7	1	5	4	20	1	5.3	-	-	**8**	**9.2**
Juvenile	3	13	3	15	4	20	7	36.8	2	40	**19**	**21.8**
Total	**23**	**26.4**	**20**	**23**	**20**	**23**	**19**	**21.8**	**5**	**5.7**	**87**	**14.2**

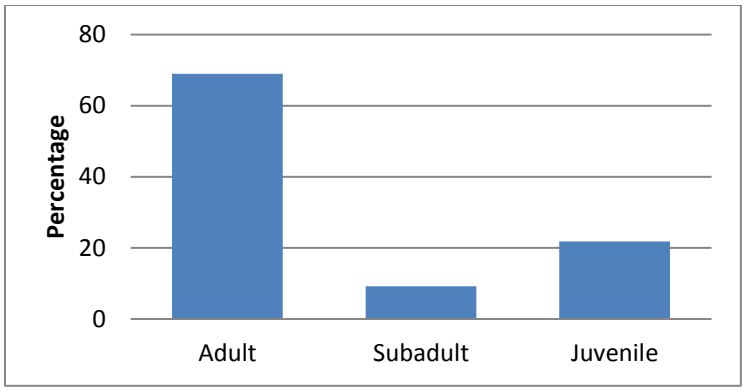


Figure 6.84. Age categories in mammal remains from Profile Four

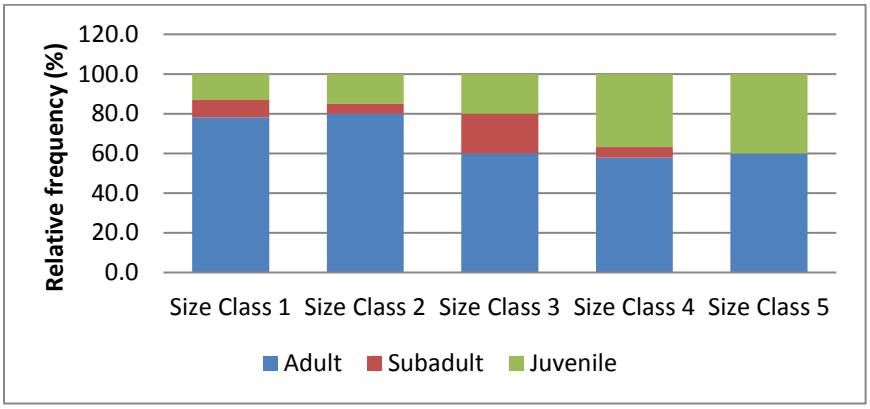


Figure 6.85. Age categories and body size class in mammal remains from Profile Four

Table 6.44. Age categories by spit in mammal remains from Profile Four

	Spit 1		Spit 2		Spit 3		Spit 4		Spit 5		Spit 7		Spit 8		Spit 9		Spit 10		Total	
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Adult	7	77.8	3	75	8	80	19	70.4	6	75	6	66.7	3	75	5	62.5	3	37.5	**60**	**69**
Subadult	-	-	-	-	-	-	-	-	1	12.5	1	11.1	-	-	3	37.5	3	37.5	**8**	**9.2**
Juvenile	2	22.2	1	25	2	20	8	29.6	1	12.5	2	22.2	1	25	-	-	2	25	**19**	**21.8**
Total	**9**	**10.3**	**4**	**4.6**	**10**	**11.5**	**27**	**31**	**8**	**9.2**	**9**	**10.3**	**4**	**4.6**	**8**	**9.2**	**8**	**9.2**	**87**	**14.2**

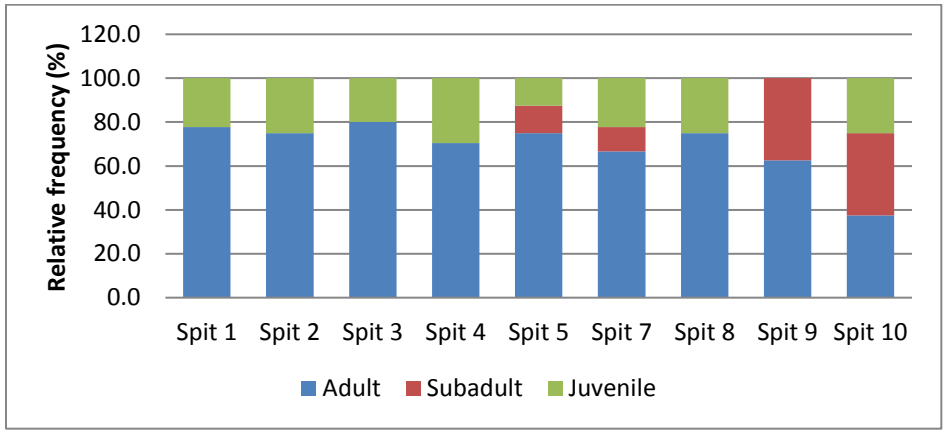


Figure 6.86. Age categories by spit in mammal remains from Profile Four

Table 6.45. Completeness and body size class in mammal remains from Profile Four

		Size Class 1		Size Class 2		Size Class 3		Size Class 4		Size Class 5		Total	
		N	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
?*Mesembriportax acrae*	Thoracic vertebra	-	-	-	-	-	-	1	100	-	-	**1**	**2.6**
	Lumbar vertebra	-	-	-	-	-	-	6	100	-	-	**6**	**15.4**
Bovidae indet.	Premolar	-	-	-	-	1	100	-	-	-	-	**1**	**2.6**
	Distal phalange	1	50	1	5	-	-	-	-	-	-	**2**	**5.1**
Phocidae	Tarsal/carpal	-	-	-	-	1	100	-	-	-	-	**1**	**2.6**
Hyaenidae	Premolar/mandible	-	-	-	-	1	100	-	-	-	-	**1**	**2.6**
Herpestidae	Proximal phalange	1	100	-	-	-	-	-	-	-	-	**1**	**2.6**
Carnivore indet.	Proximal phalange	1	50	-	-	1	50	-	-	-	-	**2**	**5.1**
	Middle phalange	-	-	1	100	-	-	-	-	-	-	**1**	**2.6**
	Caudal vertebra	-	-	1	100	-	-	-	-	-	-	**1**	**2.6**
aff. *Lepus*	Tarsal/carpal	1	100	-	-	-	-	-	-	-	-	**1**	**2.6**
	Proximal phalange	1	100	-	-	-	-	-	-	-	-	**1**	**2.6**
Rodentia	Humerus	1	100	-	-	-	-	-	-	-	-	**1**	**2.6**
Mammal indet.	Proximal phalange	2	66.6	1	33.3	-	-	-	-	-	-	**3**	**7.7**
	Middle phalange	1	100	-	-	-	-	-	-	-	-	**1**	**2.6**
	Distal phalange	1	100	-	-	-	-	-	-	-	-	**1**	**2.6**
	Calcaneous	2	100	-	-	-	-	-	-	-	-	**2**	**5.1**
	Sesamoid	1	33.3	3	66.6	-	-	-	-	-	-	**4**	**10.3**
	Tarsal/carpal	1	16.7	2	33.3	1	16.7	-	-	2	33.3	**6**	**15.4**
	Caudal vertebra	-	-	-	-	1	100	-	-	-	-	**1**	**2.6**
	Vertebra	1	100	-	-	-	-	-	-	-	-	**1**	**2.6**
	Total	**15**	**35.7**	**9**	**69.2**	**6**	**33.3**	**7**	**29.2**	**2**	**28.6**	**39**	**6.4**

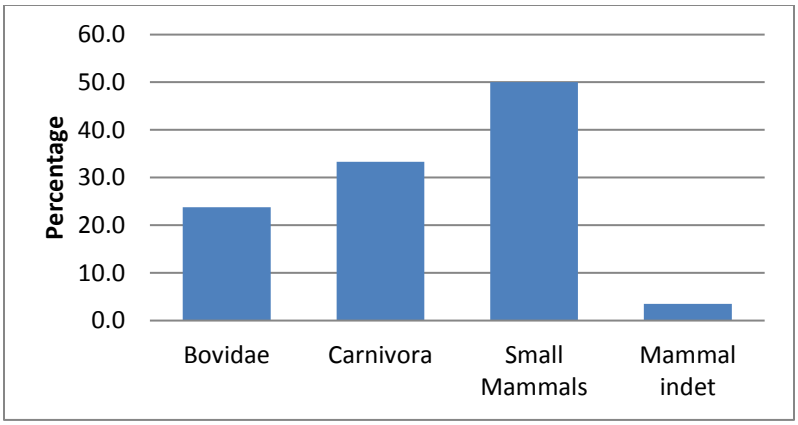


Figure 6.87. Relative frequency of complete bones in mammal groups from Profile Four

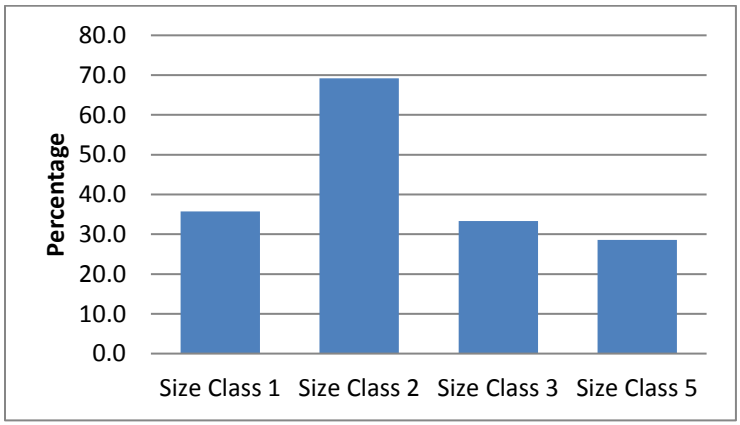


Figure 6.88. Relative frequency of complete mammal bones by size class in Profile Four

Table 6.46. Complete mammal bones by spit in Profile Four

		Spit 1		Spit 2		Spit 3		Spit 4		Spit 5		Spit 6		Spit 7		Spit 8		Spit 9		Total	
		N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%
?Mesembriportax acrae	Thoracic vertebra	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	100	**1**	**2.6**
	Lumbar vertebra	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	16.7	5	83.3	**6**	**15.4**
Bovidae indet.	Premolar	-	-	-	-	-	-	-	-	1	100	-	-	-	-	-	-	-	-	**1**	**2.6**
	Distal phalange	-	-	-	-	-	-	1	50	-	-	1	50	-	-	-	-	-	-	**2**	**5.1**
Phocidae	Tarsal/carpal	-	-	-	-	-	-	1	100	-	-	-	-	-	-	-	-	-	-	**1**	**2.6**
Hyaenidae	Premolar/mandible	-	-	1	100	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**1**	**2.6**
Herpestidae	Proximal phalange	-	-	-	-	-	-	-	-	1	100	-	-	-	-	-	-	-	-	**1**	**2.6**
Carnivore indet.	Proximal phalange	-	-	-	-	-	-	-	-	1	50	-	-	1	5	-	-	-	-	**2**	**5.1**
	Middle phalange	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	100	-	-	**1**	**2.6**
	Caudal vertebra	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	100	-	-	**1**	**2.6**
aff. *Lepus*	Tarsal/carpal	-	-	-	-	-	-	1	100	-	-	-	-	-	-	-	-	-	-	**1**	**2.6**
	Proximal phalange	-	-	-	-	-	-	1	100	-	-	-	-	-	-	-	-	-	-	**1**	**2.6**
Rodentia	Humerus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	100	**1**	**2.6**
Mammal indet.	Proximal phalange	-	-	-	-	1	33.3	-	-	-	-	-	-	2	66.6	-	-	-	-	**3**	**7.7**
	Middle phalange	-	-	-	-	1	100	-	-	-	-	-	-	-	-	-	-	-	-	**1**	**2.6**
	Distal phalange	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	100	**1**	**2.6**
	Calcaneous	-	-	-	-	-	-	-	-	-	-	1	50	1	50	-	-	-	-	**2**	**5.1**
	Sesamoid	-	-	-	-	1	25	-	-	1	25	-	-	-	-	-	-	2	50	**4**	**10.3**
	Tarsal/carpal	-	-	-	-	1	16.7	2	33.3	-	-	-	-	2	33.3	-	-	1	16.7	**6**	**15.4**
	Caudal vertebra	1	100	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**1**	**2.6**
	Vertebra	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	100	**1**	**2.6**
	Total	**1**	**0.8**	**1**	**1.1**	**4**	**2.3**	**6**	**1.9**	**4**	**1.8**	**2**	**3.6**	**6**	**3.8**	**2**	**1.1**	**6**	**2.8**	**39**	**6.4**

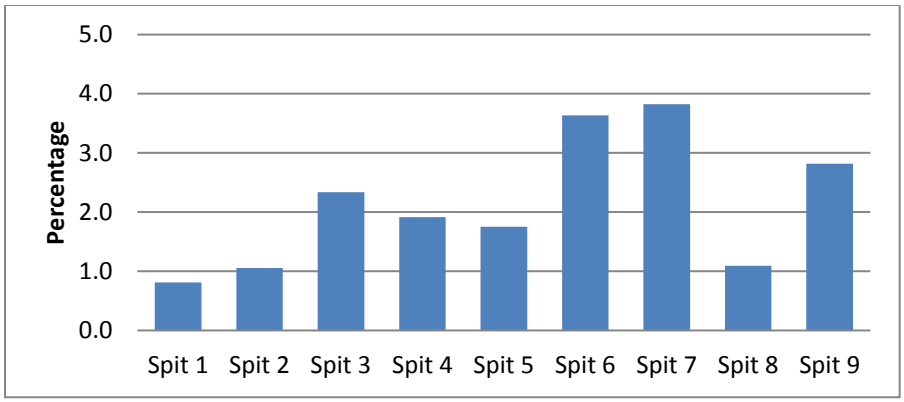


Figure 6.89. Relative frequency of complete mammal bones by spit

Table 6.47. Breakage patterns in mammal vertebra and rib remains from Profile Four

		Complete		Centrum		Neural Arch		Transverse Process		Spinous Process		Epiphysis		Zygppophysis		Fragmentary	
		N	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
?*Mesembriportax acrae*	Thoracic vertebra	1	100	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	Lumbar vertebra	6	100	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Bovidae indet.	Thoracic vertebra	-	-	-	-	-	-	-	-	1	50	-	-	-	-	1	50
Bovidae indet.	Vertebra	-	-	1	20	3	60	1	20	-	-	-	-	-	-	-	-
Carnivore indet.	Caudal vertebra	1	100	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mammal indet.	Thorcic vertebra	-	-	-	-	2	50	-	-	-	-	-	-	-	-	2	50
	Lumbar vertebra	-	-	1	100	-	-	-	-	-	-	-	-	-	-	-	-
	Caudal vertebra	1	16.7	5	83.3	-	-	-	-	-	-	-	-	-	-	-	-
	Vertebra	1	2.8	7	19.4	2	5.6	11	30.6	1	2.8	5	13.9	4	11.1	5	13.9
	Total	**10**	**18.2**	**14**	**25.5**	**7**	**12.7**	**12**	**21.8**	**2**	**3.6**	**5**	**9.1**	**4**	**7.3**	**8**	**14.5**

		Ventral		Dorsal		Shaft	
		n	**%**	**n**	**%**	**n**	**%**
Bovidae indet.	Rib	1	25	3	75	-	-
Felidae	Rib	-	-	1	100	-	-
Mammal indet.	Rib	-	-	-	-	2	100
	Total	**1**	**14.3**	**4**	**57.1**	**2**	**28.6**

Table 6.48. Breakage patterns in mammal long bone, phalange and metapodial remains from Profile Four

		Complete		Proximal		Shaft		Distal	
		N	%	N	%	N	%	N	%
Sylvicapra hircus	Ulna	-	-	1	100	-	-	-	-
Bovidae indet.	Humerus	-	-	2	100	-	-	-	-
	Femur	-	-	-	-	1	100	-	-
	Metapodial	-	-	1	25	4	75	-	-
	Proximal phalange	-	-	-	-	-	-	2	100
	Distal phalange	2	66.6	1	33.3	-	-	-	-
	Phalange	-	-	1	100	-	-	-	-
aff. *Vulpes*	Proximal phalange	-	-	-	-	-	-	1	100
aff. *Canis*	Tibia	-	-	-	-	-	-	1	100
aff. Felidae	Radius	-	-	-	-	-	-	1	100
Phocidae	Tibia	-	-	-	-	1	100	-	-
Herpestidae	Proximal phalange	1	100	-	-	-	-	-	-
Carnivore indet.	Radius	-	-	1	100	-	-	-	-
	Metapodial	-	-	1	100	-	-	-	-
	Proximal phalange	2	100	-	-	-	-	-	-
	Middle phalange	1	33.3	-	-	-	-	2	66.6
Pronolagus sp.	Femur	-	-	1	100	-	-	-	-
aff. *Lepus*	Proximal phalange	1	100	-	-	-	-	-	-
Rodentia	Humerus	-	-	-	-	-	-	1	100
Mammal indet.	Humerus	-	-	1	100	-	-	-	-
	Radius	-	-	2	28.6	5	71.4	-	-
	Ulna	-	-	1	50	1	50	-	-
	Femur	-	-	2	66.6	-	-	1	33.3
	Tibia	-	-	5	71.4	2	28.6	-	-
	Metapodial	-	-	6	54.5	1	9.1	4	36.4
	Proximal phalange	3	100	-	-	-	-	-	-
	Middle phalange	1	100	-	-	-	-	-	-
	Distal phalange	-	-	1	25	1	25	2	50
	Phalange	-	-	-	-	1	100	-	-
	Total	**11**	**15.9**	**26**	**37.7**	**17**	**24.6**	**15**	**21.7**

Table 6.49. Breakage patterns in mammal remains from Profile Four

		Complete		Fragmentary	
		N	**%**	**N**	**%**
Bovidae indet.	Premolar deciduous	-	-	1	100
	Premolar	1	100	-	-
	Incisor	1	100	-	-
	Molar	-	-	5	100
	Tooth indet	-	-	1	100
	Horncore	-	-	1	100
	Astragalus	-	-	1	100
	Patella	-	-	1	100
Equidae	Long bone fragment	-	-	1	100
Sivatherium hendeyi	Incisor	1	100	-	-
	Molar	-	-	1	100
Giraffidae indet.	Tooth indet.	-	-	1	100
Hyaenidae	Maxilla	-	-	1	100
Phocidae	Tarsal/carpal	1	100	-	-
Herpestidae	Mandible	-	-	1	100
Herpestidae	Canine	-	-	1	100
Carnivore indet.	Incisor	-	-	1	100
Carnivore indet.	Maxilla	-	-	1	100
Carnivore indet.	Calcaneous	-	-	1	100
aff. *Lepus*	Tarsal/carpal	1	100	-	-
Bathyergidae	Mandible	-	-	1	100
Mammal indet.	Cranium	-	-	2	100
	Auditory Bulla	1	100	-	-
	Astragalus	-	-	1	100
	Calcaneous	2	100	-	-
	Sesamoid	4	100	-	-
	Tarsal/carpal	6	85.7	1	14.3
	Tooth indet.	-	-	18	100
	Total	**18**	**30**	**42**	**70**

Table 6.50. Fracture outline in mammal long bones from Profile Four

	Spiral (fresh)		Transverse (dry)		Splintered		Irregular		Total	
	N	%	N	%	N	%	N	%	N	%
Size Class 1	14	28	1	2	-	-	1	2	**16**	**32**
Size Class 2	89	42.8	21	10.1	17	8.2	-	-	**127**	**61.1**
Size Class 3	151	42.2	44	12.3	38	10.6	1	0.3	**234**	**65.4**
Size Class 4	112	42.4	31	11.7	23	8.7	2	0.8	**168**	**63.6**
Size Class 5	9	50	-	-	5	27.8	-	-	**14**	**77.8**
Total	**375**	**67.1**	**97**	**17.4**	**83**	**14.8**	**4**	**0.7**	559	**62.2**

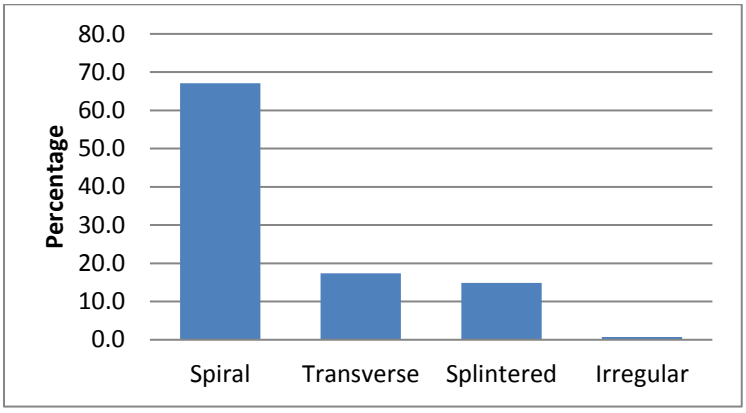


Figure 6.90. Relative frequency of fracture outline types in mammal long bones

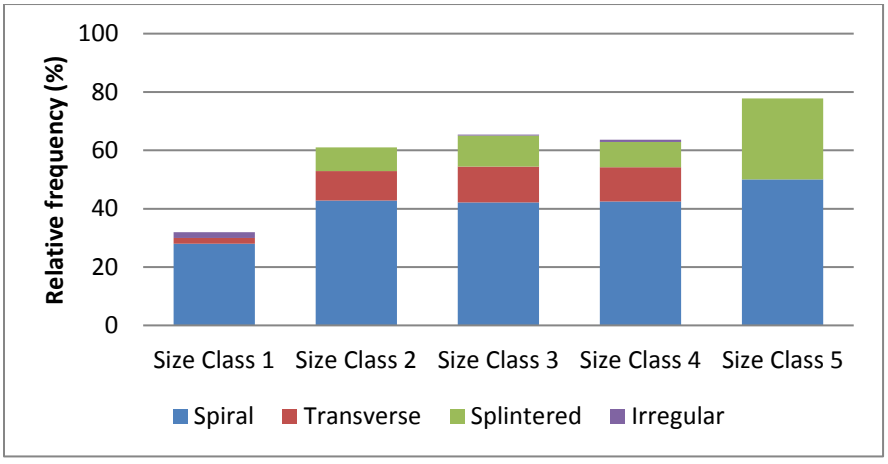


Figure 6.91. Fracture outline type with mammal body size classes

Table 6.51. Fracture outline in mammal long bones by spit in Profile Four

	Spiral (fresh)		Transverse (dry)		Splintered		Irregular		Total	
	N	%	N	%	N	%	N	%	N	%
Spit 1	64	45.7	18	12.9	9	6.4	-	-	**91**	**65**
Spit 2	24	37.5	7	10.9	10	15.6	-	-	**41**	**64.1**
Spit 3	48	45.3	7	6.6	6	5.7	-	-	**61**	**57.5**
Spit 4	129	40.3	43	13.4	37	11.6	2	0.6	**211**	**91.7**
Spit 5	76	42.2	17	9.4	18	10.0	-	-	**111**	**61.7**
Spit 7	7	29.2	1	4.2	1	4.2	-	-	**9**	**37.5**
Spit 8	11	45.8	1	4.2	-	-	-	-	**12**	**50**
Spit 9	12	42.9	2	7.1	1	3.6	-	-	**15**	**53.6**
Spit 10	4	40	1	10	1	10	2	20	**8**	**80**
Total	**375**	**67.1**	**97**	**17.4**	**83**	**14.8**	**4**	**0.7**	**559**	

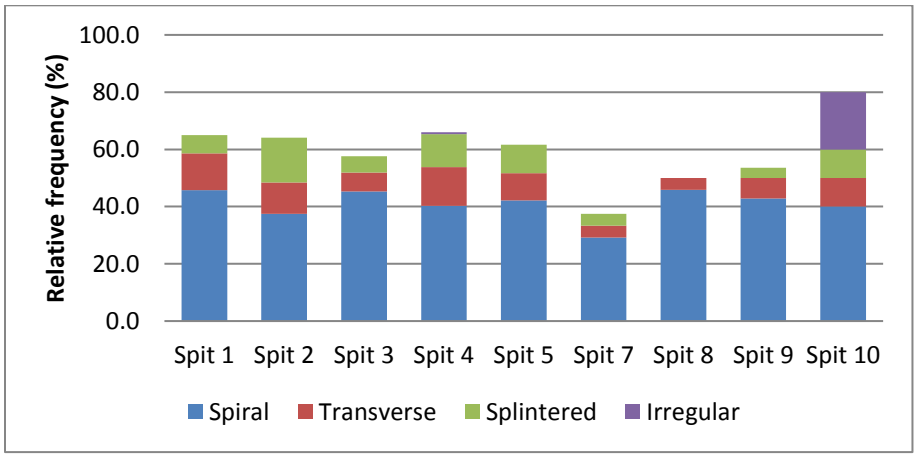


Figure 6.92. Fracture outline type by spit in mammal long bones

Table 6.52. Fracture angle in mammal long bones from Profile Four

	Oblique		Right		Mixed		Total	
	N	%	N	%	N	%	N	%
Size Class 1	8	16	3	6	6	12	**17**	**34**
Size Class 2	57	27.4	47	22.6	37	17.8	**141**	**67.8**
Size Class 3	80	22.3	84	23.5	76	21.2	**240**	**67**
Size Class 4	62	23.5	66	25	55	20.8	**183**	**69.3**
Size Class 5	4	22.2	4	22.2	3	16.7	**11**	**61.1**
Total	**211**	**35.6**	**204**	**34.5**	**177**	**29.9**	**592**	**65.9**

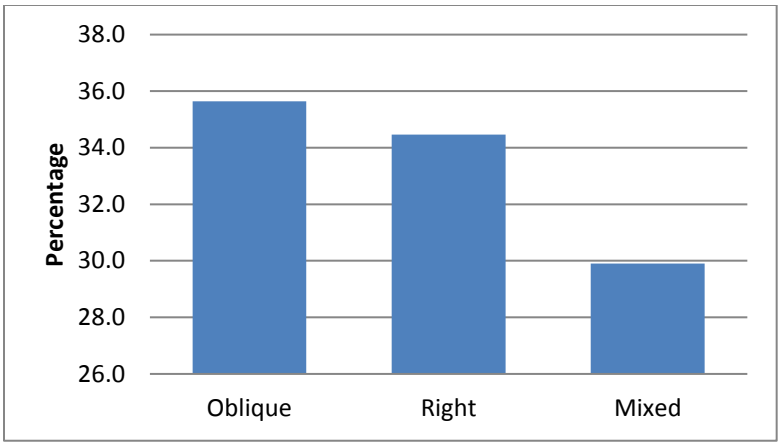


Figure 6.93. Relative frequency of fracture angle type in mammal long bones from Profile Four



Figure 6.94. Fracture angle and body size class in mammal long bones

Table 6.53. Fracture angle by spit in mammal long bones from Profile Four

	Oblique		Right		Mixed		Total	
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Spit 1	40	28.6	40	28.6	19	13.6	**99**	**70.7**
Spit 2	13	20.3	15	23.4	16	25	**44**	**68.75**
Spit 3	22	20.8	20	18.9	30	28.3	**72**	**67.9**
Spit 4	83	25.9	75	23.4	57	17.8	**215**	**67.2**
Spit 5	33	18.3	44	24.4	38	21.1	**115**	**63.9**
Spit 7	3	12.5	2	8.3	3	12.5	**8**	**33.3**
Spit 8	5	20.8	2	8.3	5	20.8	**12**	**50**
Spit 9	8	28.6	3	10.7	7	25	**18**	**64.3**
Spit 10	4	40	3	30	2	20	**9**	**90**
Total	**211**	**35.6**	**204**	**34.4**	**177**	**29.8**	**592**	**65.9**

Table 6.54. Weathering in mammal remains from Profile Four

	Large mammals		Carnivore		Small mammals		Mammal indet		Total	
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Stage 1	17	36.2	3	14.3	2	33.3	87	16.1	**109**	**17.8**
Stage 2	4	8.5	1	4.8	-	-	24	4.4	**29**	**4.7**
Stage 3	-	-	-	-	-	-	1	0.2	**1**	**0.2**
Total	**21**	**44.7**	**4**	**19**	**2**	**33.3**	**112**	**20.7**	**139**	**22.6**

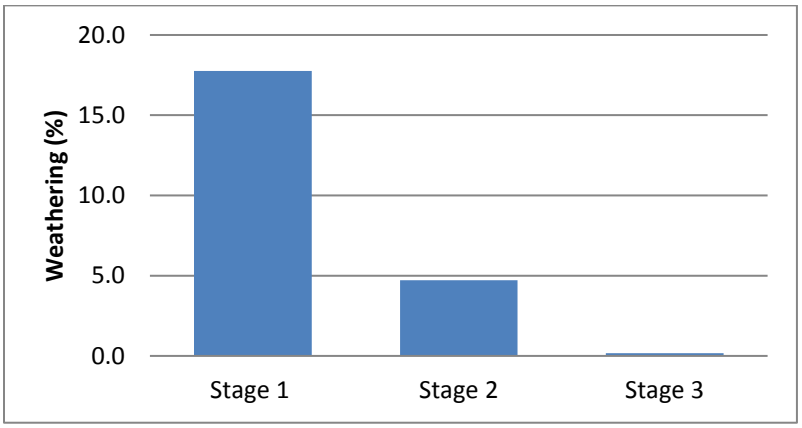


Figure 6.95. Weathering intensity in mammal remains from Profile Four

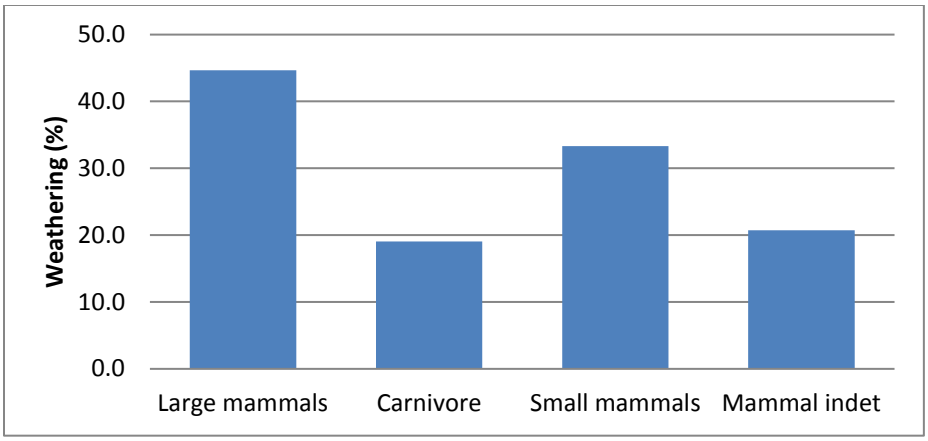


Figure 6.96. Relative frequency of weathering in mammal groups from Profile Four

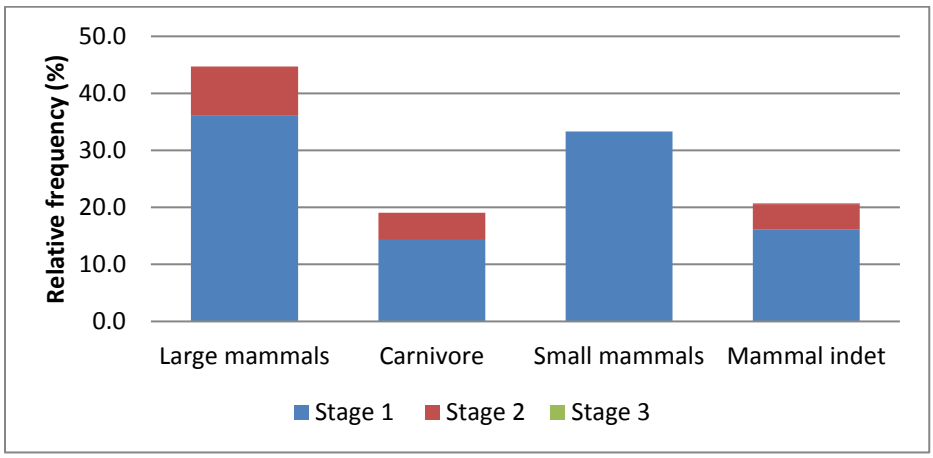


Figure 6.97. Weathering intensity in mammal groups from Profile Four

Table 6.55. Burning in mammal remains from Profile Four

	Size Class 1		Size Class 2		Size Class 3		Size Class 4		Total	
	N	%	**N**	%	**N**	%	**N**	%	**N**	%
Stage 2	1	2.4	-	-	1	5.6	-	-	**2**	**0.3**
Stage 3	-	-	4	30.8	1	5.6	1	4.2	**6**	**1**
Stage 4	-	-	2	15.4	-	-	-	-	**2**	**0.3**
Stage 6	1	2.4	-	-	-	-	-	-	**1**	**0.2**
Total	**2**	**4.8**	**6**	**46.2**	**2**	**11.1**	**1**	**4.2**	**11**	**1.8**

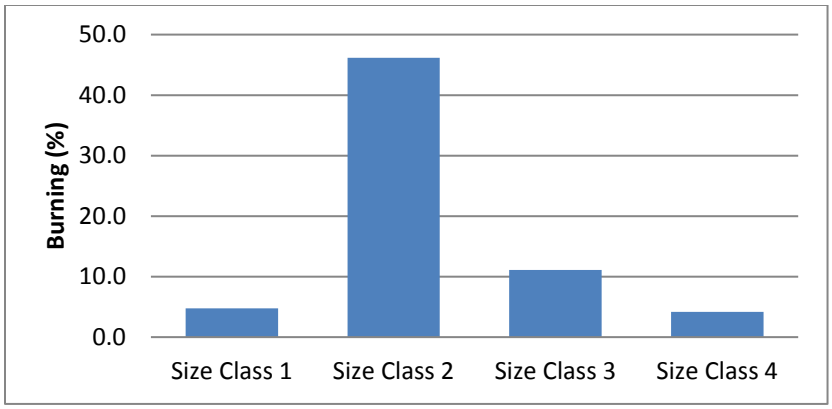


Figure 6.98. Relative frequency of burning with body size class in mammal remains from Profile Four

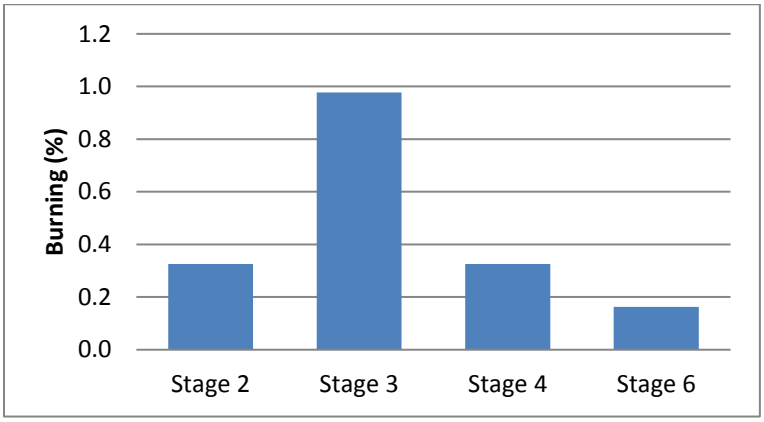


Figure 6.99. Intensity of burning damage in mammal remains from Profile Four

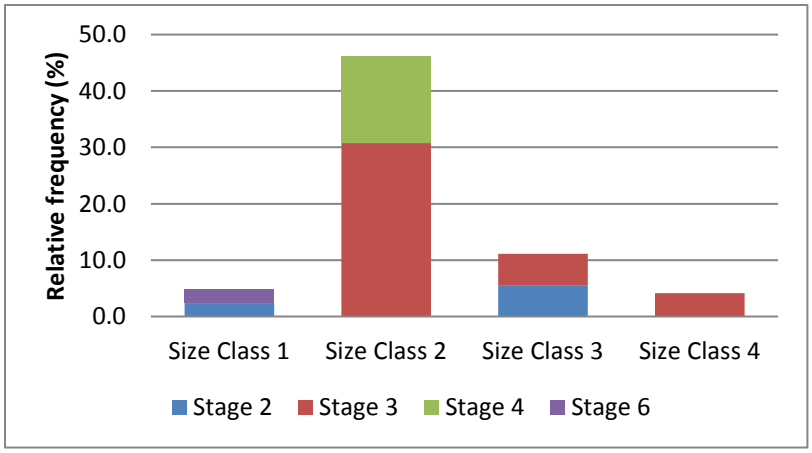


Figure 6.100. Burning intensity with body size class in mammals

Table 6.56. Staining in mammal remains in Profile Four

	Large mammals		Carnivore		Small mammals		Mammal indet		Total	
	N	%	N	%	N	%	N	%	N	%
Stage 1	21	44.7	6	28.6	1	16.7	196	36.3	**224**	**36.5**
Stage 2	8	17	4	19	2	33.3	151	28	**165**	**26.9**
Stage 3	9	19.1	2	9.5	1	16.7	86	15.9	**98**	**16**
Stage 4	1	2.1	-	-	-	-	-	-	**1**	**0.2**
Total	**39**	**83**	**12**	**57.1**	**4**	**66.7**	**433**	**80.2**	**488**	**79.5**

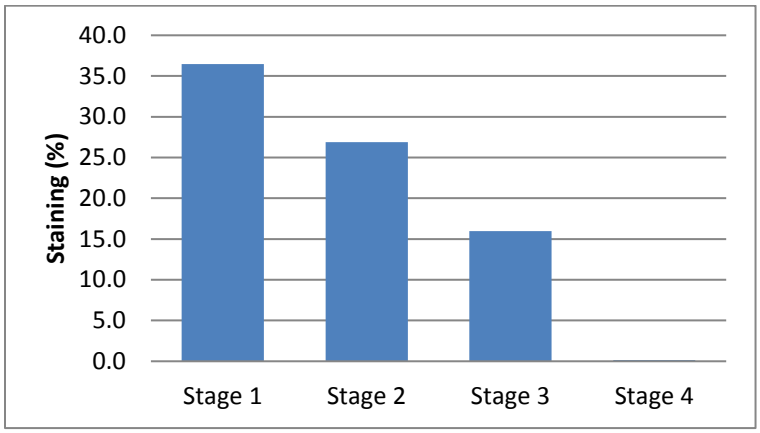


Figure 6.101. Staining intensity in mammal remains from Profile Four

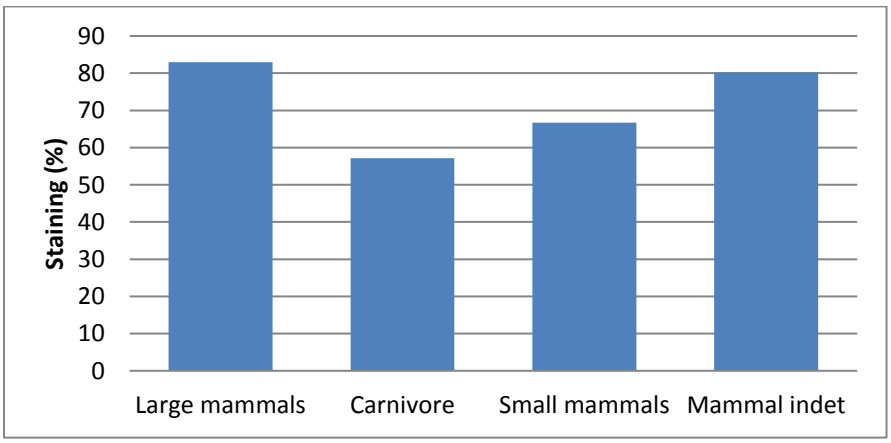


Figure 6.102. Relative frequency of staining in mammal groups from Profile Four

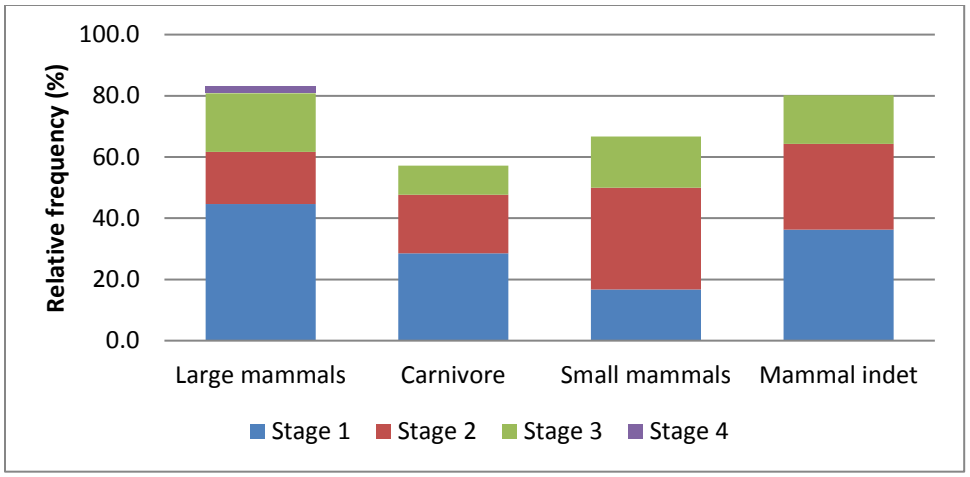


Figure 6.103. Staining intensity in mammal groups from Profile Four

Table 6.57. Abrasion in mammal remains from Profile Four

	Large mammals		Carnivore		Small mammals		Mammal indet		Total	
	N	%	N	%	N	%	N	%	N	%
Stage 1	17	36.2	6	28.6	2	33.3	208	38.5	**233**	**37.9**
Stage 2	4	8.5	1	4.8	1	16.7	131	24.3	**137**	**22.3**
Stage 3	5	10.6	2	9.5	-	-	101	18.7	**108**	**17.6**
Stage 4	1	2.1	-	-	-	-	55	10.2	**56**	**9.1**
Total	**27**	**57.4**	**9**	**42.9**	**3**	**50**	**495**	**91.7**	**534**	**87**

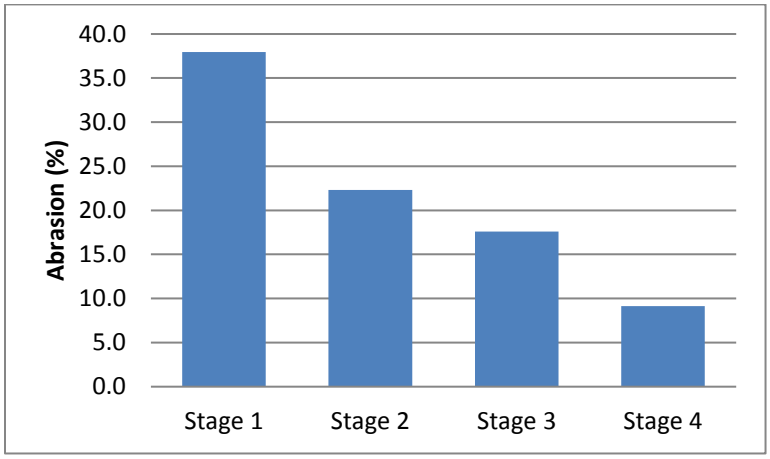


Figure 6.104. Abrasion intensity in mammal remains from Profile Four

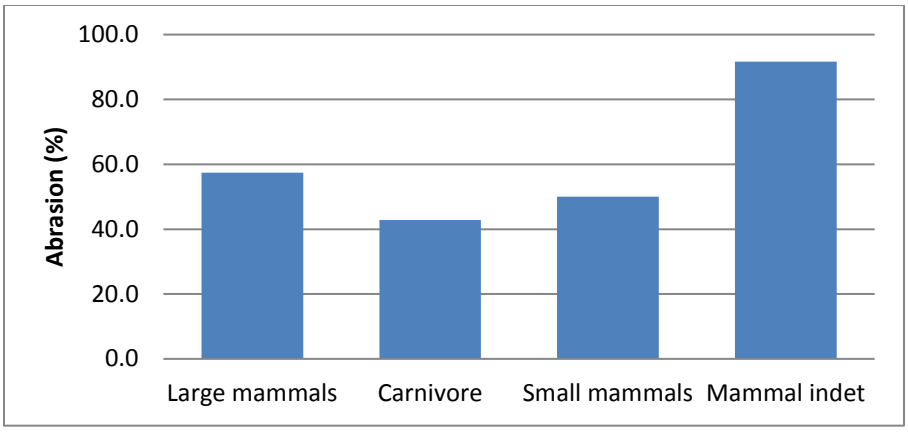


Figure 6.105. Relative frequency of abrasion in mammal groups from Profile Four

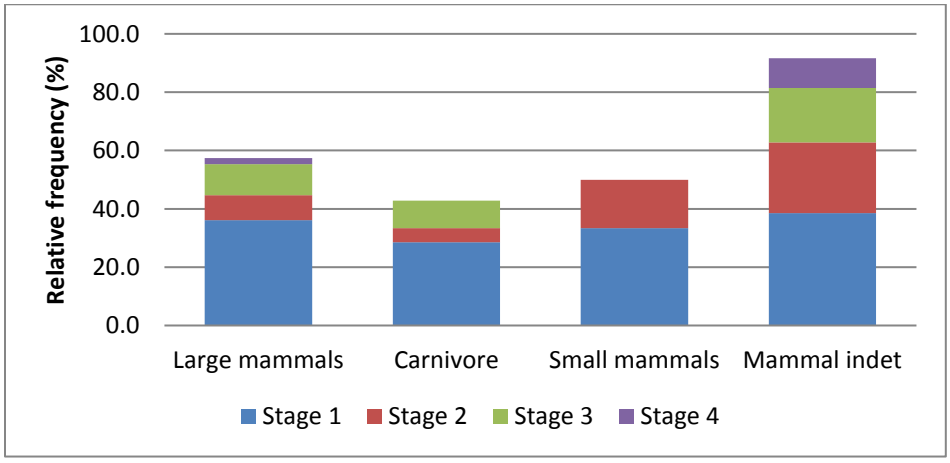


Figure 6.106. Abrasion intensity in mammal groups from Profile Four

Table 6.58. Sheen in mammal remains from Profile Four

	Large mammals		Carnivore		Small mammals		Mammal indet		Total	
	N	%	N	%	N	%	N	%	N	%
Stage 1	7	14.9	-	-	1	16.7	64	11.9	**72**	**11.7**
Stage 2	4	8.5	6	28.6	-	-	31	5.7	**41**	**6.7**
Stage 3	7	14.9	3	14.3	2	33.3	13	2.4	**25**	**4.1**
Stage 4	2	4.3	-	-	-	-	-	-	**2**	**0.3**
Total	**20**	**42.6**	**9**	**42.9**	**3**	**50**	**108**	**20**	**140**	**22.8**

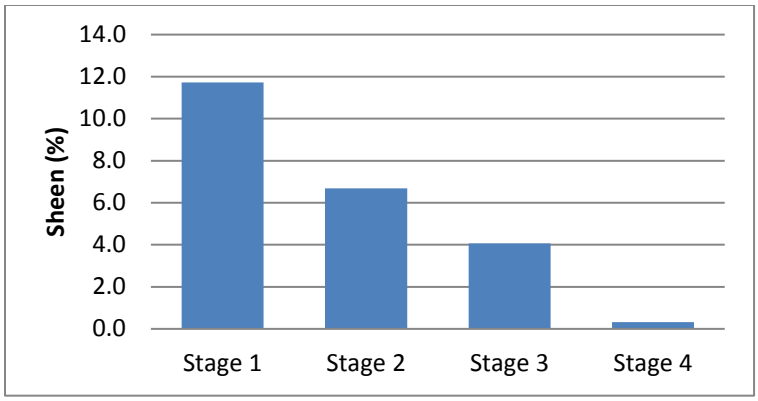


Figure 6.107. Sheen intensity in mammal remains from Profile Four

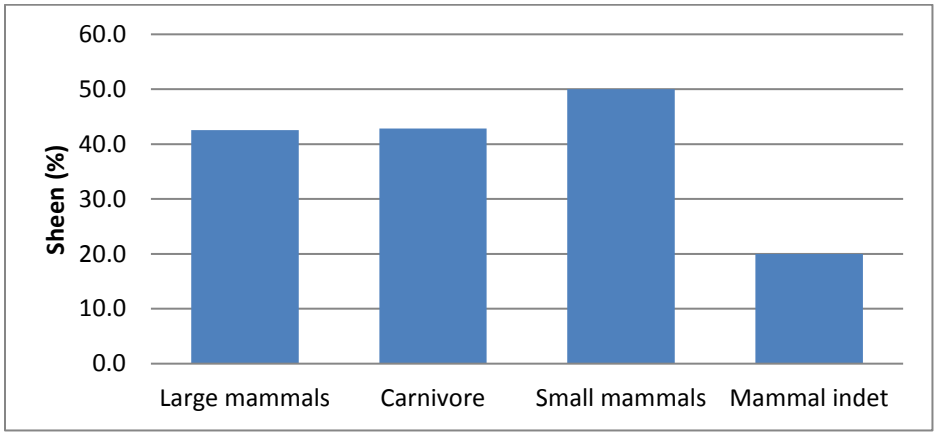


Figure 6.108. Relative frequency of sheen in mammal groups from Profile Four

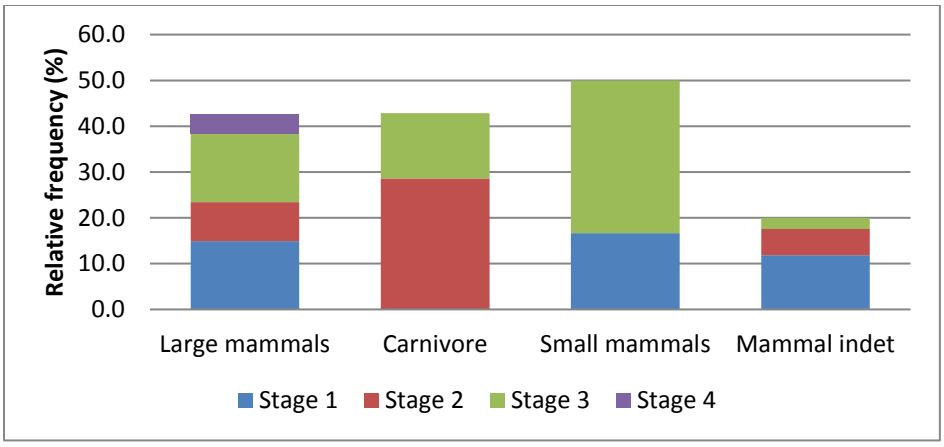


Figure 6.109. Sheen intensity in mammal groups from Profile Four

Table 6.59. Trampling in mammal remains from Profile Four

	Large mammals		Carnivore		Small mammals		Mammal indet		Total	
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Stage 1	11	23.4	6	28.6	1	16.7	139	25.7	**157**	**25.6**
Stage 2	2	4.3	-	-	-	-	28	5.2	**30**	**4.9**
Stage 3	-	-	-	-	-	-	3	0.6	**3**	**0.5**
Total	**13**	**27.7**	**6**	**28.6**	**1**	**16.7**	**170**	**31.5**	**190**	**30.9**

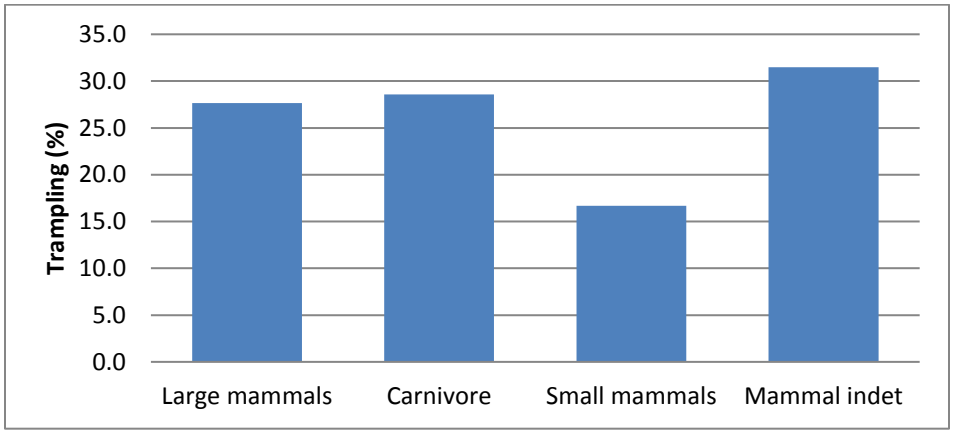


Figure 6.110. Relative frequency of trampling in mammal groups from Profile Four

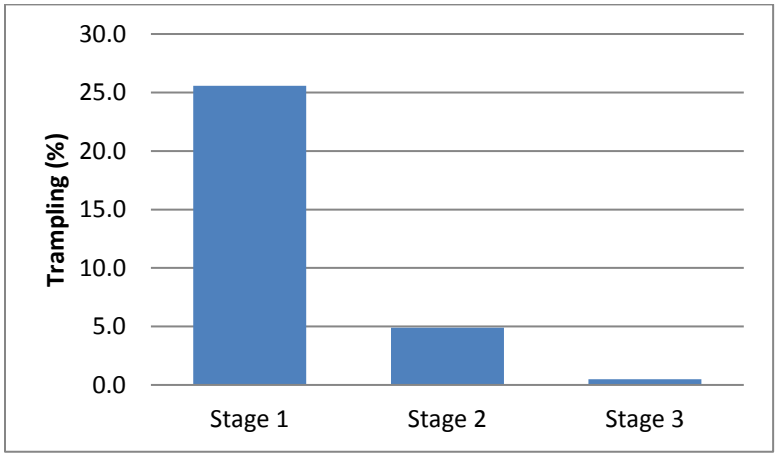


Figure 6.111. Trampling intensity in mammal remains from Profile Four

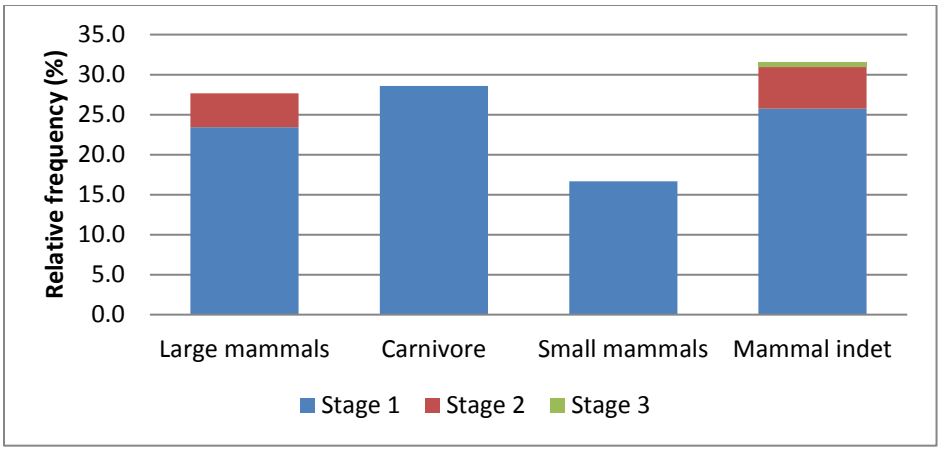


Figure 6.112. Trampling intensity in mammal groups from Profile Four

Table 6.60. Tooth marked bone and body size class in mammal remains from Profile Four

	N	%
Size Class 1	3	7.1
Size Class 2	2	15.4
Size Class 3	11	61.1
Size Class 4	3	12.5
Size Class 5	1	14.3
Total	20	3.3

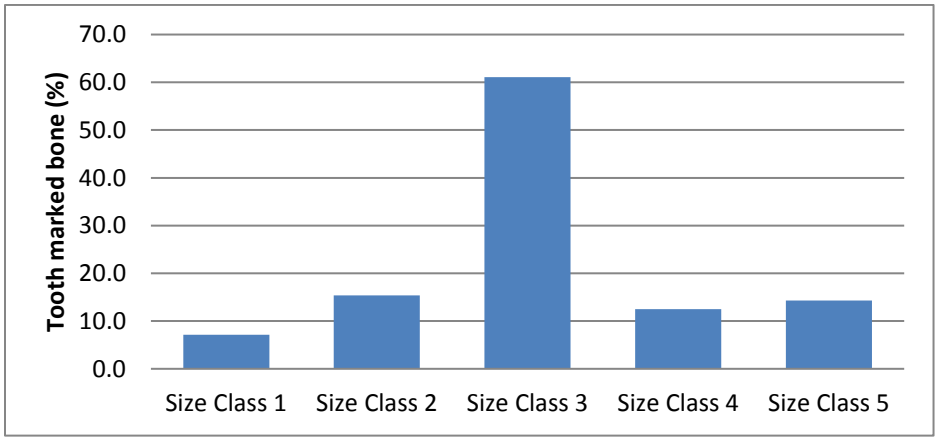


Figure 6.113. Relative frequency of tooth marked bone with body size class in mammal remains from Profile Four

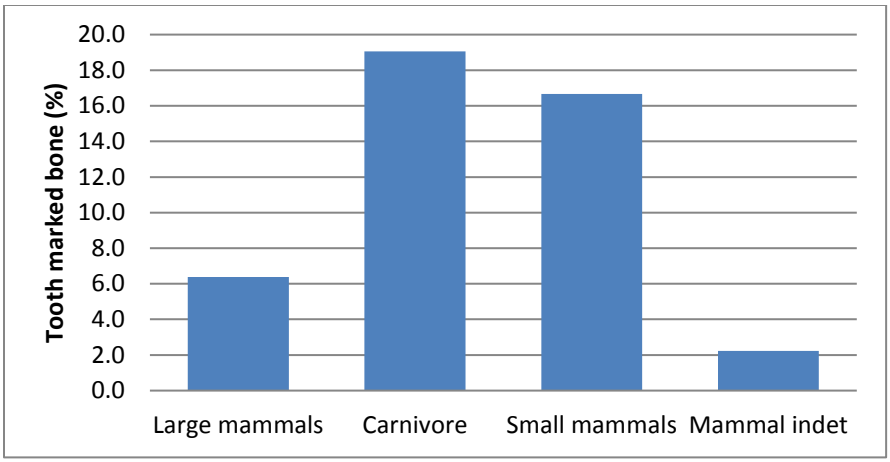


Figure 6.114. Relative frequency of tooth marked bone in mammal groups from Profile Four

Table 6.61. Tooth markes on skeletal elements in mammal remains from Profile Four

			N	%
Bovidae	*Raphicerus paralius*	Ulna	1	100
	Bovidae indet.	Patella	1	100
Giraffidae	*Sivatherium hendeyi*	Incisor	1	100
Carnivore	Herpestidae	Premolar/mandible	1	100
	Phocidae	Tibia	1	100
Carnivore indet.	Carnivore indet.	Middle phalange	2	67
Leporidae	*Pronolagus* sp.	Femur	1	100
Mammal indet.	Mammal indet.	Radius	1	11
		Femur	1	33
		Tibia	1	14
		Metapodial	1	9
		Rib	1	5
		Vertebra	2	5
		Long bone fragment	5	1
		Total	**20**	

Table 6.62. Relative frequency of digestive corrosion in mammal remains from Profile Four

	N	%
Size Class 1	2	4.8
Size Class 2	4	30.8
Size Class 3	6	33.3
Size Class 4	2	8.3
Total	**14**	**2.3**

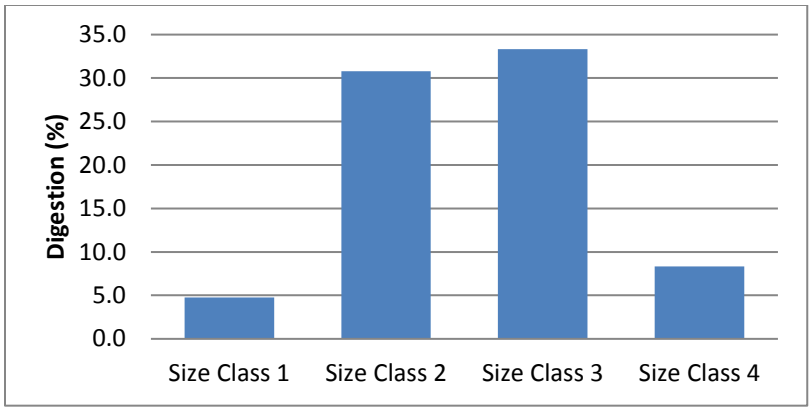


Figure 6.115. Relative frequency of digestive corrosion with body size class in mammal remains from Profile Four

Figure 6.63. Relative frequency of digestive corrosion and skeletal elements in mammal remains from Profile Four

		N	%
Carnivore indet.	Proximal phalange	1	50
	Middle phalange	3	100
Mammal indet.	Femur	2	66.7
	Metapodial	1	9.1
	Tarsal/carpal	1	11.1
	Rib	2	10
	Caudal vertebra	1	16.7
	Vertebra	2	5.3
	Long bone fragment	1	0.3
	Total	**14**	

Table 6.64. Root etching in mammal remains from Profile Four

	Large mammals		Carnivore		Small mammals		Mammal indet		Total	
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Stage 1	5	10.6	4	19	1	16.7	118	21.9	**128**	**20.8**
Stage 2	2	4.3	1	4.8	-	-	48	8.9	**51**	**8.3**
Stage 3	3	6.4	2	9.5	-	-	14	2.6	**19**	**3.1**
Total	**10**	**21.3**	**7**	**33.3**	**1**	**16.7**	**180**	**33.3**	**198**	**32.2**

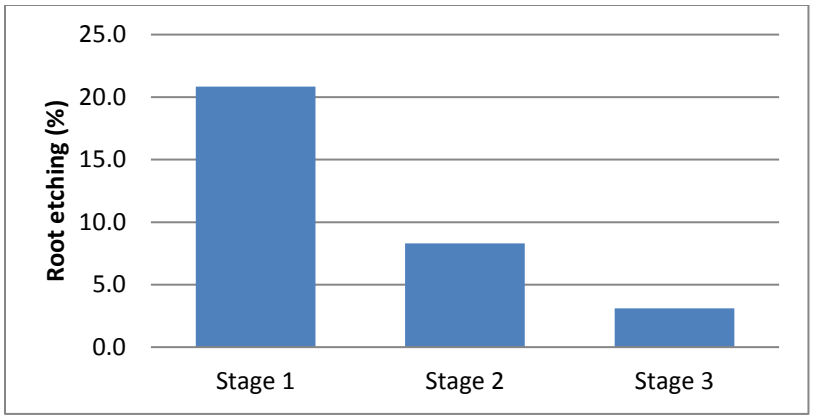


Figure 6.116. Root etching intensity in mammal remains from Profile Four

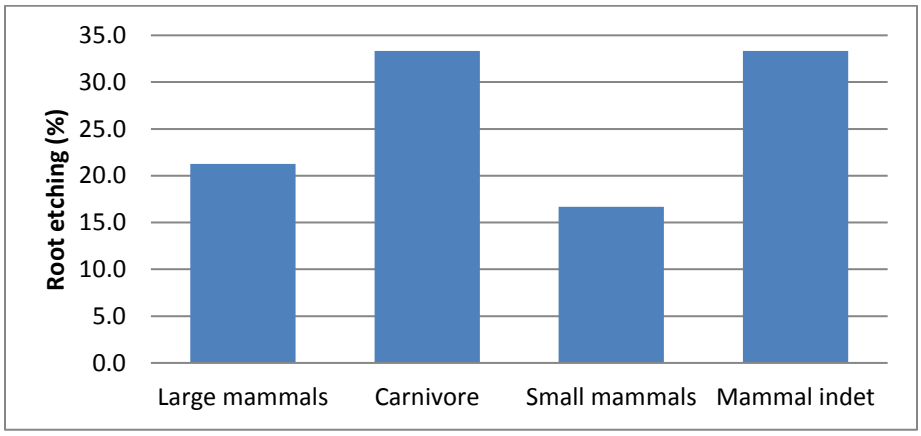


Figure 6.117. Relative frequency of root etching in mammal groups from Profile Four

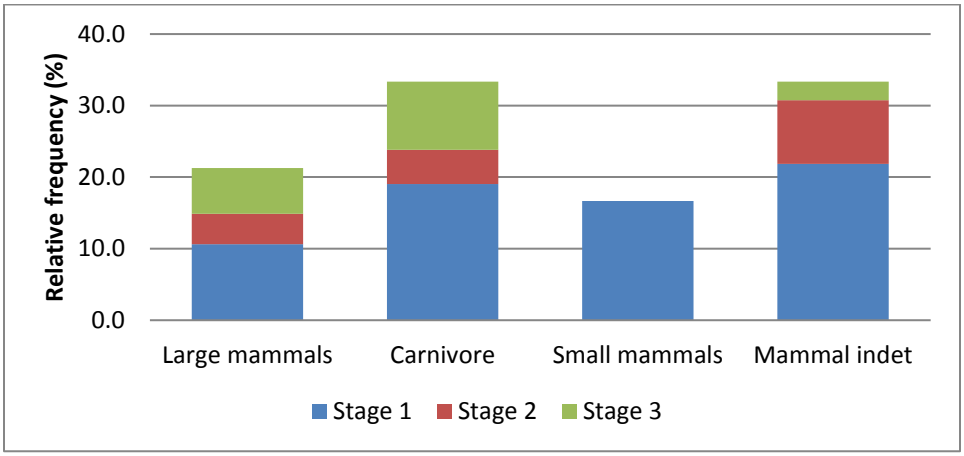


Figure 6.118. Root etching intensity in mammal groups in Profile Four

Table 6.65. Insect modifications and intensity with mammal body size classes and spit depth from Profile Four

	N	%
Stage 1	7	26.9
Stage 2	14	53.8
Stage 3	5	19.2
Spit 4	23	7.3
Spit 5	3	1.3
Size Class 2	2	15.4
Size Class 3	10	55.6
Size Class 4	11	45.8
Size Class 5	3	42.9
Total	**26**	**4.2**

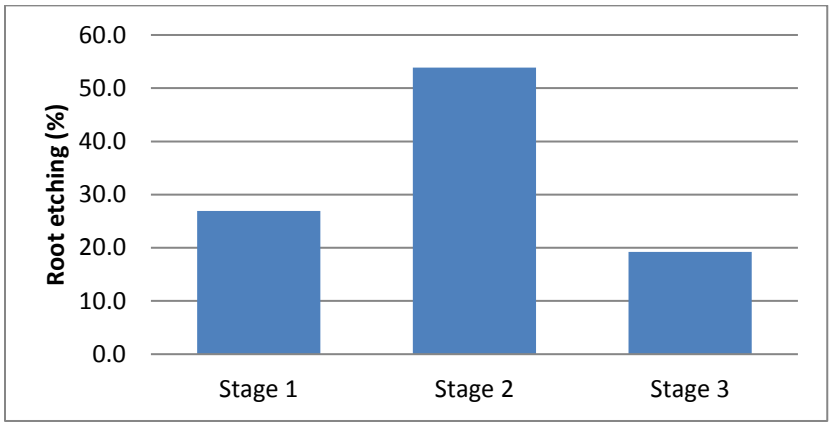


Figure 6.119. Root etching intensity in mammal remains from Profile Four

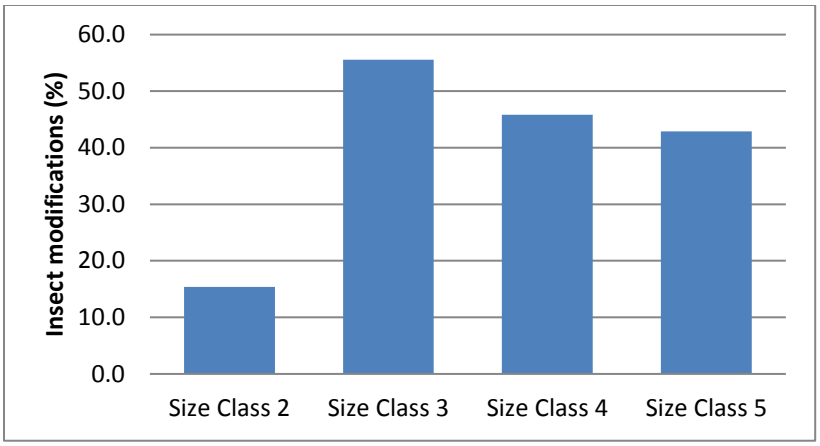


Figure 6.120. Relative frequency of insect modifications with body size classe of mammal in Profile Four

Table 6.66. Prevalence of insect modifications in mammal skeletal elements in Profile Four

		N	%
Bovidae indet.	Humerus	1	50
Mammal indet.	Radius	1	11.1
	Ulna	1	50
	Rib	2	10
	Vertebra	1	2.6
	Long bone fragment	20	5.1
	Total	**26**	

Table 6.67. Body size class representation in chelonia remains from Profile Four

	N	%
Size Class 1	199	22.5
Size Class 2	385	43.5
Size Class 3	231	26.1
Size Class 4	71	8
Total	**886**	**55.8**

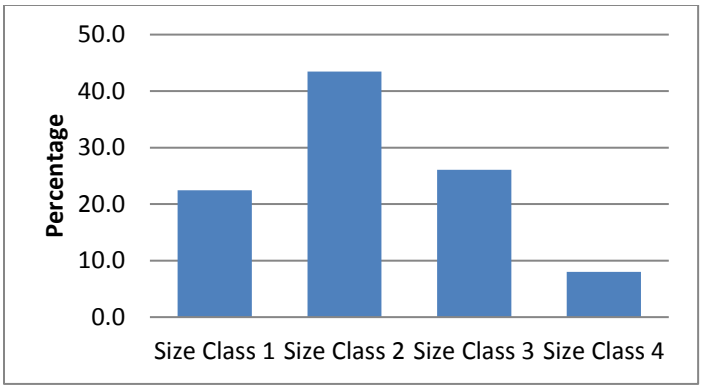


Figure 6.121. Body size class representation in chelonia remains from Profile Four

Table 6.68. Relative frequency of chelonia bones by spit in Profile Four

	N	%
Spit 1	27	22
Spit 2	46	48.4
Spit 3	97	56.7
Spit 4	85	27.2
Spit 5	109	47.8
Spit 6	51	92.7
Spit 7	129	82.2
Spit 8	148	80.9
Spit 9	166	77.9
Spit 10	28	54.9
Total	**886**	

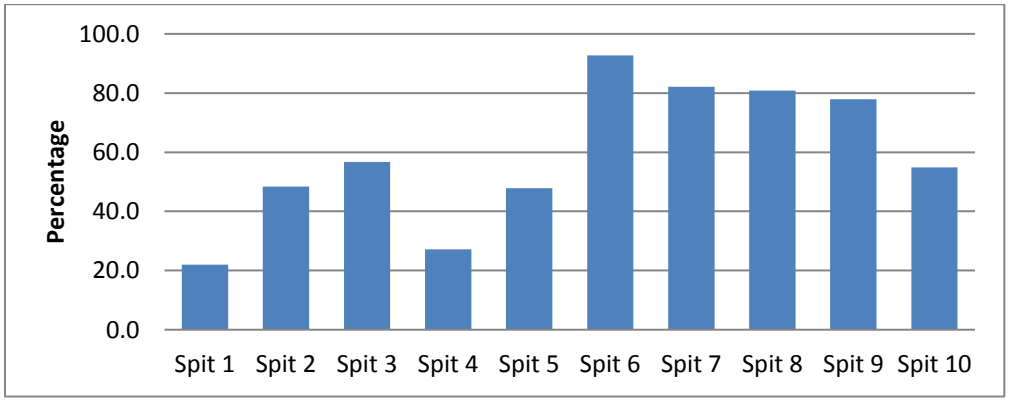


Figure 6.122. Relative frequency of chelonian bones by spit in Profile Four

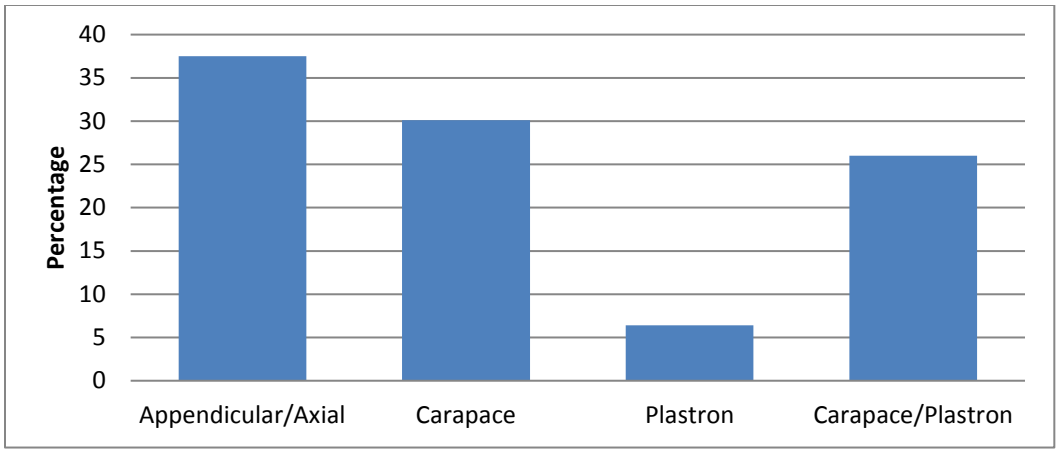


Figure 6.123. Relative frequency of chelonia skeletal parts in Profile Four

Table 6.69. Anatomical composition and body size class in chelonian appendicular and axial remains from Profile Four

	Size Class 1		Size Class 2		Size Class 3		Size Class 4		Total	
Element	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Cranium	1	100	-	-	-	-	-	-	**1**	**0.3**
Mandible	-	-	2	100	-	-	-	-	**2**	**0.6**
Coracoid	-	-	4	80	-	-	1	20	**5**	**1.5**
Scapula	-	-	6	60	4	40	-	-	**10**	**3**
Humerus	4	9.8	20	48.8	16	39	1	2.4	**41**	**12.3**
Radius	-	-	8	38.1	12	57.1	1	4.8	**21**	**6.3**
Ulna	-	-	2	18.2	8	72.7	1	9.1	**11**	**3.3**
Ilium	2	8.3	11	45.8	11	45.8	-	-	**24**	**7.2**
Ischium	-	-	6	75	2	25	-	-	**8**	**2.4**
Pubis	-	-	3	75	1	25	-	-	**4**	**1.2**
Femur	-	-	12	37.5	20	62.5	-	-	**32**	**9.6**
Tibia	-	-	6	28.6	13	61.9	2	9.5	**21**	**6.3**
Fibula	-	-	7	36.8	9	47.4	3	15.8	**19**	**5.7**
Tarsal/carpal	-	-	-	-	2	100	-	-	**2**	**0.6**
Middle phalange	-	-	1	100	-	-	-	-	**1**	**0.3**
Distal phalange	-	-	17	48.6	15	42.9	3	8.6	**35**	**10.5**
Phalange	1	1.4	54	78.3	14	20.3	-	-	**69**	**20.8**
Vertebra	1	7.1	12	85.7	1	7.1	-	-	**14**	**4.2**
Long bone fragment	-	-	6	50	5	41.7	1	8.3	**12**	**3.6**
Total	**9**	**2.7**	**177**	**53.3**	**133**	**40.1**	**13**	**3.9**	**332**	**37.5**

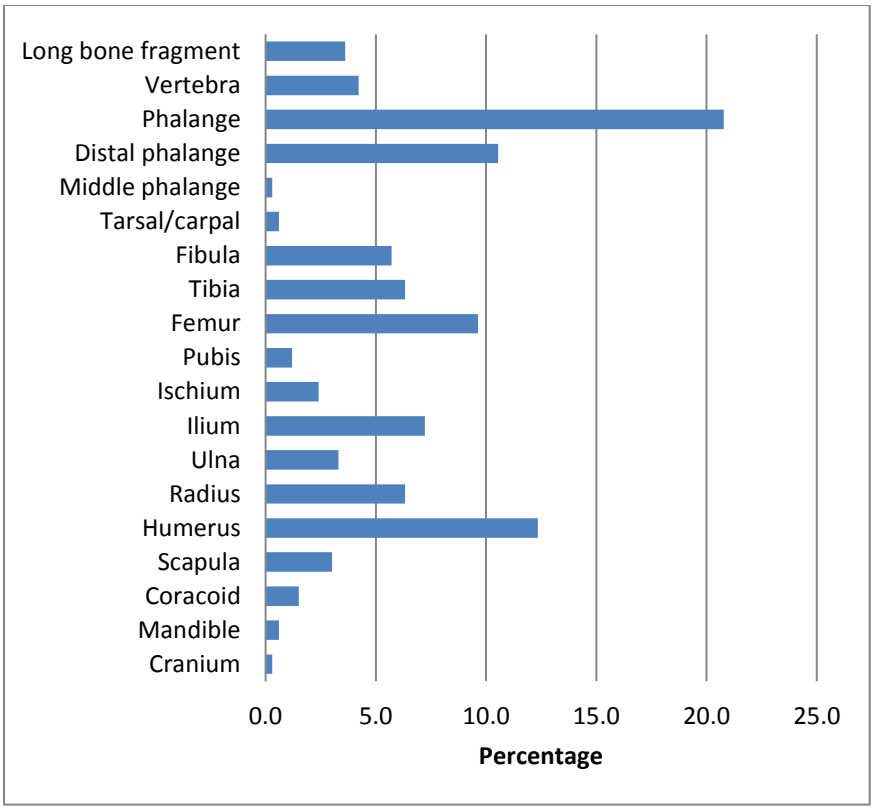


Figure 6.124. Relative frequency of chelonian appendicular and axial elements from Profile Four

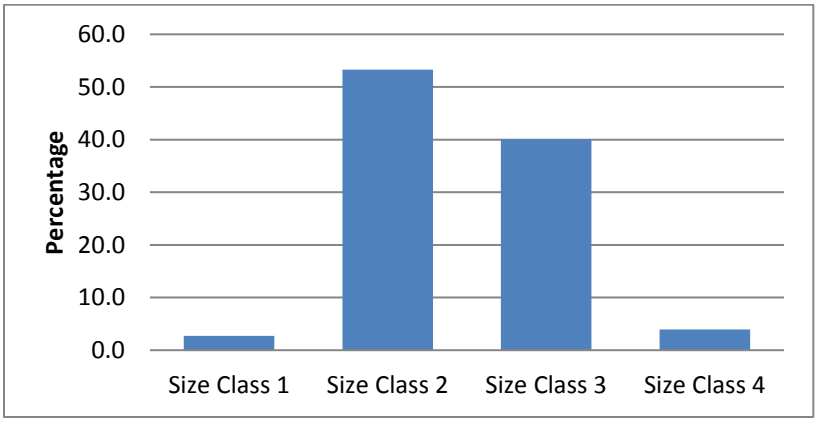


Figure 6.125. Relative frequency of body size class in chelonia appendicular and axial skeleton from Profile Four

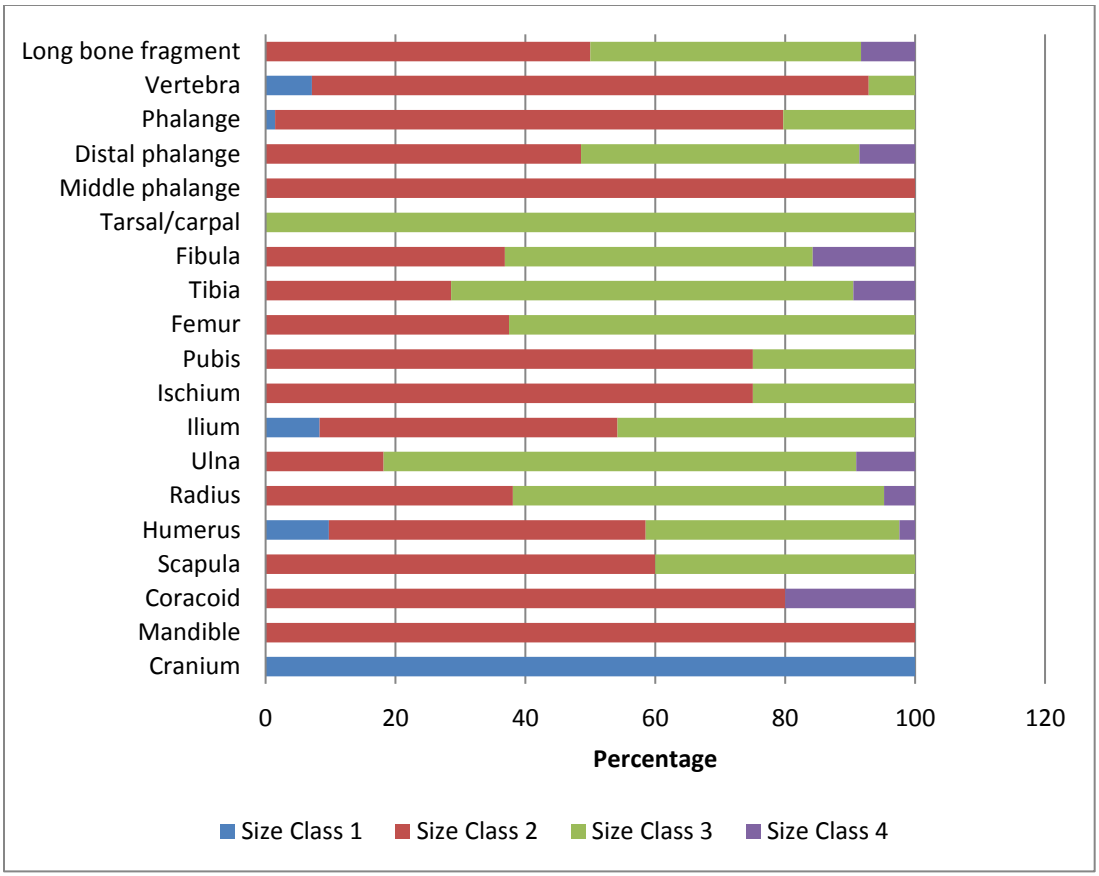


Figure 6.126. Body size class in chelonia appendicular and axial elements in Profile Four

Table6.70. Anatomical composition and spit in chelonia appendicular and axial remains from Profile Four

	Spit 1		Spit 2		Spit 3		Spit 4		Spit 5		Spit 6		Spit 7		Spit 8		Spit 9		Spit 10		Total	
Element	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Cranium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	100	-	-	**1**	**0.3**
Mandible	-	-	-	-	1	50	-	-	1	50	-	-	-	-	-	-	-	-	-	-	**2**	**0.6**
Coracoid	-	-	-	-	2	40	-	-	-	-	-	-	2	40	-	-	1	20	-	-	**5**	**1.5**
Scapula	-	-	-	-	1	10	2	20	-	-	-	-	1	10	2	20	4	40	-	-	**10**	**3**
Humerus	-	-	2	4.9	-	-	3	7.3	6	14.6	1	2.4	11	26.8	9	22	7	17.1	2	4.9	**41**	**12.3**
Radius	-	-	-	-	3	14.3	2	9.5	4	19	-	-	2	9.5	6	28.6	3	14.3	1	4.8	**21**	**6.3**
Ulna	-	-	-	-	-	-	-	-	2	18.2	-	-	5	45.5	3	27.3	1	9.1	-	-	**11**	**3.3**
Ilium	-	-	1	4.2	4	16.7	2	8.3	6	25	2	8.3	2	8.3	3	12.5	3	12.5	1	4.2	**24**	**7.2**
Ischium	1	13.75	-	-	1	13.75	-	-	1	13.75	-	-	1	13.8	2	27.5	2	27.5	-	-	**8**	**2.4**
Pubis	-	-	-	-	2	50	-	-	1	25	-	-	-	-	1	25	-	-	-	-	**4**	**1.2**
Femur	-	-	-	-	6	18.8	1	3.1	3	9.4	5	15.6	3	9.4	8	25	5	15.6	1	3.1	**32**	**9.6**
Tibia	-	-	2	9.5	1	4.8	-	-	5	23.8	-	-	4	19	5	23.8	2	9.5	2	9.5	**21**	**6.3**
Fibula	1	5.3	1	5.3	-	-	-	-	3	15.8	-	-	2	10.5	10	52.6	2	10.5	-	-	**19**	**5.7**
Tarsal/carpal	-	-	-	-	-	-	2	100	-	-	-	-	-	-	-	-	-	-	-	-	**2**	**0.6**
Middle phalange	-	-	1	100	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**1**	**0.3**
Distal phalange	-	-	2	5.7	2	5.7	2	5.7	4	11.4	7	20	6	17.1	8	22.9	3	8.6	1	2.9	**35**	**10.5**
Phalange	-	-	-	-	-	-	-	-	11	15.9	2	2.9	18	26.1	19	27.5	17	24.6	2	2.9	**69**	**20.8**
Vertebra	-	-	-	-	-	-	-	-	1	7.1	-	-	4	28.6	2	14.3	5	35.7	2	14.3	**14**	**4.2**
Long bone fragment	-	-	-	-	5	41.7	3	25	2	16.7	-	-	-	-	-	-	2	16.7	-	-	**12**	**3.6**
Total	**2**	**0.6**	**9**	**2.7**	**28**	**8.4**	**17**	**5.1**	**50**	**15.1**	**17**	**5.1**	**61**	**18.4**	**78**	**23.5**	**58**	**17.5**	**12**	**3.6**	**332**	**37.5**

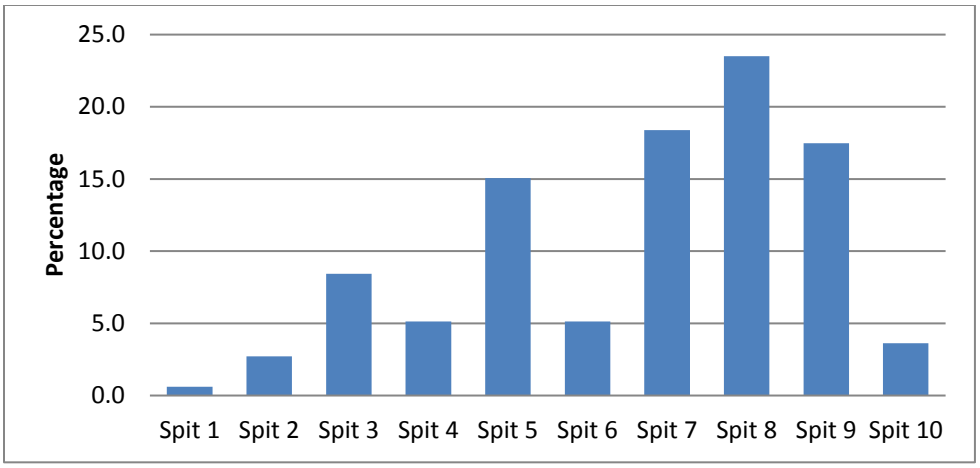


Figure 6.127. Relative frequency of chelonia appendicular and axial remains by spit from Profile Four

Table 6.71. Skeletal element frequencies in chelonia appendicular and axial elements from Profile Four

Element	NISP	MNE	MAU	%MAU	MNI
Cranium	1	1	1	16.7	1
Mandible	2	2	1	16.7	1
Coracoid	5	3	3	50	3
Scapula	10	5	3	50	4
Humerus	41	11	5	83.3	6
Radius	21	7	5	83.3	5
Ulna	11	5	4	66.7	4
Ilium	24	7	7	116.7	9
Ischium	8	3	3	50	3
Pubis	4	3	3	50	3
Femur	32	11	6	100	6
Tibia	21	8	4	66.7	4
Fibula	19	7	4	66.7	4
Tarsal/carpal	2	2	2	33.3	2
Middle phalange	1	1	1	16.7	1
Distal phalange	35	35	4	66.7	4
Phalange	69	69	4	66.7	4
Vertebra	14	8	3	50	3
Long bone fragment	12	3	3	50	3
Total	**332**				**6**

Table 6.72. Chelonia shell elements with body size class recovered in Profile Four

	Size Class 1		Size Class 2		Size Class 3		Size Class 4		Total	
Element	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Nuchal	2	33.3	1	16.7	3	50	-	-	**6**	**2.2**
Neural 1	-	-	-	-	1	100	-	-	**1**	**0.4**
Neural 8	-	-	1	100	-	-	-	-	**1**	**0.4**
Neural	13	52	5	20	4	16	3	12	**25**	**9.4**
Coastal 3	-	-	-	-	2	100	-	-	**2**	**0.7**
Coastal 4	-	-	-	-	1	100	-	-	**1**	**0.4**
Coastal	16	59.3	5	18.5	3	11.1	3	11.1	**27**	**10.1**
Marginal 1	-	-	3	75	1	25	-	-	**4**	**1.5**
Marginal 3	2	40	2	40	-	-	1	20	**5**	**1.9**
Marginal 4	-	-	1	100	-	-	-	-	**1**	**0.4**
Marginal 7	1	25	1	25	2	50	-	-	**4**	**1.5**
Marginal 10	-	-	-	-	1	50	1	50	**2**	**0.7**
Marginal 11	-	-	2	100	-	-	-	-	**2**	**0.7**
Marginal	65	45.8	44	31	19	13.4	14	9.9	**142**	**53.2**
Carapace indet.	16	36.4	19	43.2	5	11.4	4	9.1	**44**	**16.5**
Total Carapace	**115**	**43.1**	**84**	**31.5**	**42**	**15.7**	**26**	**9.7**	**267**	**30.1**
Xiphiplastron	-	-	1	100	-	-	-	-	**1**	**1.8**
Hypoplastron	3	42.9	-	-	3	42.9	1	14.3	**7**	**12.3**
Hyoplastron	1	25	-	-	3	75	-	-	**4**	**7**
Entoplastron	-	-	-	-	1	50	1	50	**2**	**3.5**
Epiplastron	3	27.3	6	54.5	1	9.1	1	9.1	**11**	**19.3**
Plastron indet.	3	9.4	6	18.8	5	15.6	18	56.3	**32**	**56.1**
Total Plastron	**10**	**17.5**	**13**	**22.8**	**13**	**22.8**	**21**	**36.8**	**57**	**6.4**
Carapace/Plastron	**65**	**28.3**	**111**	**48.3**	**43**	**18.7**	**11**	**4.8**	**230**	**26**
Total Shell	**190**	**34.3**	**208**	**37.5**	**98**	**17.7**	**58**	**10.5**	**554**	**55.8**

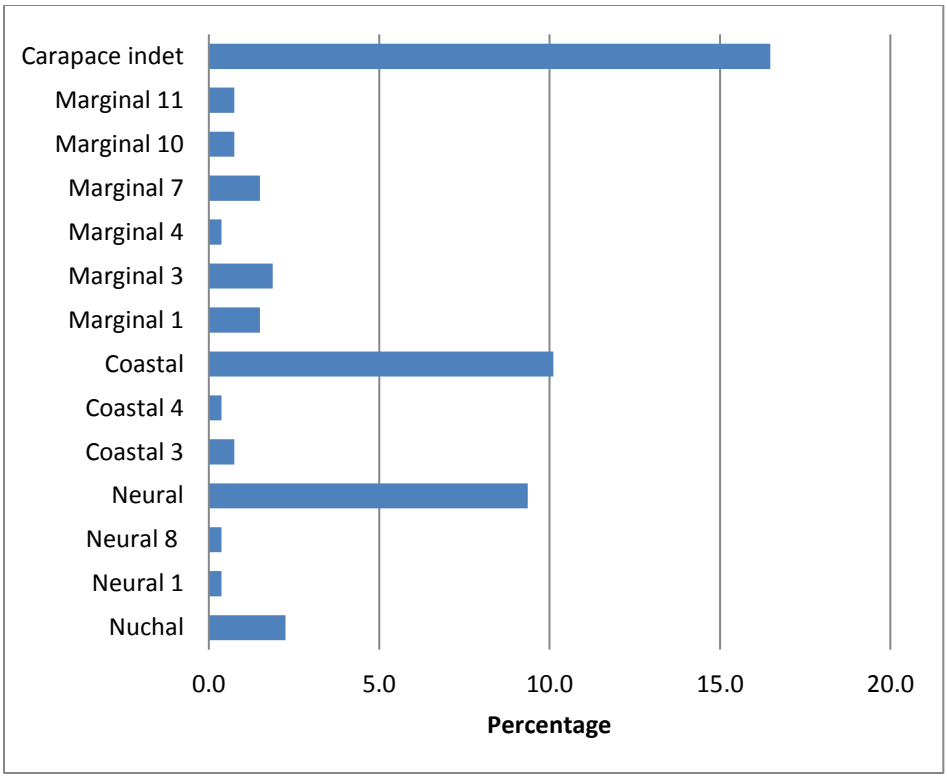


Figure 6.128. Relative frequency of chelonia carapace elements in Profile Four

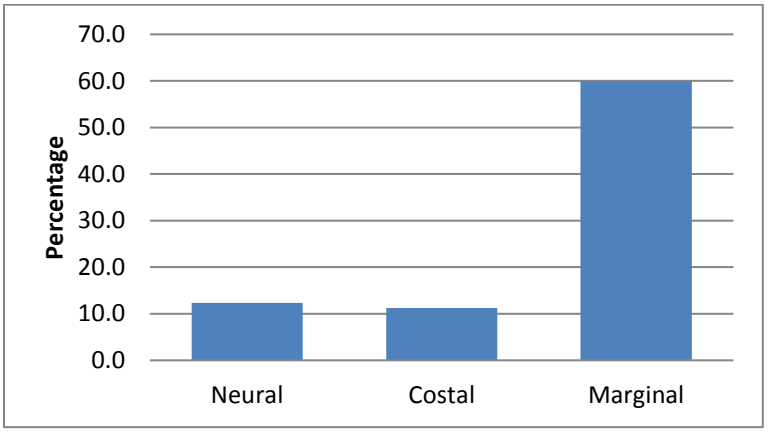


Figure 6.129. Relative frequency of chelonian carapace parts in Profile Four

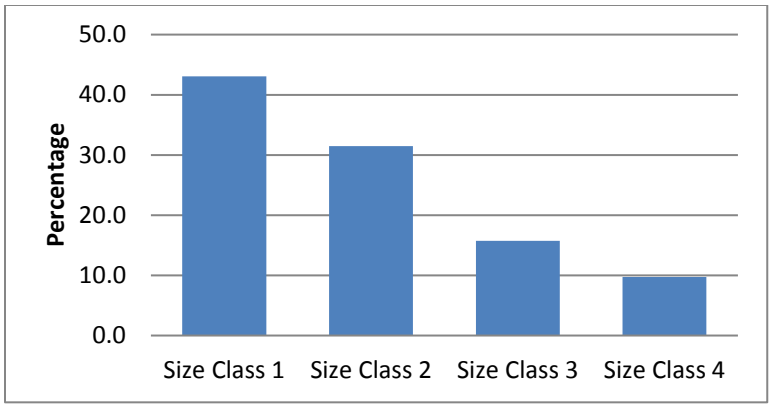


Figure 6.130. Body size class in chelonia carapace remains from Profile Four

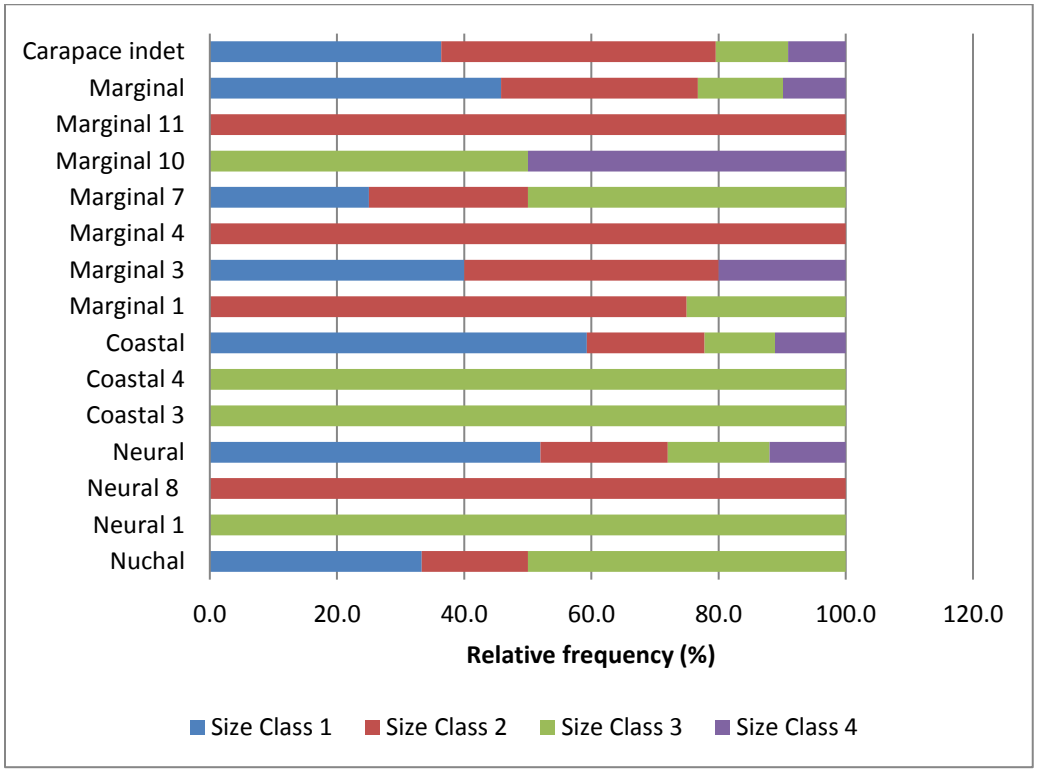


Figure 6.131. Chelonia carapace elements with body size class from Profile Four

Table6.73. Anatomical composition of chelonia shell elements with depth in Profile Four

	Spit 1		Spit 2		Spit 3		Spit 4		Spit 5		Spit 6		Spit 7		Spit 8		Spit 9		Spit 10		Total	
Element	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Nuchal	1	16.7	1	16.7	-	-	1	16.7	-	-	-	-	1	16.7	1	16.7	1	16.7	-	-	**6**	**2.2**
Neural 1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	100	-	-	**1**	**0.4**
Neural 8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	100	**1**	**0.4**
Neural	1	4	1	4	2	8	4	16	3	12	3	12	3	12	1	4	6	24	1	4	**25**	**9.4**
Coastal 3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	100	-	-	**2**	**0.7**
Coastal 4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	100	-	-	**1**	**0.4**
Coastal	-	-	1	3.7	1	3.7	1	3.7	3	11.1	3	11.1	7	25.9	3	11.1	8	29.6	-	-	**27**	**10.1**
Marginal 1	-	-	-	-	-	-	-	-	-	-	1	25	-	-	-	-	3	75	-	-	**4**	**1.5**
Marginal 3	-	-	-	-	-	-	1	20	-	-	-	-	1	20	2	40	1	20	-	-	**5**	**1.9**
Marginal 4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	100	-	-	**1**	**0.4**
Marginal 7	-	-	-	-	-	-	-	-	-	-	-	-	1	25	1	25	2	50	-	-	**4**	**1.5**
Marginal 10	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	1	100	-	-	**2**	**0.7**
Marginal 11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	100	-	-	**2**	**0.7**
Marginal	7	4.9	13	9.2	34	23.9	20	14.1	13	9.2	7	4.9	23	16.2	12	8.5	13	9.2	-	-	**142**	**53.2**
Carapace indet.	-	-	2	4.5	3	6.8	5	11.4	5	11.4	2	4.5	3	6.8	8	18.2	15	34.1	1	2.3	**44**	**16.5**
Total Carapace	**9**	**3.4**	**18**	**6.7**	**41**	**15.4**	**32**	**12**	**24**	**9**	**16**	**6**	**39**	**14.6**	**28**	**10.5**	**57**	**21.3**	**3**	**1.1**	**267**	**30.1**
Xiphiplastron	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	100	-	-	**1**	**1.8**
Hypoplastron	1	14.3	-	-	-	-	-	-	1	14.3	-	-	1	14.3	2	28.6	2	28.6	-	-	**7**	**12.3**
Hyoplastron	-	-	1	25	-	-	1	25	1	25	-	-	1	25	-	-	-	-	-	-	**4**	**7**
Entoplastron	-	-	-	-	1	50	1	50	-	-	-	-	-	-	-	-	-	-	-	-	**2**	**3.5**
Epiplastron	-	-	1	9.1	-	-	1	9.1	3	27.3	-	-	3	27.3	-	-	2	18.2	1	9.1	**11**	**19.3**
Plastron indet.	4	12.5	3	9.4	4	12.5	4	12.5	1	3.1	2	6.3	3	9.4	1	3.1	9	28.1	1	3.1	**32**	**56.1**
Total Plastron	**5**	**8.8**	**5**	**8.8**	**5**	**8.8**	**7**	**12.3**	**6**	**10.5**	**2**	**3.5**	**8**	**14**	**3**	**5.3**	**14**	**24.6**	**2**	**3.5**	**57**	**6.4**
Carapace/Plastron	**11**	**4.8**	**14**	**6.1**	**23**	**10**	**31**	**13.5**	**29**	**12.6**	**16**	**7**	**21**	**9.1**	**39**	**17**	**37**	**16.1**	**9**	**3.9**	**230**	**26**
Total Shell	**25**	**4.5**	**37**	**6.7**	**69**	**12.5**	**70**	**12.6**	**59**	**10.6**	**34**	**6.1**	**68**	**12.3**	**70**	**12.6**	**108**	**19.5**	**14**	**2.5**	**554**	**55.8**

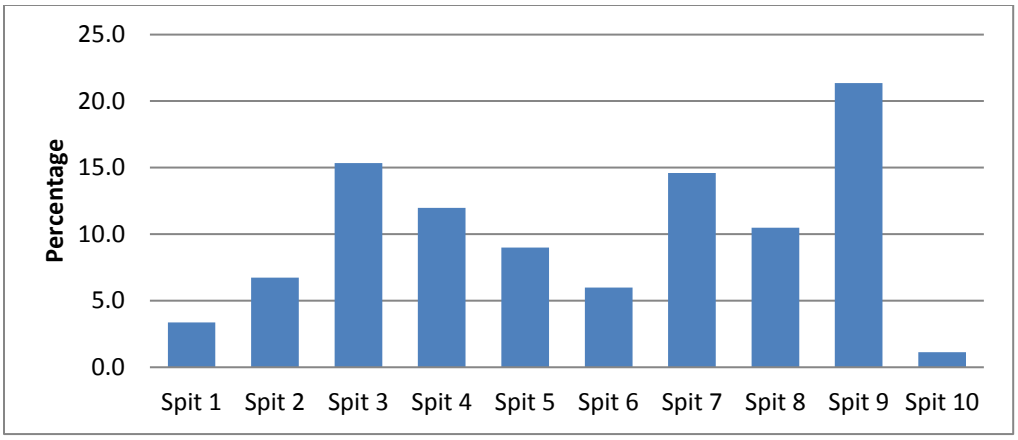


Figure 6.132. Relative frequency of chelonia carapace elements with depth

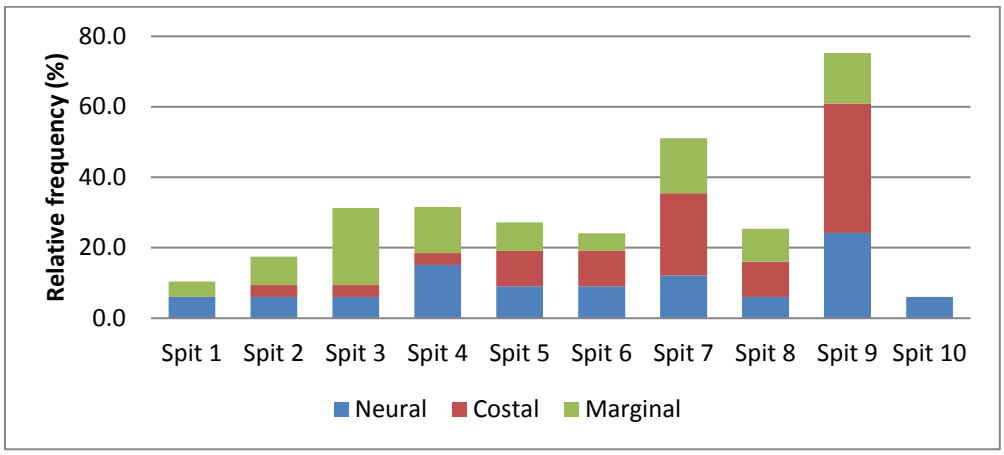


Figure 6.133. Relative frequency of chelonian carapace parts with depth from Profile Four

Table 6.74. Skeletal element frequencies in chelonia carapace elements from Profile Four

Element	NISP	MNE	MAU	%MAU	MNI
Nuchal	6	5	3	75	3
Neural 1	1	1	1	25	1
Neural 8	1	1	1	25	1
Neural	25	12	3	75	3
Coastal 3	2	2	2	50	2
Coastal 4	1	1	1	25	1
Coastal	27	4	4	100	1
Marginal 1	4	4	2	50	2
Marginal 3	5	4	2	50	2
Marginal 4	1	1	1	25	1
Marginal 7	4	4	2	50	2
Marginal 10	2	2	2	50	2
Marginal 11	2	2	2	50	2
Marginal	142	34	4	100	4
Carapace indet.	44	44	4	100	4
Total Carapace	**267**				**4**

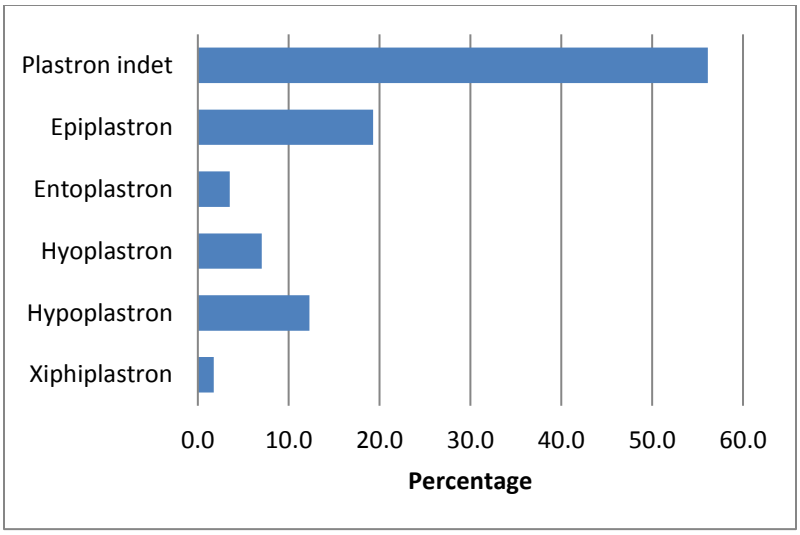


Figure 6.134. Relative frequency of chelonian plastron elements from Profile Four

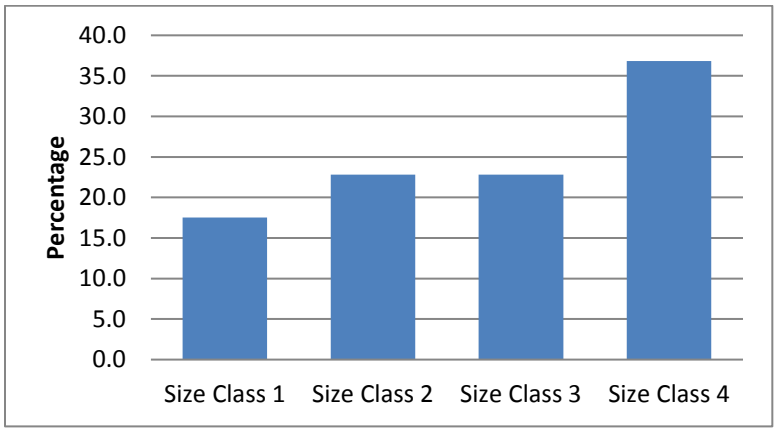


Figure 6.135. Relative frequency of body size class in chelonian plastron remains from Profile Four

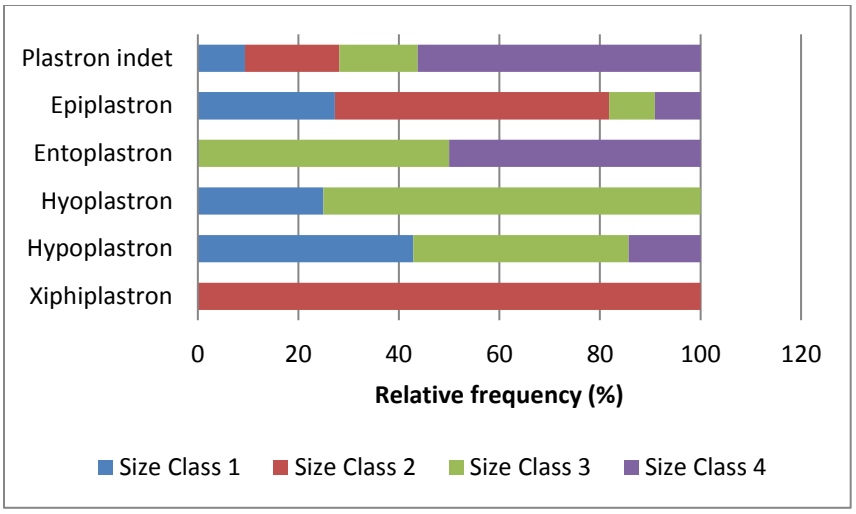


Figure 6.136. Chelonia plastron remains with body size class from Profile Four

Table 6.75. Anatomical composition of chelonia shell remains by spit in Profile Four

	Spit 1		Spit 2		Spit 3		Spit 4		Spit 5		Spit 6		Spit 7		Spit 8		Spit 9		Spit 10		Total	
Element	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Nuchal	1	16.7	1	16.7	-	-	1	16.7	-	-	-	-	1	16.7	1	16.7	1	16.7	-	-	**6**	**2.2**
Neural 1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	100	-	-	**1**	**0.4**
Neural 8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	100	**1**	**0.4**
Neural	1	4	1	4	2	8	4	16	3	12	3	12	3	12	1	4	6	24	1	4	**25**	**9.4**
Coastal 3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	100	-	-	**2**	**0.7**
Coastal 4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	100	-	-	**1**	**0.4**
Coastal	-	-	1	3.7	1	3.7	1	3.7	3	11.1	3	11.1	7	25.9	3	11.1	8	29.6	-	-	**27**	**10.1**
Marginal 1	-	-	-	-	-	-	-	-	-	-	1	25	-	-	-	-	3	75	-	-	**4**	**1.5**
Marginal 3	-	-	-	-	-	-	1	20	-	-	-	-	1	20	2	40	1	20	-	-	**5**	**1.9**
Marginal 4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	100	-	-	**1**	**0.4**
Marginal 7	-	-	-	-	-	-	-	-	-	-	-	-	1	25	1	25	2	50	-	-	**4**	**1.5**
Marginal 10	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	1	100	-	-	**2**	**0.7**
Marginal 11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	100	-	-	**2**	**0.7**
Marginal	7	4.9	13	9.2	34	23.9	20	14.1	13	9.2	7	4.9	23	16.2	12	8.5	13	9.2	-	-	**142**	**53.2**
Carapace indet.	-	-	2	4.5	3	6.8	5	11.4	5	11.4	2	4.5	3	6.8	8	18.2	15	34.1	1	2.3	**44**	**16.5**
Total Carapace	**9**	**3.4**	**18**	**6.7**	**41**	**15.4**	**32**	**12**	**24**	**9**	**16**	**6**	**39**	**14.6**	**28**	**10.5**	**57**	**21.3**	**3**	**1.1**	**267**	**30.1**
Xiphiplastron	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	100	-	-	**1**	**1.8**
Hypoplastron	1	14.3	-	-	-	-	-	-	1	14.3	-	-	1	14.3	2	28.6	2	28.6	-	-	**7**	**12.3**
Hyoplastron	-	-	1	25	-	-	1	25	1	25	-	-	1	25	-	-	-	-	-	-	**4**	**7.0**
Entoplastron	-	-	-	-	1	50	1	50	-	-	-	-	-	-	-	-	-	-	-	-	**2**	**3.5**
Epiplastron	-	-	1	9.1	-	-	1	9.1	3	27.3	-	-	3	27.3	-	-	2	18.2	1	9.1	**11**	**19.3**
Plastron indet.	4	12.5	3	9.4	4	12.5	4	12.5	1	3.1	2	6.3	3	9.4	1	3.1	9	28.1	1	3.1	**32**	**56.1**
Total Plastron	**5**	**8.8**	**5**	**8.8**	**5**	**8.8**	**7**	**12.3**	**6**	**10.5**	**2**	**3.5**	**8**	**14**	**3**	**5.3**	**14**	**24.6**	**2**	**3.5**	**57**	**6.4**
Carapace/Plastron	**11**	**4.8**	**14**	**6.1**	**23**	**10**	**31**	**13.5**	**29**	**12.6**	**16**	**7**	**21**	**9.1**	**39**	**17**	**37**	**16.1**	**9**	**3.9**	**230**	**26**
Total Shell	**25**	**4.5**	**37**	**6.7**	**69**	**12.5**	**70**	**12.6**	**59**	**10.6**	**34**	**6.1**	**68**	**12.3**	**70**	**12.6**	**108**	**19.5**	**14**	**2.5**	**554**	**55.8**

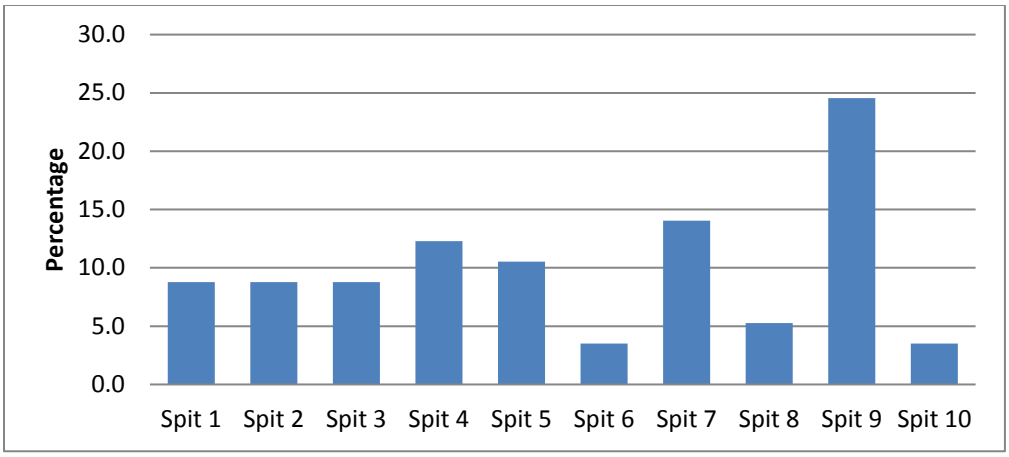


Figure 6.137. Relative frequency of chelonian plastron by spit from Profile Four

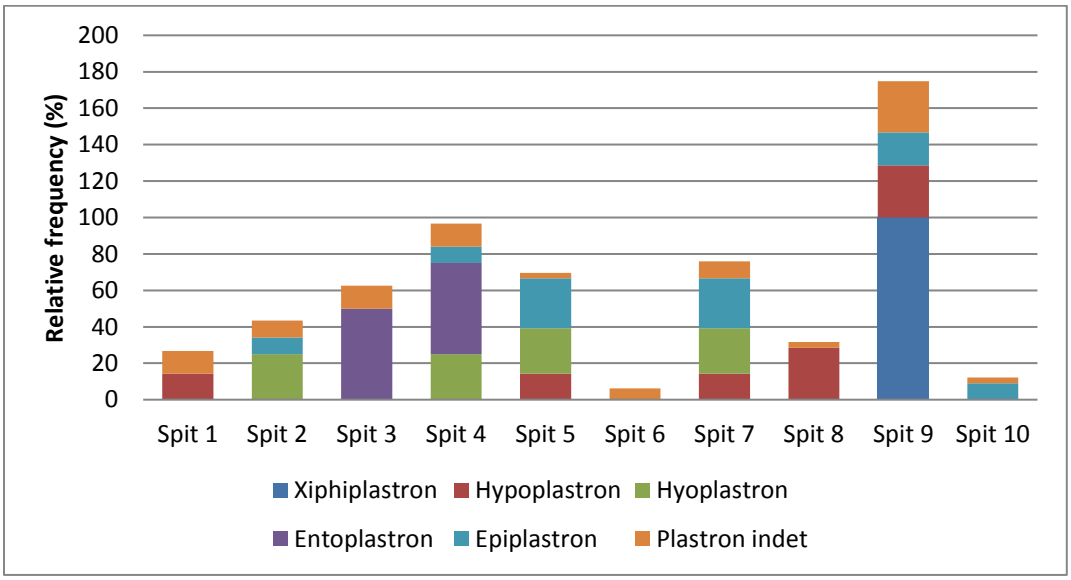


Figure 6.138. Relative frequency of chelonian plastron elements by spit from Profile Four

Table 6.76. Skeletal element frequencies in chelonia plastron elements from Profile Four

Element	NISP	MNE	MAU	%MAU	MNI
Xiphiplastron	1	1	1	20	1
Hypoplastron	7	3	3	60	3
Hyoplastron	4	2	2	40	2
Entoplastron	2	2	2	40	2
Epiplastron	11	6	5	100	5
Plastron indet.	32	6	4	80	4
Total Plastron	**57**				**5**



Figure 6.139. Relative frequency of indeterminate shell remains with body size class in Profile Four

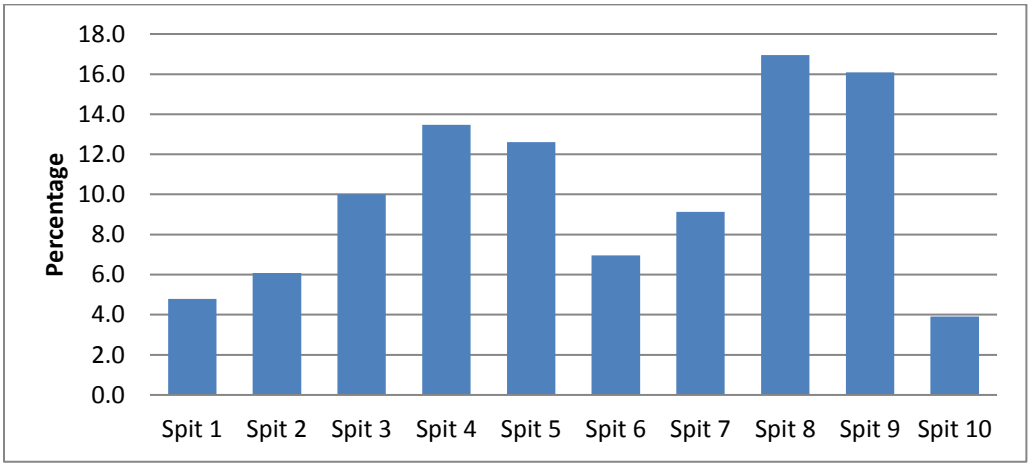


Figure 6.140. Relative frequency of indeterminate shell remains by spit from Profile Four

Table 6.77. Descriptive statistics of maximum specimen length in chelonia remains from Profile Four

	Size Class 1	Size Class 2	Size Class 3	Size Class 4	Combined
N	198	384	231	70	883
Minimum	6	4	6	10	4
Maximum	20	65	77	76	77
Mean	11.8	14.8	22.7	30.8	17.5
Standard Deviation	3.07	7.17	11.14	10.89	9.88

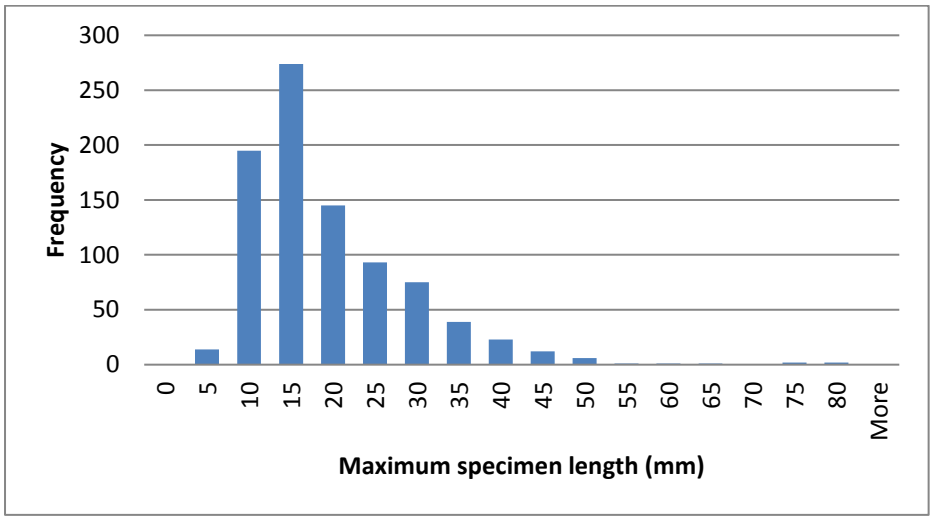


Figure 6.141. Histogram of maximum specimen length in combined chelonia sample from Profile Four

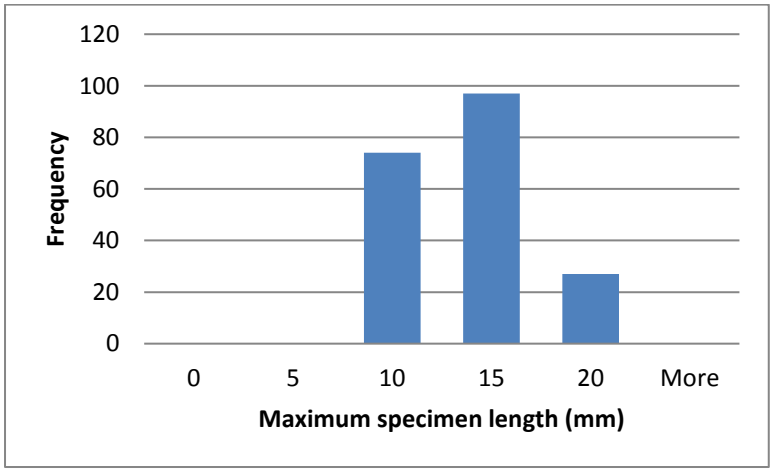


Figure 6.142. Histogram of maximum specimen length in size class one chelonia remains from Profile Four

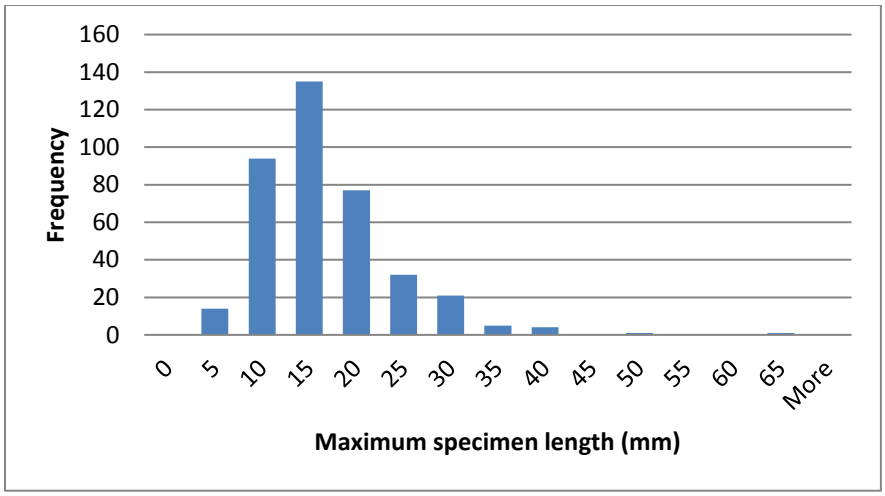


Figure 6.143. Histogram of maximum specimen length in size class two chelonia remains from Profile Four

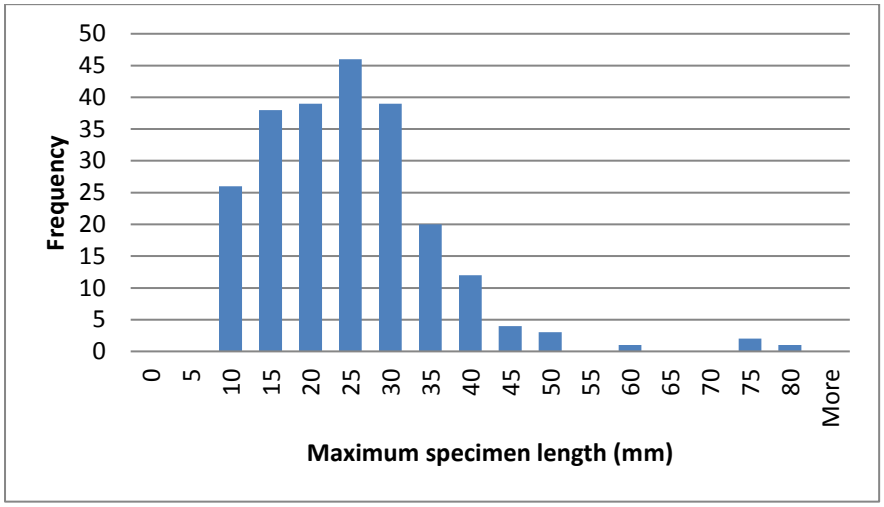


Figure 6.144. Histogram of maximum specimen length in size class three chelonia remains from Profile Four

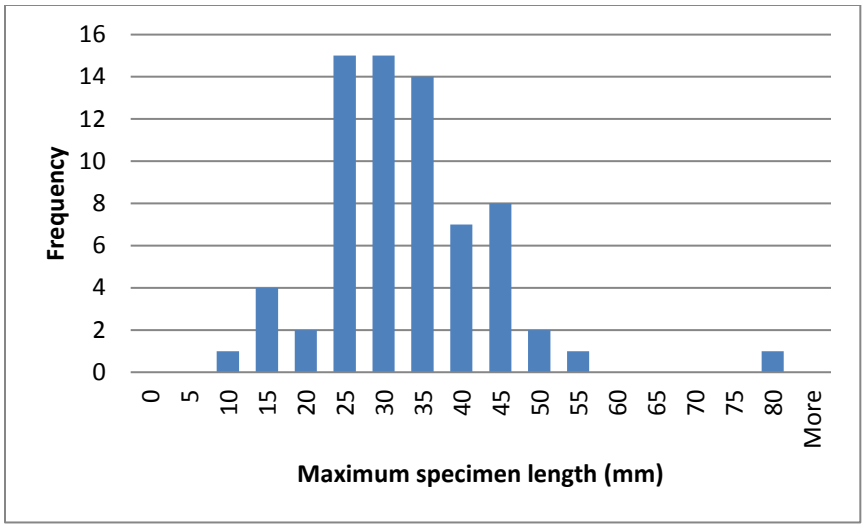


Figure 6.145. Histogram of maximum specimen length in size class four chelonia remains from Profile Four

Table 6.78. Complete chelonia elements with body size class from Profile Four

	Size Class 1		Size Class 2		Size Class 3		Size Class 4		Total	
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Femur	-	-	-	-	1	100	-	-	**1**	**0.8**
Tibia	-	-	-	-	2	66.6	1	33.3	**3**	**2.3**
Tarsal/carpal	-	-	-	-	2	100	-	-	**2**	**1.6**
Distal phalange	-	-	12	44.4	12	44.4	3	11.1	**27**	**20.9**
Phalange	1	1.6	50	79.4	12	19	-	-	**63**	**48.8**
Vertebra	1	50	1	50	-	-	-	-	**2**	**1.6**
Nuchal	1	50	-	-	1	50	-	-	**2**	**1.6**
Neural 8	-	-	1	100	-	-	-	-	**1**	**0.8**
Neural	3	50.0	1	16.7	2	33.3	-	-	**6**	**4.7**
Coastal 3	-	-	-	-	1	100	-	-	**1**	**0.8**
Coastal 4	-	-	-	-	1	100	-	-	**1**	**0.8**
Coastal	-	-	-	-	1	100	-	-	**1**	**0.8**
Marginal 1	-	-	2	100	-	-	-	-	**2**	**1.6**
Marginal 4	-	-	1	100	-	-	-	-	**1**	**0.8**
Marginal 7	1	100	-	-	-	-	-	-	**1**	**0.8**
Marginal 11	-	-	1	100	-	-	-	-	**1**	**0.8**
Marginal	8	72.7	1	9.1	1	9.1	1	9.1	**11**	**8.5**
Epiplastron	-	-	2	100	-	-	-	-	**2**	**1.6**
Plastron indet.	-	-	1	100	-	-	-	-	**1**	**0.8**
Total	**15**	**11.6**	**73**	**56.6**	**36**	**27.9**	**5**	**3.9**	**129**	**14.6**



Figure 6.146. Relative frequency of complete remains by body size class in chelonia from Profile Four

Table 6.79. Completeness and spit in chelonia remains from Profile Four

	Spit 2		Spit 3		Spit 4		Spit 5		Spit 6		Spit 7		Spit 8		Spit 9		Spit 10		Total	
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Femur	-	-	-	-	-	-	1	100	-	-	-	-	-	-	-	-	-	-	**1**	**0.8**
Tibia	-	-	-	-	-	-	-	-	-	-	-	-	2	66.6	-	-	1	33.3	**3**	**2.3**
Tarsal/carpal	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	100	**2**	**1.6**
Distal phalange	1	3.7	2	7.4	2	7.4	4	14.8	5	18.5	3	11.1	7	25.9	2	7.4	1	3.7	**27**	**20.9**
Phalange	-	-	-	-	-	-	10	15.9	1	1.6	16	25.4	17	27.0	17	27	2	3.2	**63**	**48.8**
Vertebra	-	-	-	-	-	-	-	-	-	-	2	100	-	-	-	-	-	-	**2**	**1.6**
Nuchal	1	50	-	-	-	-	-	-	-	-	-	-	-	-	1	50	-	-	**2**	**1.6**
Neural 8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	100	**1**	**0.8**
Neural	1	16.7	-	-	-	-	-	-	1	16.7	1	16.7	-	-	2	33.3	1	16.7	**6**	**4.7**
Coastal 3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	100	-	-	**1**	**0.8**
Coastal 4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	100	-	-	**1**	**0.8**
Coastal	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	100	-	-	**1**	**0.8**
Marginal 1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	100	-	-	**2**	**1.6**
Marginal 4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	100	-	-	**1**	**0.8**
Marginal 7	-	-	-	-	-	-	-	-	-	-	1	100	-	-	-	-	-	-	**1**	**0.8**
Marginal 11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	100	-	-	**1**	**0.8**
Marginal	-	-	-	-	2	18.2	-	-	1	9.1	3	27.3	3	27.3	2	18.2	-	-	**11**	**8.5**
Epiplastron	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	100	-	-	**2**	**1.6**
Plastron indet.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	100	-	-	**1**	**0.8**
Total	**3**	**2.3**	**2**	**1.6**	**4**	**3.1**	**15**	**11.6**	**8**	**6.2**	**26**	**20.2**	**29**	**22.5**	**34**	**26.4**	**8**	**6.2**	**129**	

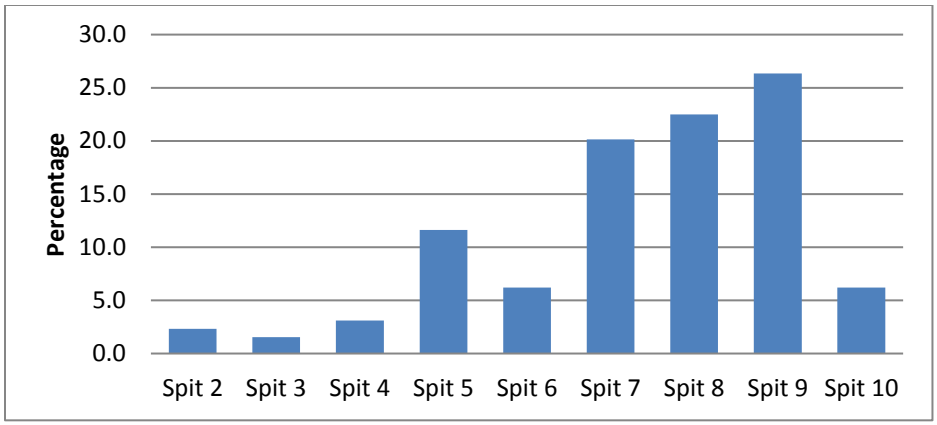


Figure 6.147. Relative frequency of complete chelonia remains by spit from Profile Four

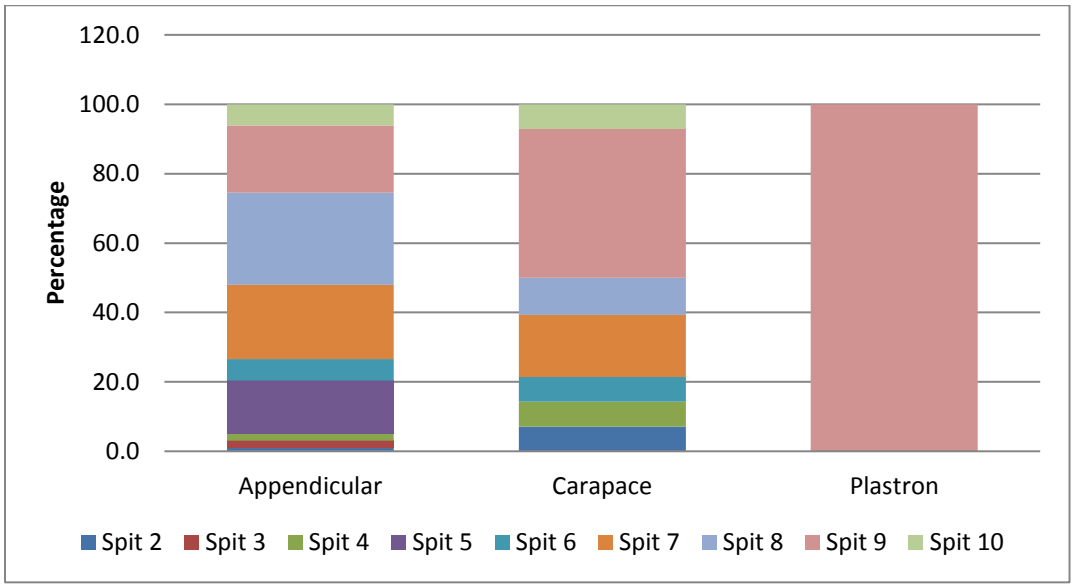


Figure 6.148. Completeness and spit depth in chelonia remains from Profile Four

Table 6.80. Breakage categories in chelonian remains from Profile Four

	Complete		Proximal		Shaft		Distal	
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Humerus	-	-	8	20	26	65	6	15
Radius	1	4.8	9	42.9	2	9.5	9	42.9
Ulna	-	-	5	45.5	1	9.1	5	45.5
Ilium	-	-	3	37.5	4	50	1	12.5
Ischium	-	-	-	-	5	100	-	-
Pubis	-	-	-	-	1	100	-	-
Femur	-	-	11	34.4	11	34.4	10	31.3
Tibia	4	20	7	35	2	10	7	35
Fibula	-	-	8	47.1	3	17.6	6	35.3
Middle phalange	1	100	-	-	-	-	-	-
Distal phalange	35	100	-	-	-	-	-	-
Phalange	66	95.7	-	-	3	4.3	-	-
Total	**107**	**41.2**	**51**	**19.6**	**58**	**22.3**	**44**	**16.9**

	Dorsal		Ventral		Shaft	
	N	**%**	**N**	**%**	**N**	**%**
Scapula	5	50	3	30	2	20
Coracoid	3	37.5	-	-	5	62.5
Total	**8**	**44.4**	**3**	**16.7**	**7**	**38.9**

	Complete		Centrum		Fragmentary	
	N	**%**	**N**	**%**	**N**	**%**
Vertebra	4	28.6	9	64.3	1	7.1

	Complete		Fragmentary	
	N	**%**	**N**	**%**
Cranium	-	-	1	100
Mandible	-	-	2	100
Tarsal/carpal	1	50	1	50
Total	**1**	**20**	**4**	**80**

Table 6.81. Fracture outline with body size class in chelonia long bones from Profile Four

	Spiral (fresh)		Transverse (dry)		Splintered		Eroded		Irregular		Total	
	N	%	N	%	N	%	N	%	N	%	N	%
Size Class 1	5	27.8	1	5.6	-	-	-	-	-	-	**6**	**33.3**
Size Class 2	79	22.3	15	4.2	-	-	6	1.7	-	-	**100**	**28.2**
Size Class 3	82	30.8	20	7.5	6	2.3	2	0.8	1	0.4	**111**	**41.7**
Size Class 4	7	26.9	1	3.8	-	-	3	11.5	-	-	**11**	**42.3**
Total	**173**	**75.9**	**37**	**16.2**	**6**	**2.6**	**11**	**4.8**	**1**	**0.4**	**228**	**34.3**

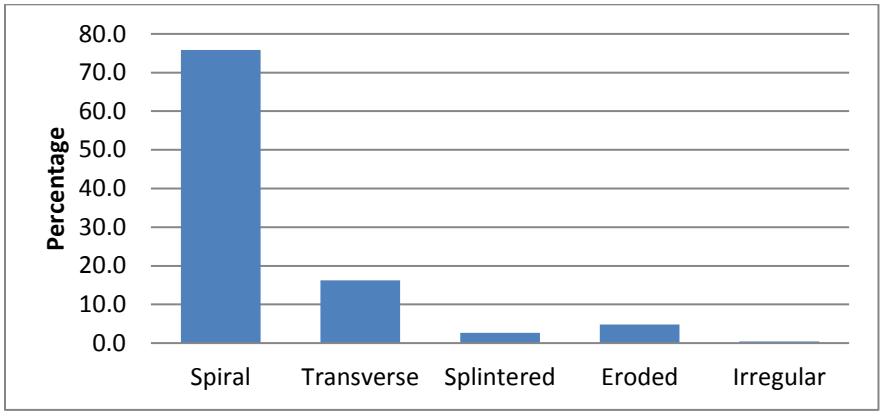


Figure 6.149. Relative frequency of fracture outline type in chelonia long bones from Profile Four

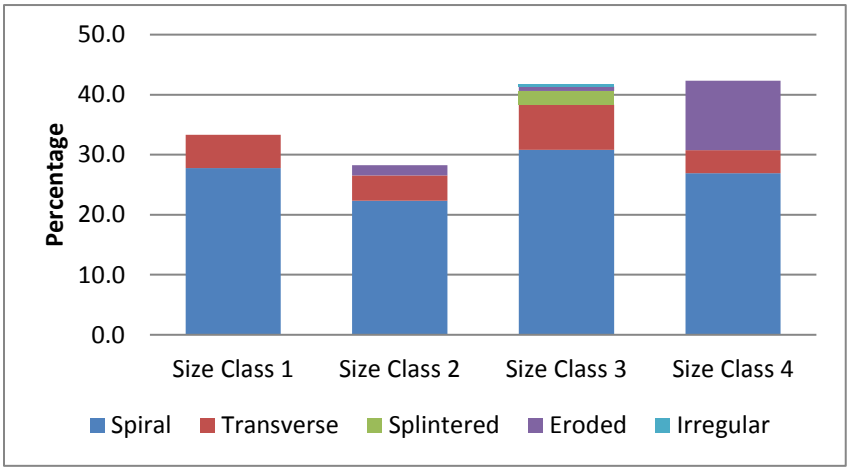


Figure 6.150. Fracture outline type with body size class in chelonia long bones from Profile Four

Table 6.82. Fracture outline and spit deptrh in chelonia long bones from Profile Four

	Spiral (fresh)		Transverse (dry)		Splintered		Eroded		Irregular		Total	
	N	%	N	%	N	%	N	%	N	%	N	%
Spit 1	2	50	-	-	-	-	-	-	-	-	**2**	**50**
Spit 2	3	16.7	4	22.2	1	5.6	-	-	-	-	**8**	**44.4**
Spit 3	21	37.5	7	12.5	-	-	-	-	-	-	**28**	**50**
Spit 4	11	32.4	4	11.8	-	-	2	5.9	-	-	**17**	**50**
Spit 5	27	27	6	6	1	1	1	1	-	-	**35**	**35**
Spit 6	8	23.5	-	-	-	-	1	2.9	-	-	**9**	**26.5**
Spit 7	29	23.8	4	3.3	-	-	1	0.8	-	-	**34**	**27.9**
Spit 8	42	26.9	6	3.8	1	0.6	4	2.6	-	-	**53**	**34**
Spit 9	26	22.4	4	3.4	3	2.6	2	1.7	1	0.9	**36**	**31**
Spit 10	4	16.7	2	8.3	-	-	-	-	-	-	**6**	**25**
Total	**173**	**75.9**	**37**	**16.2**	**6**	**2.6**	**11**	**4.8**	**1**	**0.4**	**228**	**34.3**

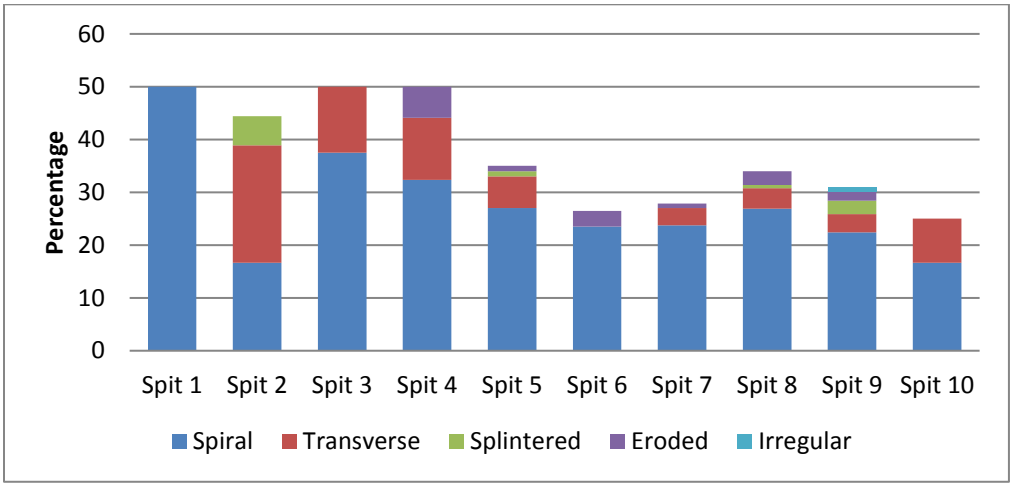


Figure 6.151. Fracture outline with spit in chelonia long bones from Profile Four

Table 6.83. Fracture outline with body size class in chelonia shell remains from Profile Four

	Spiral (fresh)		Transverse (dry)		Splintered		Eroded		Irregular		Total	
	N	%	N	%	N	%	N	%	N	%	N	%
Size Class 1	128	33.7	49	12.9	-	-	5	1.3	-	-	**182**	**47.9**
Size Class 2	144	34.6	57	13.7	1	0.2	2	0.5	-	-	**204**	**49**
Size Class 3	55	28.1	37	18.9	4	2	4	2	6	3.1	**106**	**54.1**
Size Class 4	39	33.6	23	19.8	-	-	-	-	-	-	**62**	**53.4**
Total	**366**	**66.1**	**166**	**30.0**	**5**	**0.9**	**11**	**2.0**	**6**	**1.1**	**554**	**50**

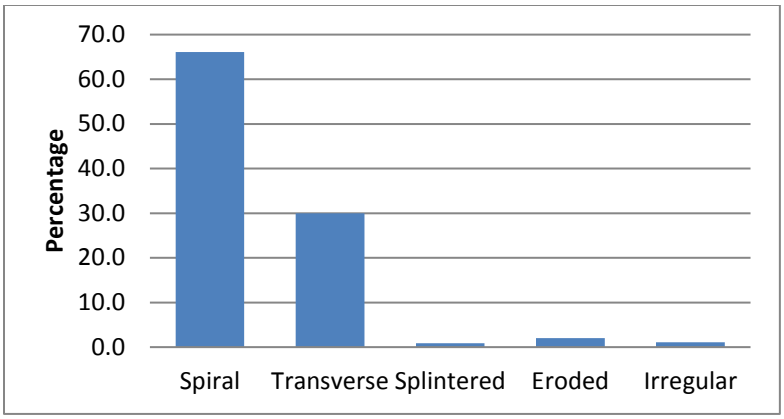


Figure 6.152. Relative frequency of fracture outline type in chelonia shell remains

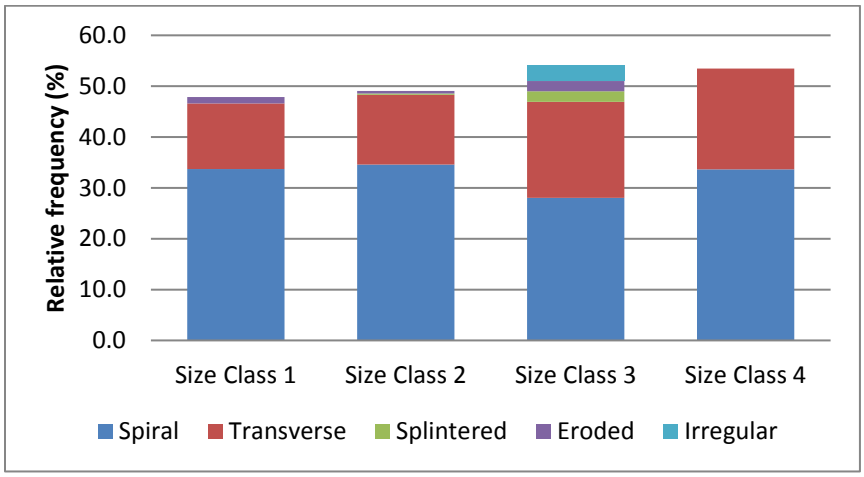


Figure 6.153. Fracture outline type and body size class in chelonia shell remains

Table6.84. Fracture outline by spit in chelonia shell remains from Profile Four

	Spiral (fresh)		Transverse (dry)		Splintered		Eroded		Irregular		Total	
	N	%	N	%	N	%	N	%	N	%	N	%
Spit 1	18	36	14	28	1	2	-	-	2	4	**35**	**70**
Spit 2	17	23	18	24.3	-	-	2	2.7	-	-	**37**	**50**
Spit 3	51	37	21	15.2	-	-	2	1.4	-	-	**74**	**53.6**
Spit 4	52	37.1	17	12.1	-	-	1	0.7	1	0.7	**71**	**50.7**
Spit 5	47	39.8	14	11.9	-	-	-	-	-	-	**61**	**51.7**
Spit 6	22	32.4	11	16.2	1	1.5	-	-	-	-	**34**	**50**
Spit 7	51	37.5	14	10.3	-	-	2	1.5	-	-	**67**	**49.3**
Spit 8	58	41.4	11	7.9	-	-	1	0.7	-	-	**70**	**50**
Spit 9	44	20.4	40	18.5	3	1.4	2	0.9	3	1.4	**92**	**42.6**
Spit 10	6	21.4	6	21.4	-	-	1	3.6	-	-	**13**	**46.4**
Total	**366**	**66.1**	**166**	**30**	**5**	**0.9**	**11**	**2**	**6**	**1.1**	**554**	**50**

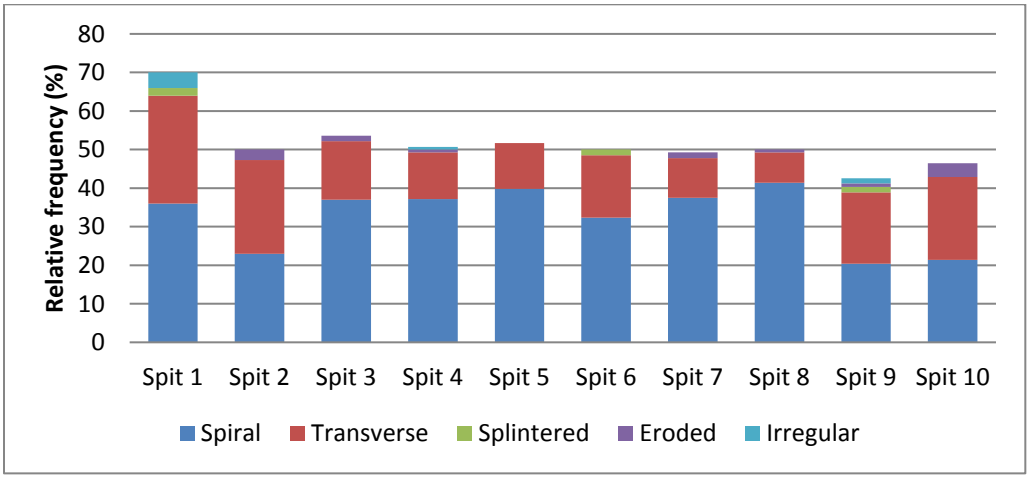


Figure 6.154. Fracture outline type by spit in chelonia shell remains from Profile Four

Table 6.85. Fracture angle in chelonia long bones with body size class from Profile Four

	Oblique		Right		Mixed		Total	
	N	%	N	%	N	%	N	%
Size Class 1	2	11.1	2	11.1	3	16.7	**7**	**38.9**
Size Class 2	48	13.6	31	8.8	34	9.6	**113**	**31.9**
Size Class 3	35	13.2	36	13.5	42	15.8	**113**	**42.5**
Size Class 4	2	7.7	2	7.7	6	23.1	**10**	**38.5**
Total	**87**	**35.8**	**71**	**29.2**	**85**	**35**	**243**	**36.6**

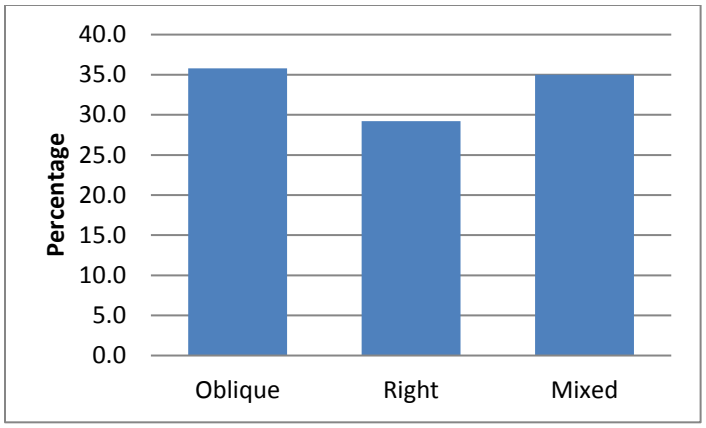


Figure 6.155. Relative frequency of fracture angle type in chelonia long bones from Profile Four

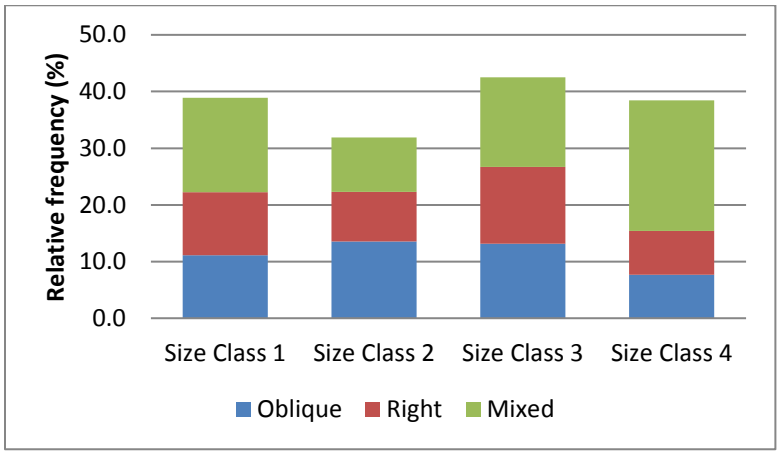


Figure 6.156. Fracture angle and body size class in chelonia long bones from Profile Four

Table 6.86. Fracture angle by spit in chelonia long bones from Profile Four

	Oblique		Right		Mixed		Total	
	N	%	N	%	N	%	N	%
Spit 1	-	-	-	-	2	50	**2**	**50**
Spit 2	3	16.7	4	22.2	1	5.6	**8**	**44.4**
Spit 3	12	21.4	10	17.9	8	14.3	**30**	**53.6**
Spit 4	9	26.5	6	17.6	1	2.9	**16**	**47.1**
Spit 5	14	14	10	10	15	15	**39**	**39**
Spit 6	5	14.7	-	-	5	14.7	**10**	**29.4**
Spit 7	16	13.1	15	12.3	10	8.2	**41**	**33.6**
Spit 8	15	9.6	13	8.3	25	16	**53**	**34**
Spit 9	11	9.5	11	9.5	15	12.9	**37**	**31.9**
Spit 10	2	8.3	2	8.3	3	12.5	**7**	**29.2**
Total	**87**	**35.8**	**71**	**29.2**	**85**	**35**	**243**	**100**

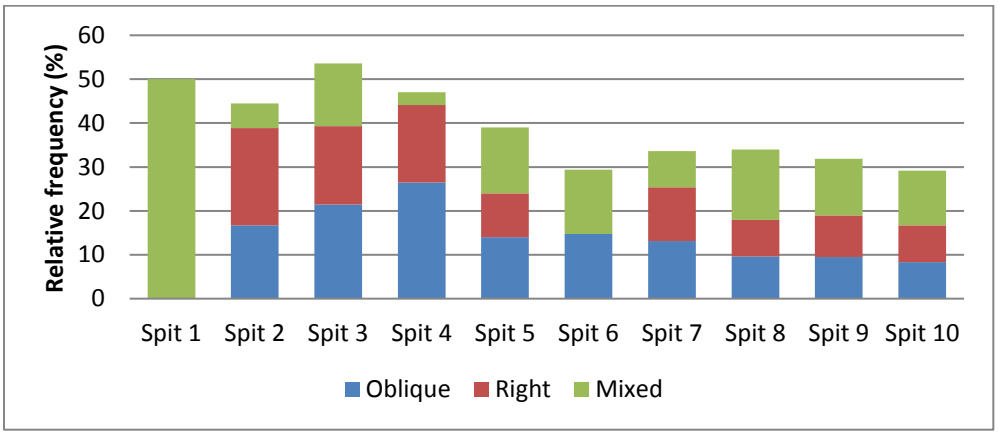


Figure 6.157. Fracture angle by spit in chelonia long bones from Profile Four

Table 6.87. Fracture angle in chelonia shell remains from Profile Four

	Oblique		Right		Mixed		Total	
	N	%	N	%	N	%	N	%
Size Class 1	36	9.5	86	22.6	60	15.8	**182**	**47.9**
Size Class 2	38	9.1	107	25.7	69	16.6	**214**	**51.4**
Size Class 3	15	7.7	53	27	29	14.8	**97**	**49.5**
Size Class 4	12	10.3	29	25	24	20.7	**65**	**56**
Total	**101**	**18.1**	**275**	**49.3**	**182**	**32.6**	**558**	**50.4**

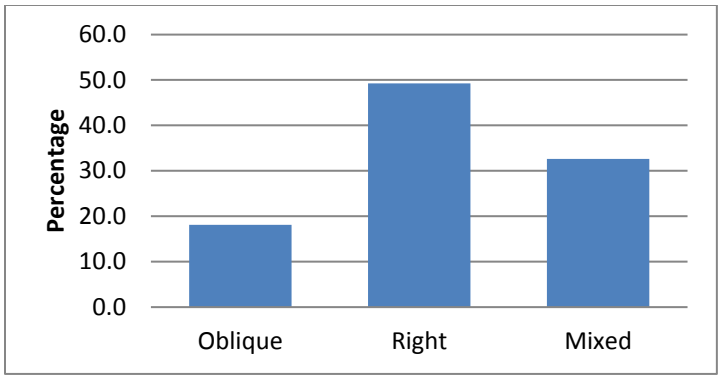


Figure 6.158. Relative frequency of fracture angle type in chelonia shell remains from Profile Four

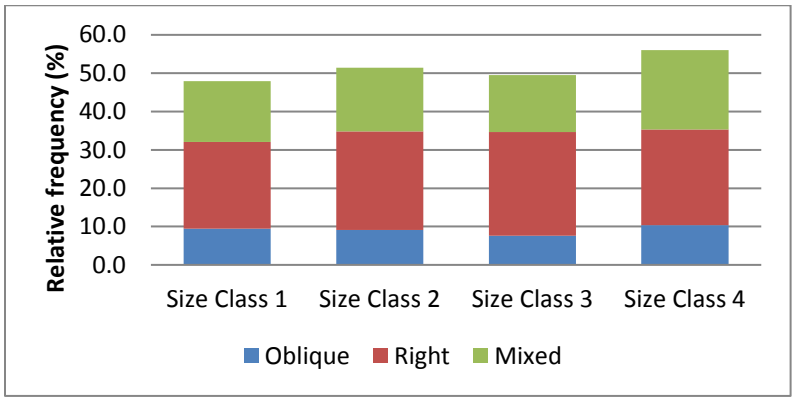


Figure 6.159. Fracture angle with body size class in chelonia shell remains from Profile Four

Table 6.88. Fracture angle with spit in chelonia shell remains from Profile Four

	Oblique		Right		Mixed		Total	
	N	%	N	%	N	%	N	%
Spit 1	6	12	17	34	10	20	**33**	**66**
Spit 2	3	4.1	19	25.7	15	20.3	**37**	**50**
Spit 3	10	7.2	35	25.4	28	20.3	**73**	**52.9**
Spit 4	14	10	29	20.7	27	19.3	**70**	**50**
Spit 5	15	12.7	32	27.1	17	14.4	**64**	**54.2**
Spit 6	7	10.3	17	25	11	16.2	**35**	**51.5**
Spit 7	15	11	29	21.3	24	17.6	**68**	**50**
Spit 8	14	10	32	22.9	26	18.6	**72**	**51.4**
Spit 9	16	7.4	56	25.9	23	10.6	**95**	**44**
Spit 10	1	3.6	9	32.1	1	3.6	**11**	**39.3**
Total	**101**	**18.1**	**275**	**49.3**	**182**	**32.6**	558	**50.4**

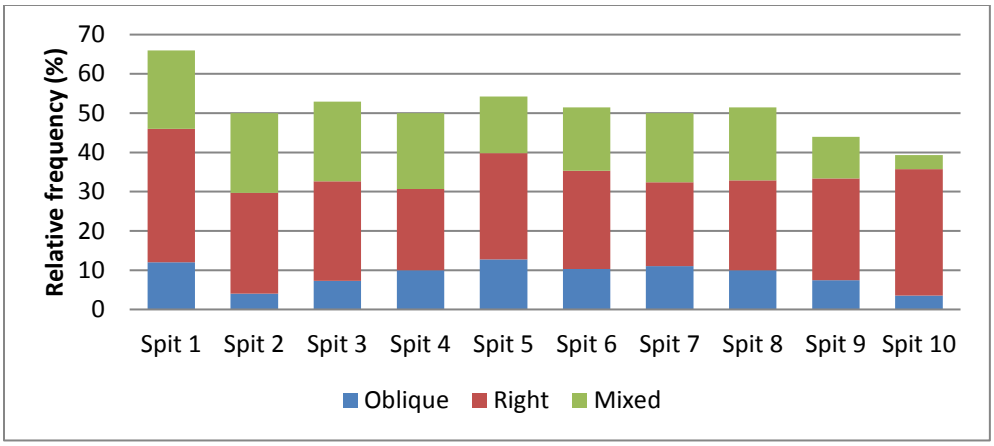


Figure 6.160. Fracture angle with spit in chelonia shell remains from Profile Four

Table 6.89. Weathering in chelonia parts from Profile Four

	Appendicular/Axial		Carapace		Plastron		Carapace/Plastron		Total	
	N	%	N	%	N	%	N	%	N	%
Stage 1	26	7.8	27	9.1	16	28.1	25	10.9	**94**	**10.6**
Stage 2	12	3.6	18	6.1	1	1.8	8	3.5	**39**	**4.4**
Total	**38**	**11.4**	**45**	**15.2**	**17**	**29.8**	**33**	**14.3**	**133**	**15**

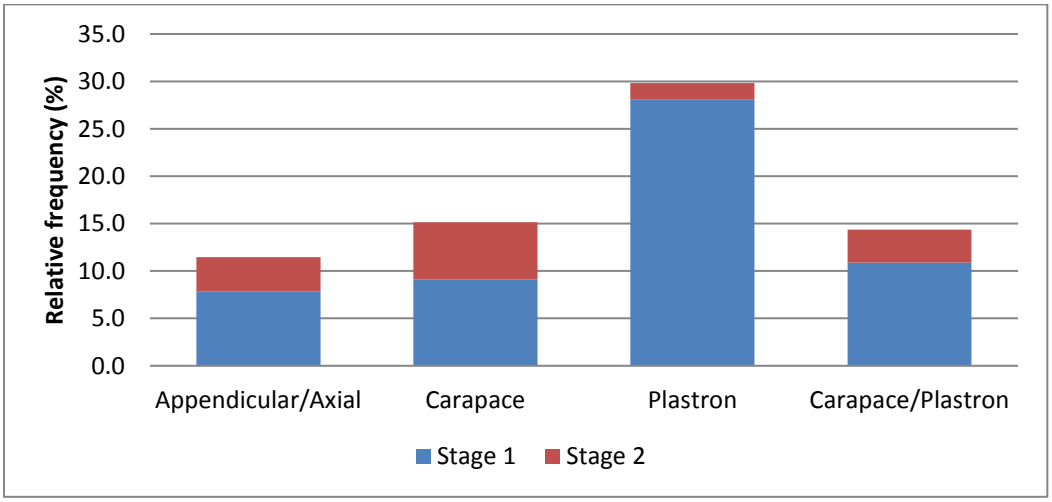


Figure 6.161. Weathering intensity in chelonian parts from Profle Four

Table 6.90. Weathering in chelonia appendicular and axial elements from Profile Four

	Stage 1		Stage 2		Totals	
	N	**%**	**N**	**%**	**N**	**%**
Scapula	2	66.6	1	33.3	**3**	**30**
Humerus	2	66.6	1	33.3	**3**	**7.3**
Radius	4	80	1	20	**5**	**23.8**
Ulna	2	100	-	-	**2**	**18.2**
Ilium	5	100	-	-	**5**	**20.8**
Ischium	2	100	-	-	**2**	**25**
Femur	5	50	5	50	**10**	**31.3**
Distal phalange	2	66.6	1	33.3	**3**	**8.6**
Vertebra	-	-	1	100	**1**	**7.1**
Long bone fragment	2	50	2	50	**4**	**33.3**
Total	**26**	**68.4**	**12**	**31.6**	**38**	**11.4**

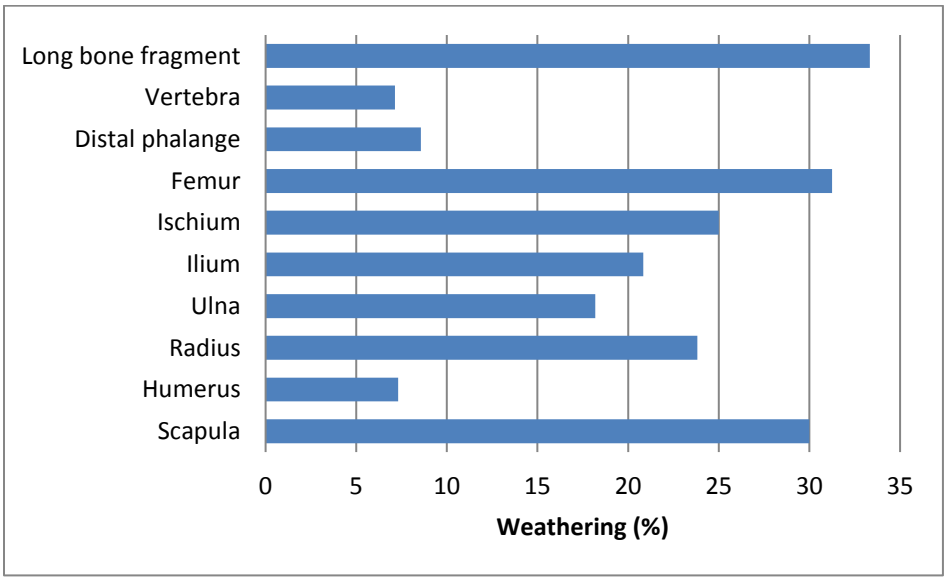


Figure 6.162. Relative frequency of weathering in chelonia appendicular and axial elements from Profile Four

Table 6.91. Weathering and body size class in chelonia shell remains from Profile Four

	Size Class 1		Size Class 2		Size Class 3		Size Class 4		Total	
	N	%	**N**	%	**N**	%	**N**	%	**N**	%
Stage 1	12	6.3	24	11.5	19	19.4	13	22.4	**68**	**12.3**
Stage 2	2	1.1	10	4.8	8	8.2	7	12.1	**27**	**4.9**
Total	**14**	**7.4**	**34**	**16.3**	**27**	**27.6**	**20**	**34.5**	**95**	**17.1**

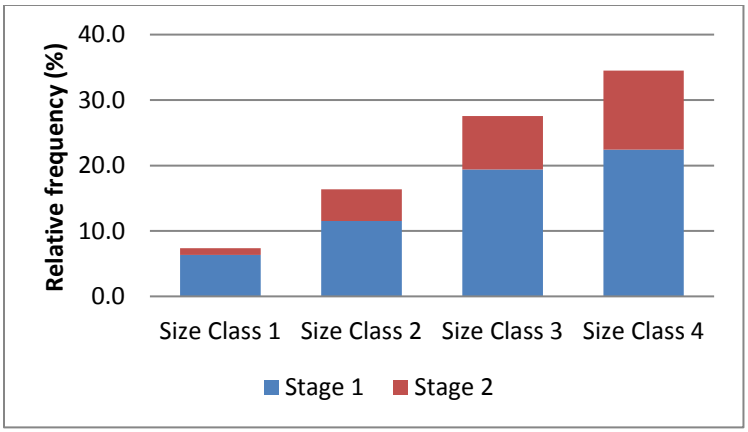


Figure 6.163. Weathering intensity with body size class in chelonia shell remains from Profile Four

Table 6.92. Burning intensity in chelonia parts from Profile Four

	Appendicular/Axial		Carapace		Carapace/Plastron		Total	
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Stage 1	10	3	6	2.2	2	0.9	**18**	**2**
Stage 2	11	3.3	7	2.6	15	6.5	**33**	**3.7**
Stage 3	5	1.5	1	0.4	4	1.7	**10**	**1.1**
Stage 4	-	-	1	0.4	4	1.7	**5**	**0.6**
Stage 5	1	0.3	-	-	-	-	**1**	**0.1**
Total	**27**	**8.1**	**15**	**5.6**	**25**	**10.9**	**67**	**7.6**

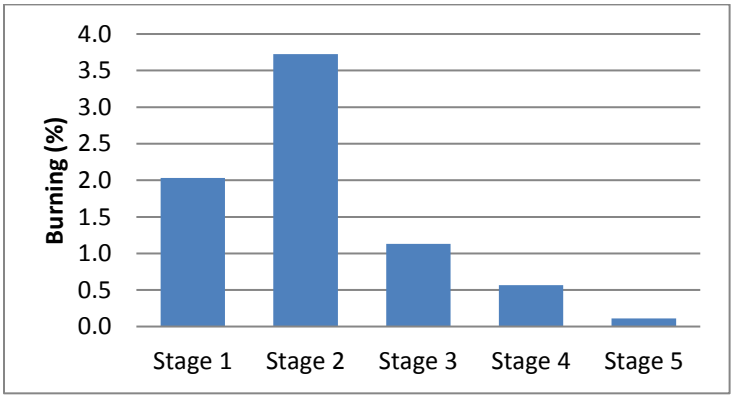


Figure 6.164. Burning intensity in chelonian remains

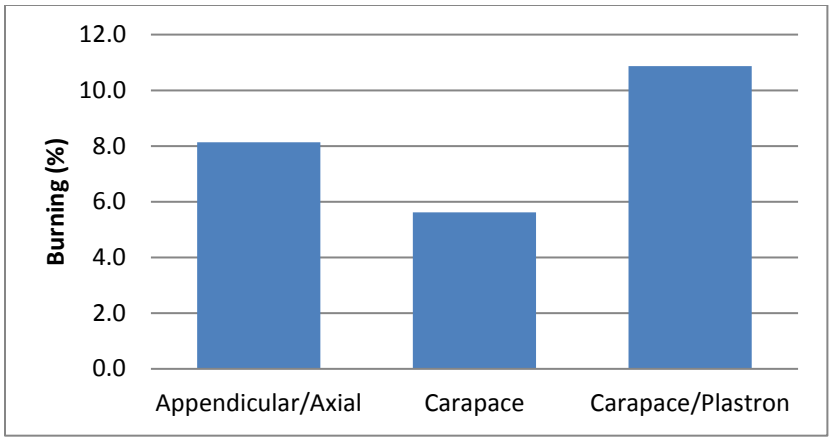


Figure6.165. Relative frequency of burning in chelonia parts from Profile Four

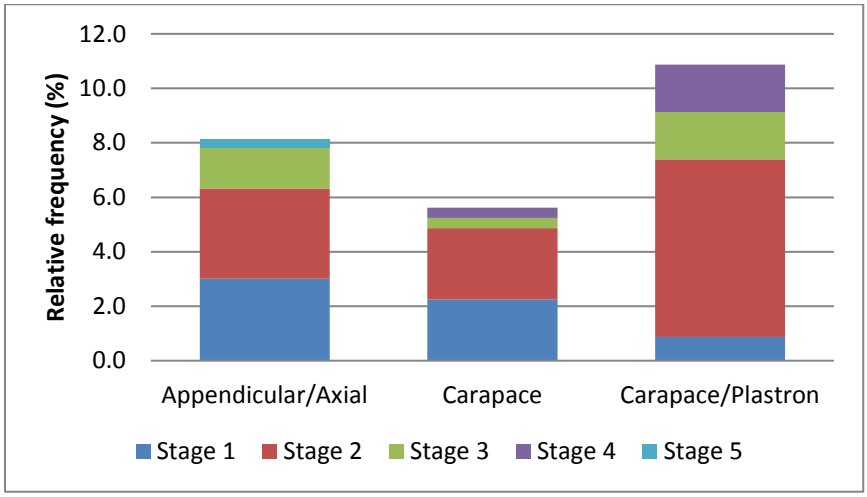


Figure 6.166. Intensity burning in chelonia parts from Profile Four

Figure 6.93. Burning modification and body size class in chelonia remains from Profile Four

	Stage 1		Stage 2		Stage 3		Stage 5		Totals	
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Humerus	4	44.4	3	33.3	1	11.1	1	11.1	**9**	**22.0**
Radius	2	66.6	1	33.3	-	-	-	-	**3**	**14.3**
Ulna	-	-	1	100	-	-	-	-	**1**	**9.1**
Ilium	-	-	1	50	1	50	-	-	**2**	**8.3**
Femur	1	25	2	50	1	25	-	-	**4**	**12.5**
Tibia	1	33.3	-	-	2	66.6	-	-	**3**	**14.3**
Fibula	1	100	-	-	-	-	-	-	**1**	**5.3**
Distal phalange	1	50	1	50	-	-	-	-	**2**	**5.7**
Phalange	-	-	1	100	-	-	-	-	**1**	**1.4**
Vertebra	-	-	1	100	-	-	-	-	**1**	**7.1**
Total	**10**	**37**	**11**	**40.7**	**5**	**18.5**	**1**	**3.7**	**27**	**8.1**

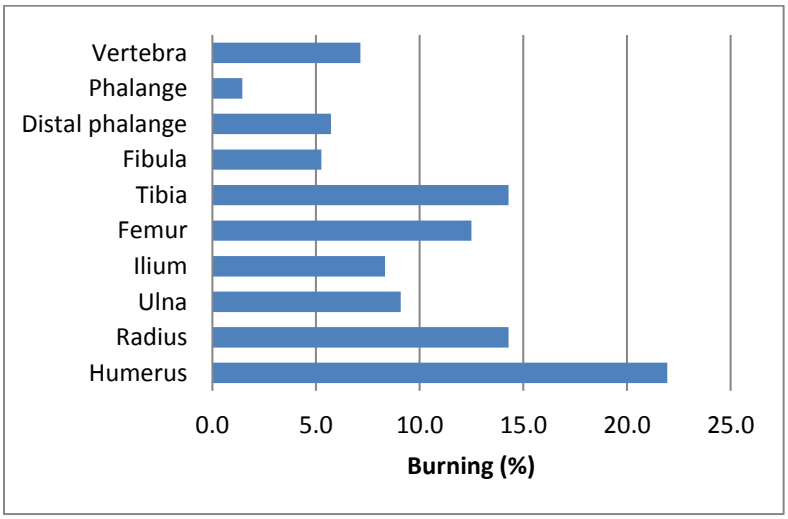


Figure 6.167. Burning in chelonia appendicular and axial remains from Profile Four

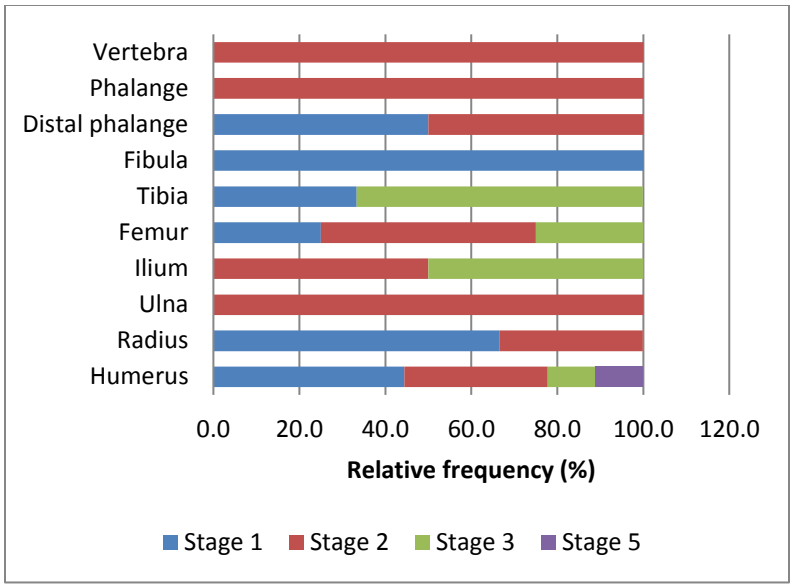


Figure 6.168. Burning intensity in chelonia appendicular remains from Profile Four

Table 6.94. Burning intensity with body size class in chelonia shell remains from Profile Four

	Size Class 1		Size Class 2		Size Class 3		Size Class 4		Total	
	N	%	N	%	N	%	N	%	N	%
Stage 1	2	1.1	8	3.8	7	7.1	1	1.7	**18**	**3.2**
Stage 2	8	4.2	19	9.1	6	6.1	-	-	**33**	**6**
Stage 3	1	0.5	3	1.4	6	6.1	-	-	**10**	**1.8**
Stage 4	3	1.6	2	1	-	-	-	-	**5**	**0.9**
Stage 5	-	-	1	0.5	-	-	-	-	**1**	**0.2**
Total	**14**	**7.4**	**33**	**15.9**	**19**	**19.4**	**1**	**1.7**	**67**	**12.1**

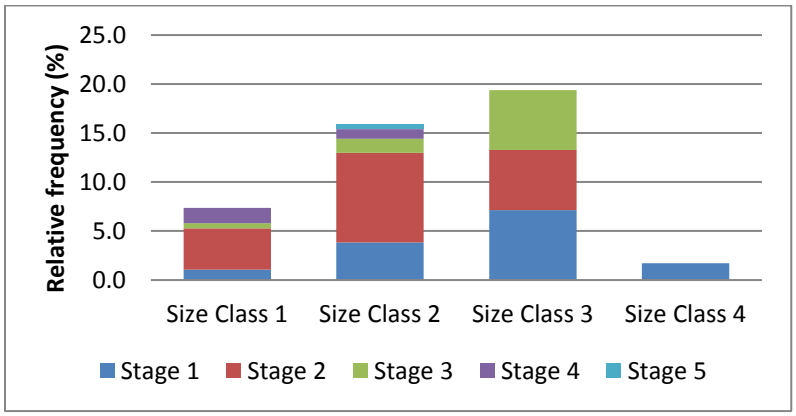


Figure 6.169. Burning intensity and body size class in chelonia shell remains from Profile Four

Table 6.95. Burning location in chelonian shell elements from Profile Four

	All Over		Outer		Inner		Totals	
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Carapace	13	86.7	-	-	2	13.3	**15**	**37.5**
Carapace/Plastron	23	92	2	8	-	-	**25**	**62.5**
Totals	**36**	**90**	**2**	**5**	**2**	**5**	**40**	

Table 6.96. Staining in chelonia remains from Profile Four

	Appendicular/Axial		Carapace		Carapace/Plastron		Total	
	N	%	**N**	%	**N**	%	**N**	**%**
Stage 1	74	22.3	97	36.3	70	30.4	**241**	**27.2**
Stage 2	17	5.1	32	12	29	12.6	**78**	**8.8**
Stage 3	11	3.3	2	0.7	3	1.3	**16**	**1.8**
Total	**102**	**30.7**	**131**	**49.1**	**102**	**44.3**	**335**	**37.8**

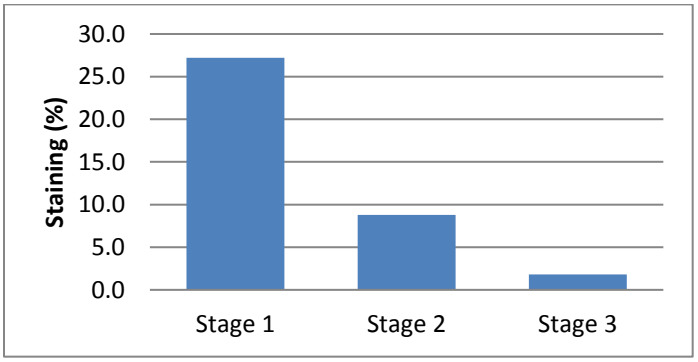


Figure 6.170. Staining intensity in chelonia remains from Profile Four

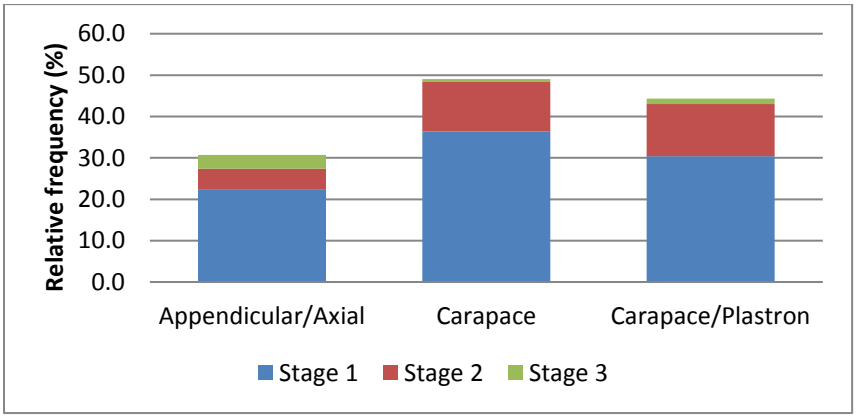


Figure 6.171. Staining intensity in chelonia parts from Profile Four

Table 6.97. Staining in chelonia appendicular and axial elements from Profile Four

	Stage 1		Stage 2		Stage 3		Totals	
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Mandible	-	-	-	-	1	100	**1**	**50**
Coracoid	1	100	-	-	-	-	**1**	**20**
Scapula	7	100	-	-	-	-	**7**	**70**
Humerus	12	80	1	6.7	2	13.3	**15**	**36.6**
Radius	5	83.3	1	16.7	-	-	**6**	**28.6**
Ulna	1	50	1	50	-	-	**2**	**18.2**
Ilium	6	75	2	25	-	-	**8**	**33.3**
Ischium	3	75	-	-	1	25	**4**	**50**
Pubis	1	33.3	2	66.6	-	-	**3**	**75**
Femur	8	66.7	2	16.7	2	16.7	**12**	**37.5**
Tibia	8	80	2	20	-	-	**10**	**47.6**
Fibula	6	75	2	25	-	-	**8**	**42.1**
Tarsal/carpal	-	-	1	100	-	-	**1**	**50**
Distal phalange	3	60	-	-	2	40	**5**	**14.3**
Phalange	5	55.6	3	33.3	1	11.1	**9**	**13**
Vertebra	4	80	-	-	1	20	**5**	**35.7**
Long bone fragment	4	80	-	-	1	20	**5**	**41.7**
Total	**74**	**72.5**	**17**	**16.7**	**11**	**10.8**	**102**	**30.7**

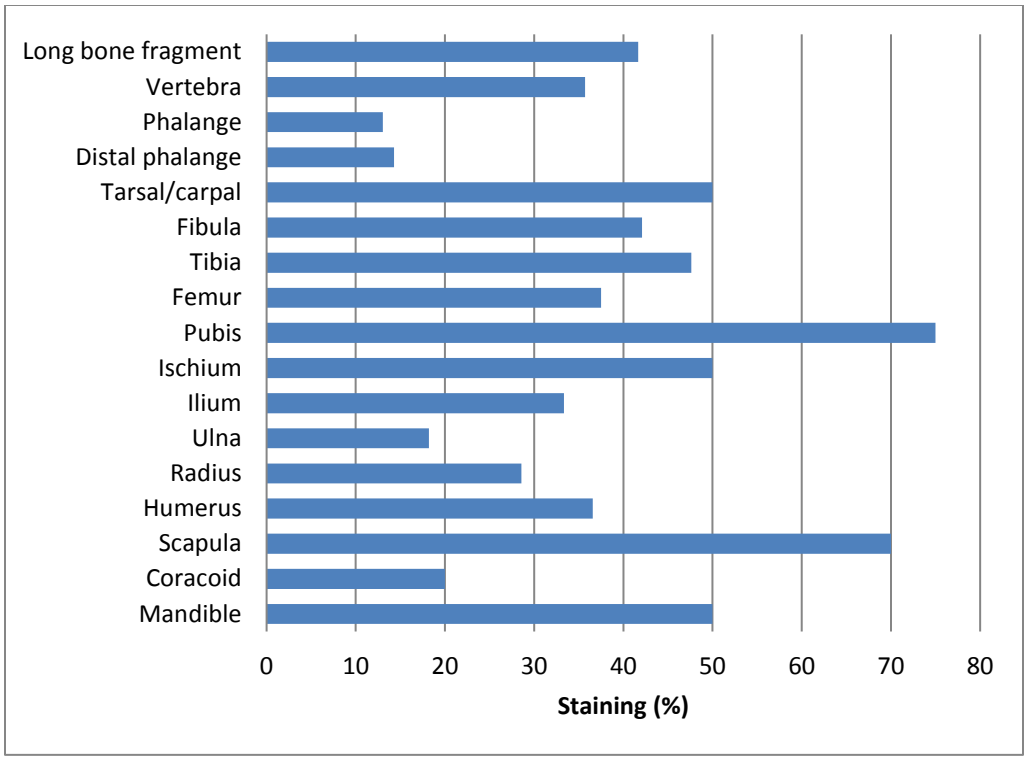


Figure 6.172. Relative frequency of staining in chelonia appendicular and axial elements from Profile Four

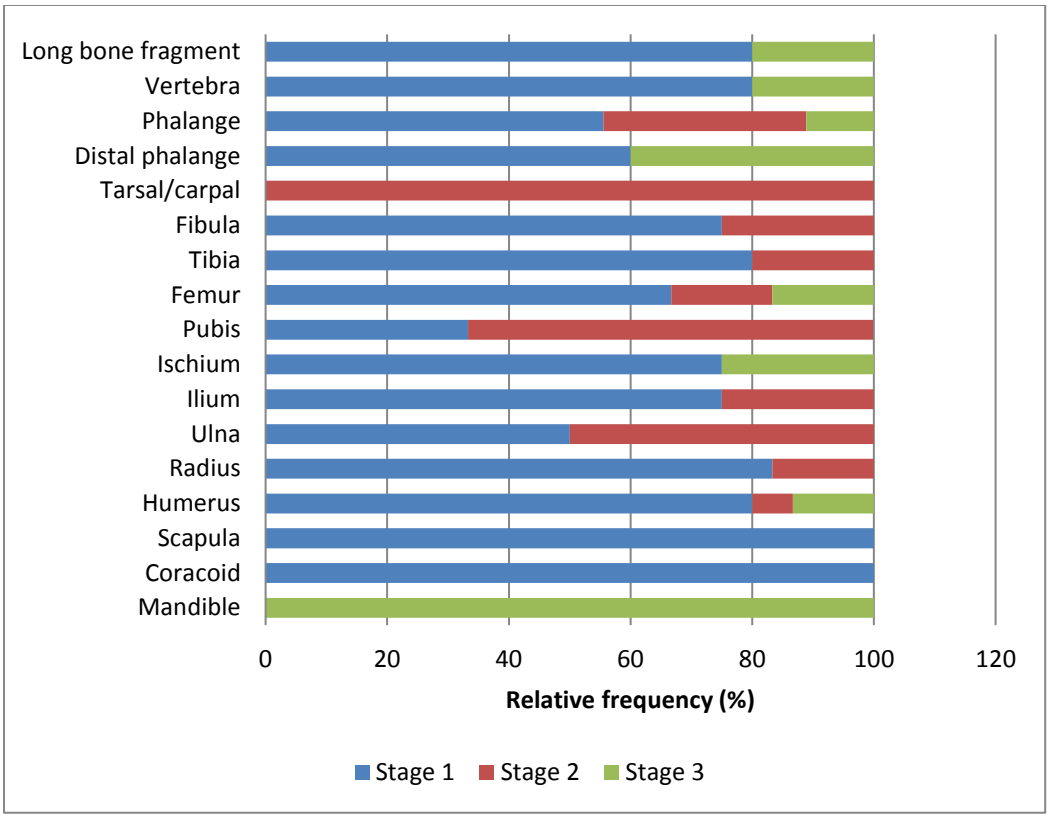


Figure 6.173. Intensity of staining in chelonia appendicular and axial elements from Profile Four

Table 6.98. Staining in chelonia shell remains from Profile Four

	Size Class 1		Size Class 2		Size Class 3		Size Class 4		Total	
	N	%	**N**	%	**N**	%	**N**	%	**N**	%
Stage 1	52	27.4	71	34.1	44	44.9	29	50	**196**	**35.4**
Stage 2	22	11.6	32	15.4	11	11.2	4	6.9	**69**	**12.5**
Stage 3	-	-	4	1.9	1	1	1	1.7	**6**	**1.1**
Total	**74**	**38.9**	**107**	**51.4**	**56**	**57.1**	**34**	**58.6**	**271**	**48.9**

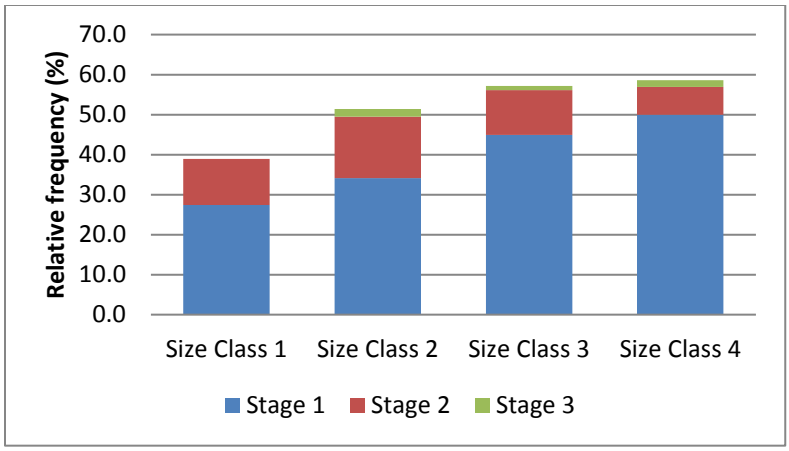


Figure 6.174. Intensity staining and body size class in chelonia shell remains from Profile Four

Table 6.99. Abrasion intensity in chelonia parts from Profile Four

	Appendicular/Axial		Carapace		Plastron		Carapace/Plastron		Total	
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Stage 1	163	49.1	103	38.6	20	35.1	83	36.1	**369**	**41.6**
Stage 2	66	19.9	71	26.6	17	29.8	58	25.2	**212**	**23.9**
Stage 3	38	11.4	28	10.5	7	12.3	54	23.5	**127**	**14.3**
Stage 4	5	1.5	3	1.1	3	5.3	8	3.5	**19**	**2.1**
Total	**272**	**81.9**	**205**	**76.8**	**47**	**82.5**	**203**	**88.3**	**727**	**82.1**

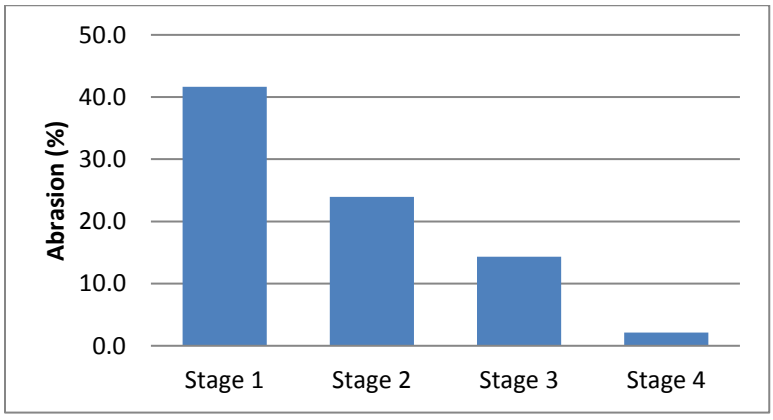


Figure 6.175. Abration intensity in chelonia remains from Profile Four

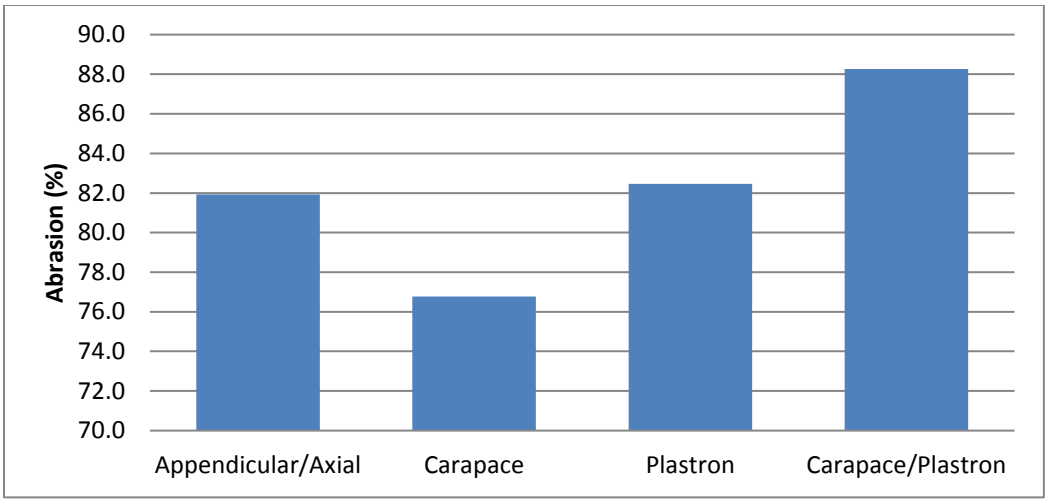


Figure 6.176. Relative frequency of abrasion in chelonia parts from Profile Four

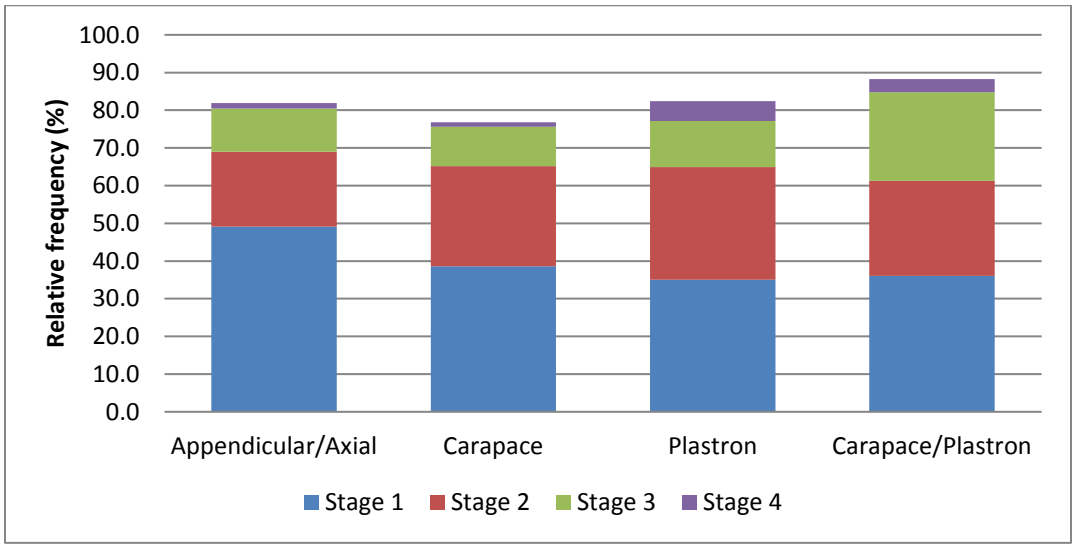


Figure 6.177. Abrasion intensity in chelonia parts from Profile Four

Table 6.100. Abrasion in chelonia appendicular and axial elements from Profile Four

	Stage 1		Stage 2		Stage 3		Stage 4		Totals	
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Mandible	1	100	-	-	-	-	-	-	**1**	**50**
Coracoid	3	75	1	25	-	-	-	-	**4**	**80**
Scapula	5	62.5	1	12.5	1	12.5	1	12.5	**8**	**80**
Humerus	16	44.4	13	36.1	6	16.7	1	2.8	**36**	**87.8**
Radius	13	81.3	3	18.8	-	-	-	-	**16**	**76.2**
Ulna	6	75	1	12.5	1	12.5	-	-	**8**	**72.7**
Ilium	11	52.4	6	28.6	4	19	-	-	**21**	**87.5**
Ischium	5	62.5	1	12.5	2	25	-	-	**8**	**100**
Pubis	3	100	-	-	-	-	-	-	**3**	**75**
Femur	14	56	6	24	4	16	1	4	**25**	**78.1**
Tibia	8	50	5	31.3	2	12.5	1	6.3	**16**	**76.2**
Fibula	9	52.9	5	29.4	3	17.6	-	-	**17**	**89.5**
Tarsal/carpal	-	-	1	100	-	-	-	-	**1**	**50**
Middle phalange	-	-	1	100	-	-	-	-	**1**	**100**
Distal phalange	20	66.7	5	16.7	5	16.7	-	-	**30**	**85.7**
Phalange	36	69.2	12	23.1	4	7.7	-	-	**52**	**75.4**
Vertebra	8	61.5	4	30.8	1	7.7	-	-	**13**	**92.9**
Long bone fragment	5	41.7	1	8.3	5	41.7	1	8.3	**12**	**100**
Total	**163**	**59.9**	**66**	**24.3**	**38**	**14**	**5**	**1.8**	**272**	**81.9**

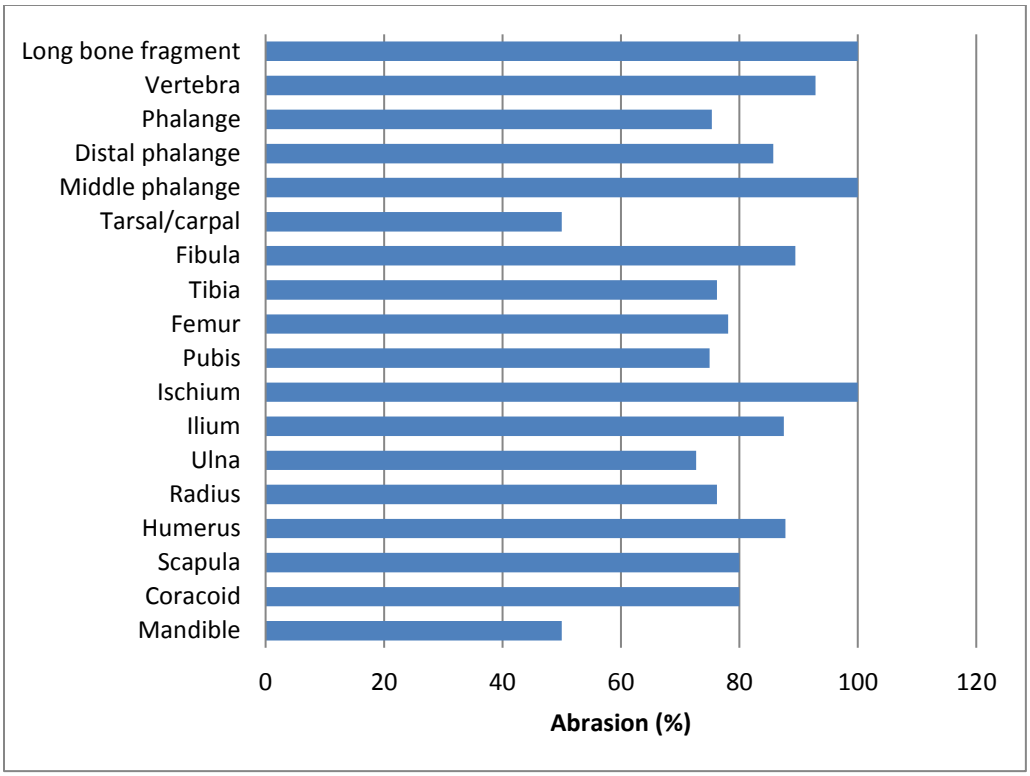


Figure 6.178. Abrasion in chelonia appendicular and axial elements from Profile Four

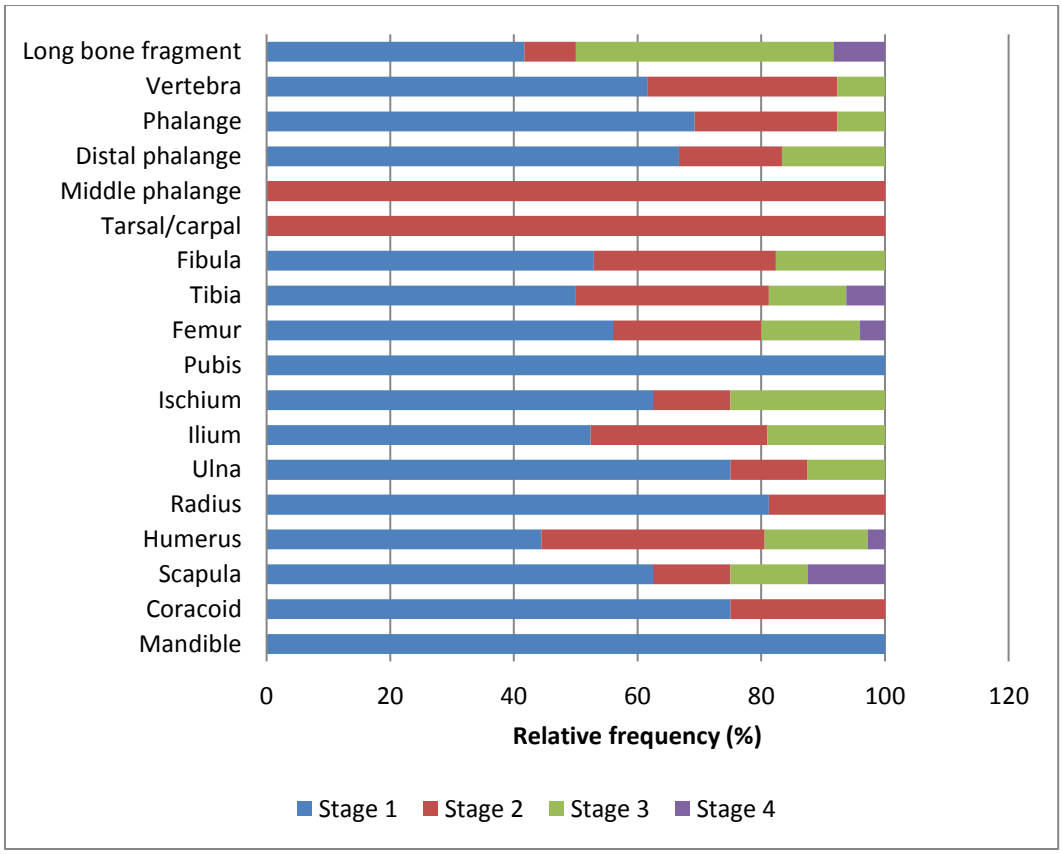


Figure 6.179. Intensity of abrasion in chelonia appendicular and axial elements from Profile Four

Table 6.101. Abrasion and body size class in chelonia shell remains from Profile Four

	Size Class 1		Size Class 2		Size Class 3		Size Class 4		Total	
	N	%	**N**	%	**N**	%	**N**	%	**N**	%
Stage 1	94	49.5	75	36.1	21	21.4	16	27.6	**206**	**37.2**
Stage 2	44	23.2	66	31.7	23	23.5	13	22.4	**146**	**26.4**
Stage 3	22	11.6	34	16.3	18	18.4	15	25.9	**89**	**16.1**
Stage 4	1	0.5	3	1.4	6	6.1	3	5.2	**13**	**2.3**
Total	**161**	**84.7**	**178**	**85.6**	**68**	**69.4**	**47**	**81**	**454**	**81.9**

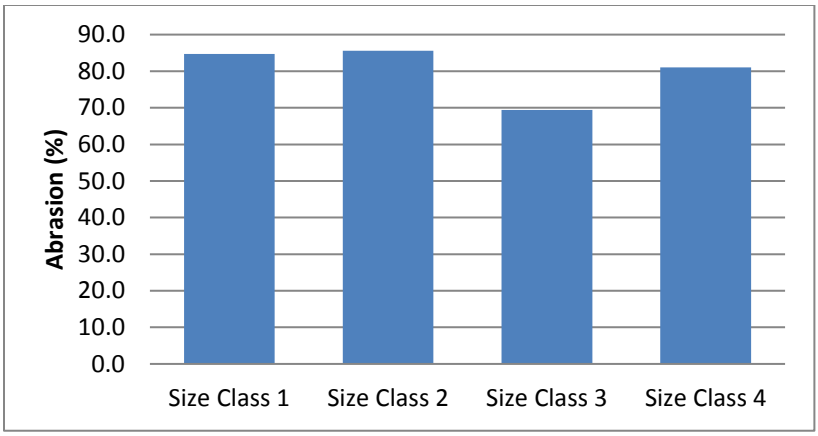


Figure 6.180. Relative frequency of abrasion by body size class in chelonia shell remains from Profile Four

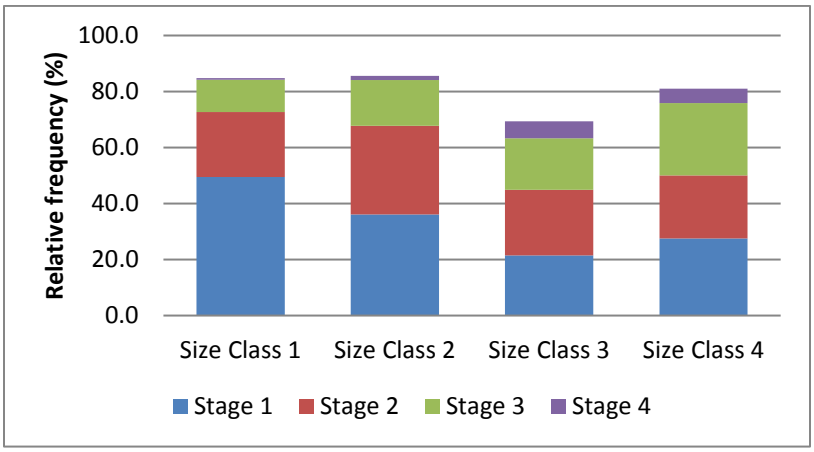


Figure 6.181. Abrasion intensity by body size class in chelonia shell remains from Profile Four

Table 6.102. Sheen intensity in chelonia parts from Profile Four

	Appendicular/Axial		Carapace		Plastron		Carapace/Plastron		Total	
	N	%	**N**	%	**N**	%	**N**	%	**N**	**%**
Stage 1	55	16.6	33	12.4	7	12.3	37	16.1	**132**	**14.9**
Stage 2	21	6.3	6	2.2	3	5.3	9	3.9	**39**	**4.4**
Stage 3	13	3.9	3	1.1	-	-	5	2.2	**21**	**2.4**
Total	**89**	**26.8**	**42**	**15.7**	**10**	**17.5**	**51**	**22.2**	**192**	**21.7**

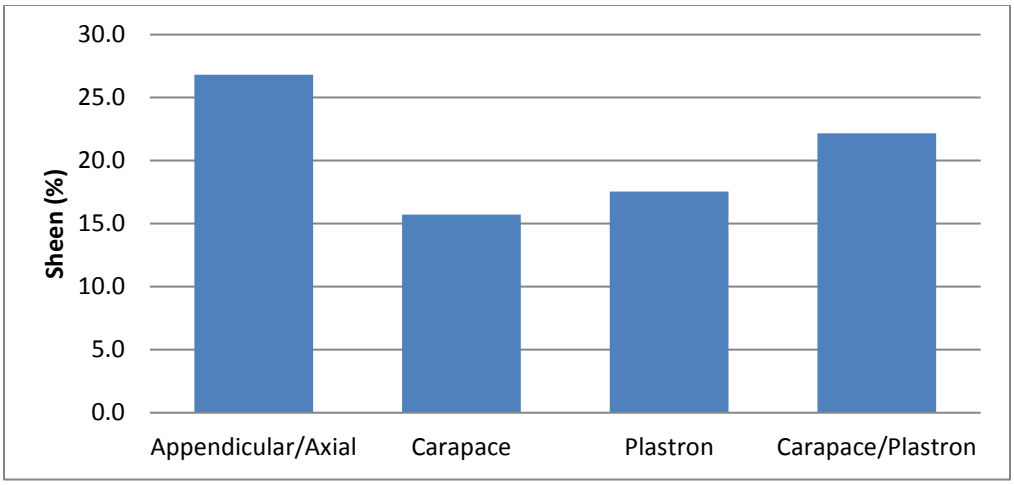


Figure 6.182. Relative frequency of sheen in tortoise parts from Profile Four

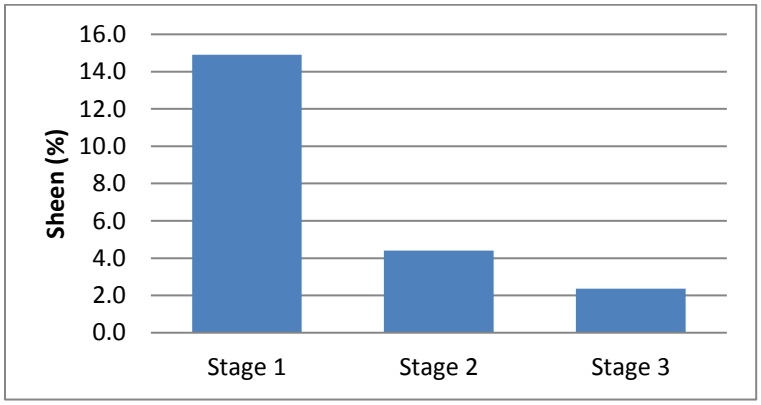


Figure 6.183. Intensity of sheen in chelonia remains from Profile Four

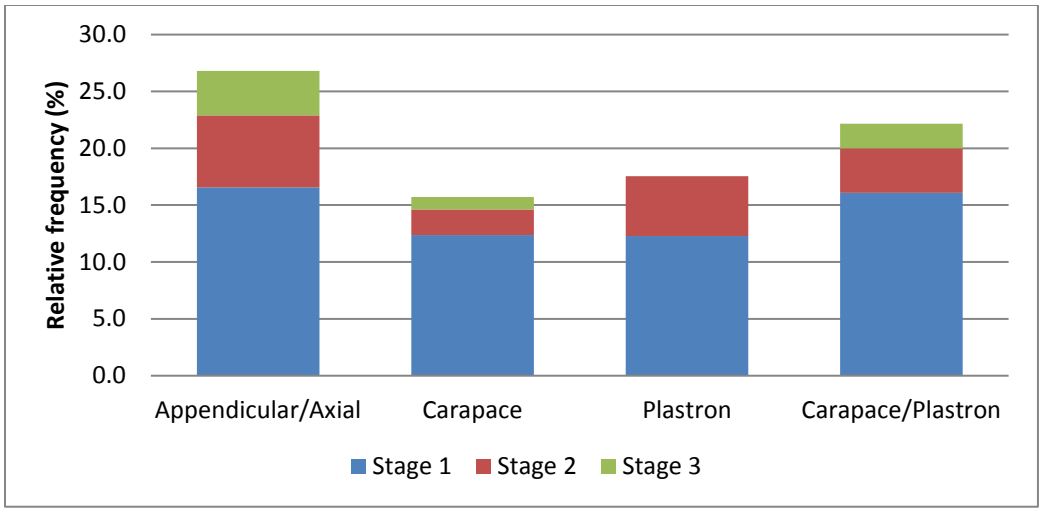


Figure 6.184. Intensity of sheen in chelonia parts from Profile Four

Table 6.103. Intensity of sheen in chelonia appendicular and axial elements from Profile Four

	Stage 1		Stage 2		Stage 3		Totals	
	N	%	N	%	N	%	N	%
Mandible	1	50	1	50	-	-	**2**	**100**
Coracoid	2	100	-	-	-	-	**2**	**40**
Scapula	4	57.1	2	28.6	1	14.3	**7**	**70**
Humerus	9	69.2	-	-	4	30.8	**13**	**31.7**
Radius	8	66.7	3	25	1	8.3	**12**	**57.1**
Ulna	2	66.6	1	33.3	-	-	**3**	**27.3**
Ilium	5	41.7	5	41.7	2	16.7	**12**	**50**
Ischium	2	66.6	-	-	1	33.3	**3**	**37.5**
Pubis	2	66.6	1	33.3	-	-	**3**	**75**
Femur	7	70	-	-	3	30	**10**	**31.3**
Tibia	4	80	1	20	-	-	**5**	**23.8**
Fibula	3	42.9	3	42.9	1	14.3	**7**	**36.8**
Distal phalange	2	66.6	1	33.3	-	-	**3**	**8.6**
Phalange	1	50	1	50	-	-	**2**	**2.9**
Long bone fragment	3	60	2	40	-	-	**5**	**41.7**
Total	**55**	**61.8**	**21**	**23.6**	**13**	**14.6**	**89**	**26.8**

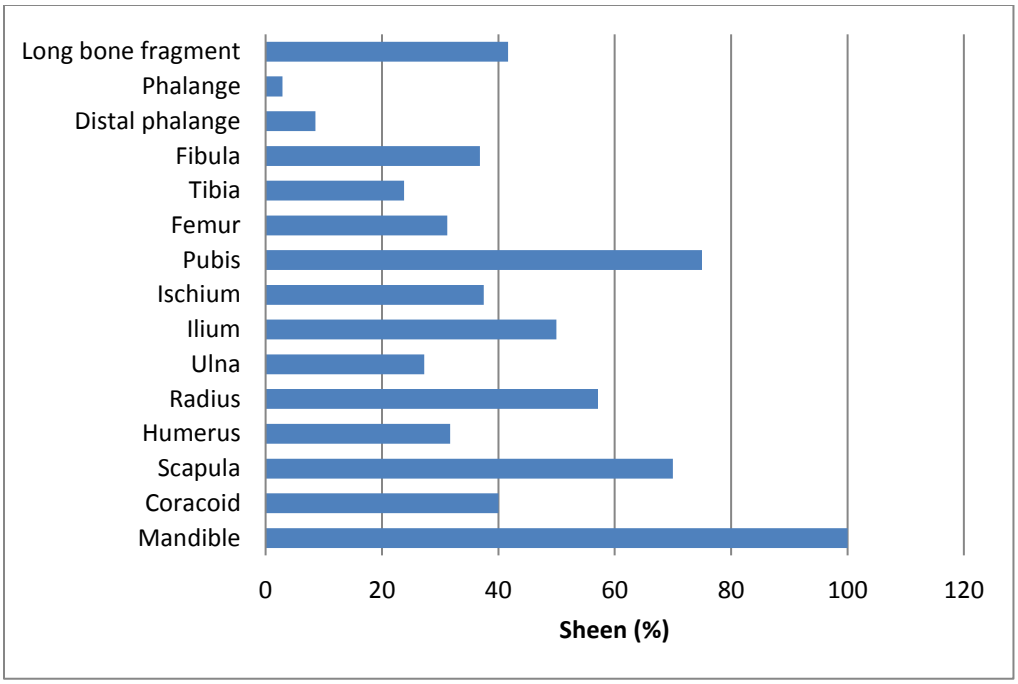


Figure 6.185. Relative frequency of sheen in chelonia appendicular and axial elements from Profile Four

Table 6.104. Sheen and body size class in chelonia shell remains from Profile Four

	Size Class 1		Size Class 2		Size Class 3		Size Class 4		Total	
	N	%	**N**	%	**N**	%	**N**	%	**N**	%
Stage 1	22	11.6	32	15.4	13	13.3	10	17.2	77	13.9
Stage 2	6	3.2	8	3.8	2	2	2	3.4	18	3.2
Stage 3	-	-	7	3.4	1	1	-	-	8	1.4
Total	28	14.7	47	22.6	16	16.3	12	20.7	103	18.6

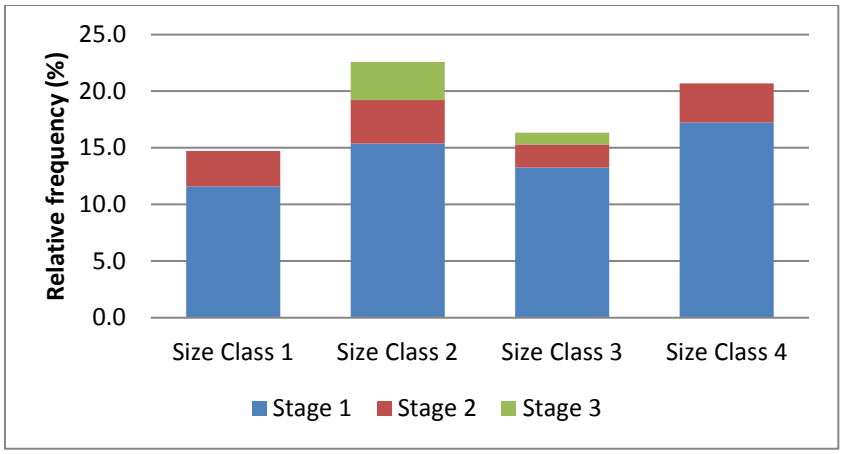


Figure 6.186. Intensity of sheen by body size class in chelonia shell remains from Profile Four

Table 6.105. Trampling in chelonia parts from Profile Four

	Appendicular/Axial		Carapace		Plastron		Carapace/Plastron		Total	
	N	%	**N**	%	**N**	%	**N**	%	**N**	**%**
Stage 1	66	19.9	69	25.8	23	40.4	57	24.8	**215**	**24.3**
Stage 2	11	3.3	4	1.5	3	5.3	16	7	**34**	**3.8**
Stage 3	-	-	1	0.4	-	-	-	-	**1**	**0.1**
Total	**77**	**23.2**	**74**	**27.7**	**26**	**45.6**	**73**	**31.7**	**250**	**28.2**

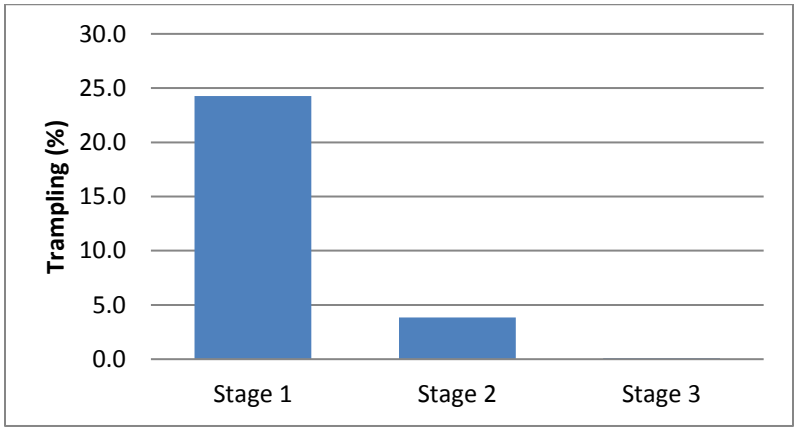


Figure 6.187. Intensity of trampling in chelonia remains from Profile Four

Table 6.106. Trampling in chelonia appendicular and axial remains from Profile Four

	Stage 1		Stage 2		Totals	
	N	**%**	**N**	**%**	**N**	**%**
Coracoid	1	100	-	-	**1**	20
Scapula	4	80	1	20	**5**	50
Humerus	10	83.3	2	16.7	**12**	29.3
Radius	9	9	1	10	**10**	47.6
Ulna	4	100	-	-	**4**	36.4
Ilium	9	90	1	10	**10**	41.7
Ischium	1	100	-	-	**1**	12.5
Pubis	1	100	-	-	**1**	25
Femur	10	83.3	2	16.7	**12**	37.5
Tibia	5	62.5	3	37.5	**8**	38.1
Fibula	5	100	-	-	**5**	26.3
Distal phalange	2	100	-	-	**2**	5.7
Phalange	1	100	-	-	**1**	1.4
Vertebra	2	100	-	-	**2**	14.3
Long bone fragment	2	66.6	1	33.3	**3**	25
Total	**66**	**19.9**	**11**	**3.3**	**77**	**23.2**

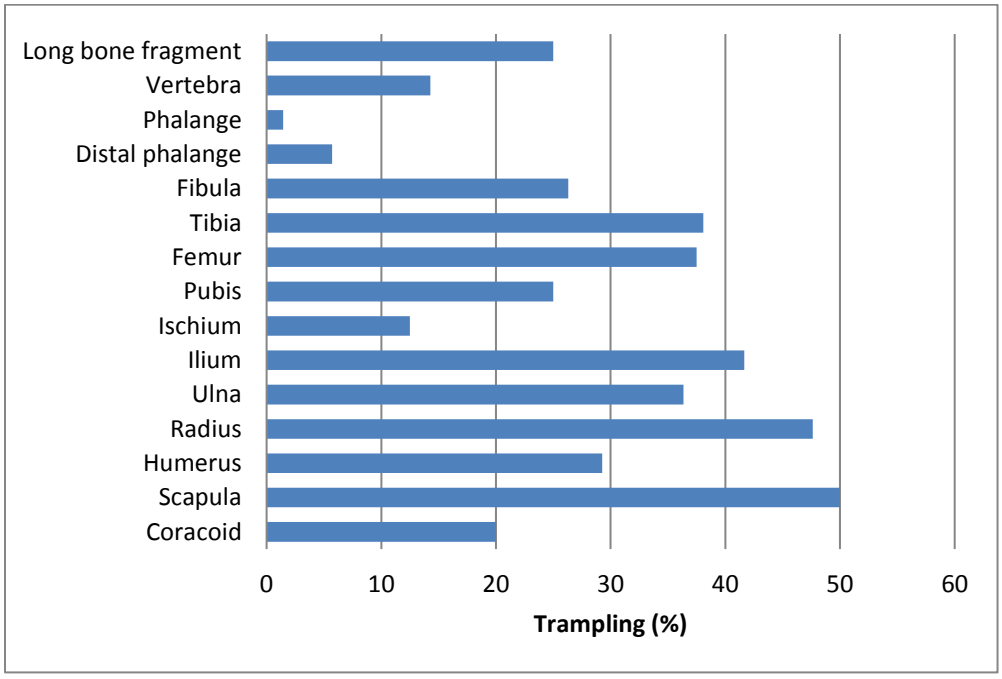


Figure 6.188. Relative frequency of trampling in chelonia appendicular and axial elements from Profile Four

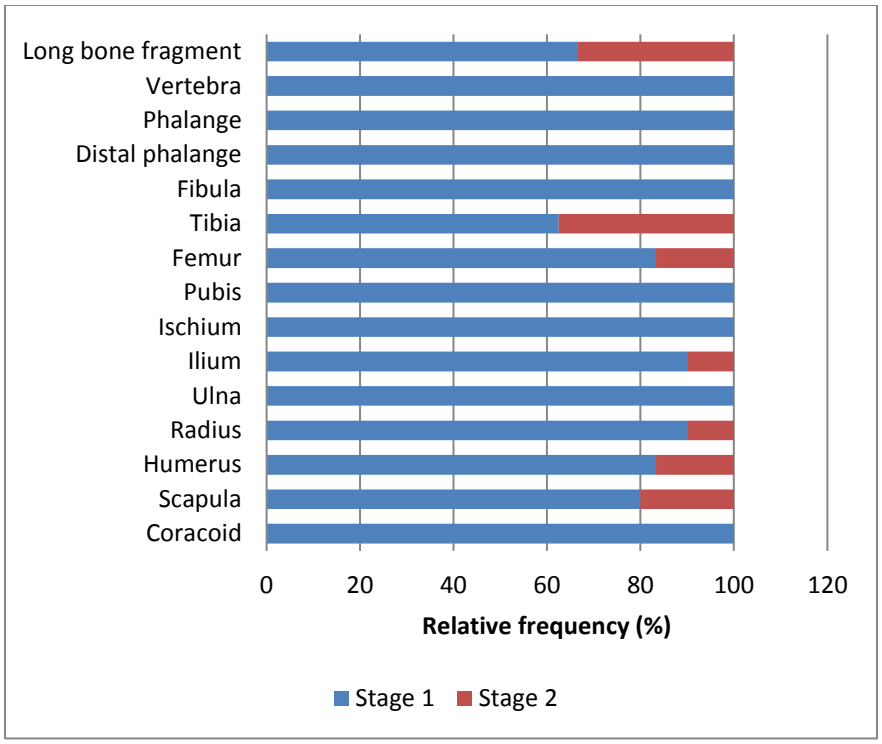


Figure 6.189. Intensity of trampling in chelonia appendicular and axial elements from Profile Four

Table 6.107. Trampling intensity and body size class in chelonia shell remains from Profile Four

	Size Class 1		Size Class 2		Size Class 3		Size Class 4		Total	
	N	%	**N**	%	**N**	%	**N**	%	**N**	%
Stage 1	29	15.3	66	31.7	32	32.7	22	37.9	**149**	**26.9**
Stage 2	5	2.6	8	3.8	4	4.1	6	10.3	**23**	**4.2**
Stage 3	-	-	-	-	-	-	1	1.7	**1**	**0.2**
Total	**34**	**17.9**	**74**	**35.6**	**36**	**36.7**	**29**	**50**	**173**	**31.2**

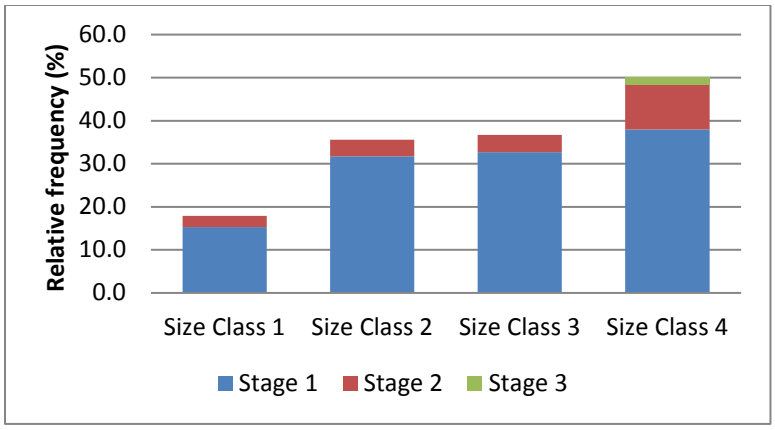


Figure 6.190. Trampling intensity and body size class in chelonia shell from Profile Four

Table 6.108. Prevalence of tooth marks in chelonia parts from Profile Four

	N	%
Appendicular/Axial	15	4.5
Carapace	13	4.9
Plastron	4	7
Carapace/Plastron	3	1.3
Total	**35**	**4**

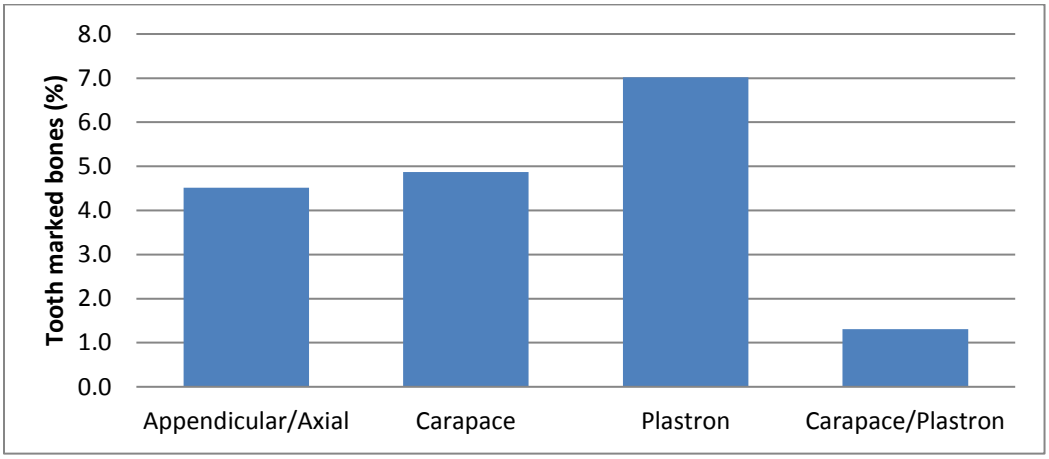


Figure 6.191. Tooth marked bones in chelonian parts from Profile Four

Table 6.109. Tooth marking in chelonia appendicular and axial remains from Profile Four

	N	%
Mandible	1	50
Scapula	2	20
Humerus	2	4.9
Radius	1	4.8
Ilium	2	8.3
Ischium	1	12.5
Femur	2	6.3
Tibia	1	4.8
Phalange	1	1.4
Vertebra	1	7.1
Long bone fragment	1	8.3
Total	**15**	**4.5**

Table 6.110. Toothed marked bones by body size class in chelonia remains from Profile Four

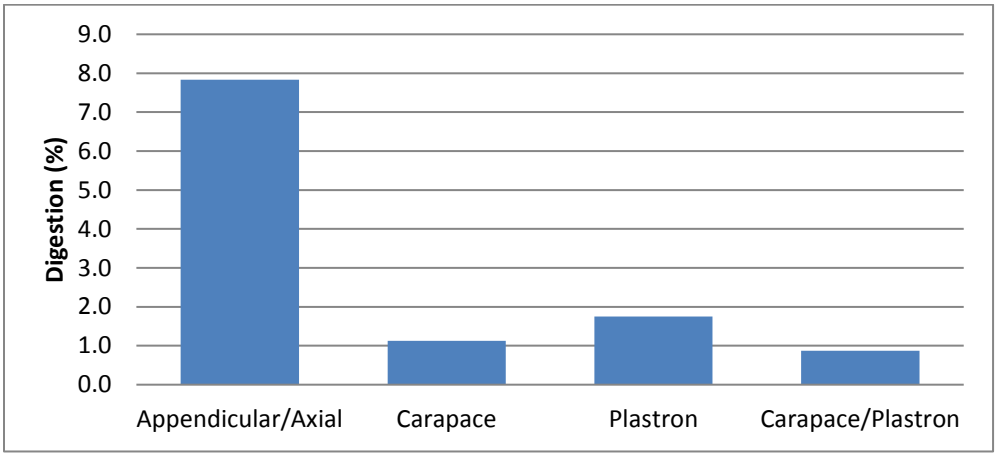
	N	%
Size Class 1	3	1.6
Size Class 2	9	4.3
Size Class 3	18	18.4
Size Class 4	5	8.6
Total	**35**	**4.0**



Figure 6.192. Relative frequency of tooth marked remains by body size class in chelonia from Profile Four

Table 6.111. Digestion in chelonia parts from Profile Four

	N	%
Appendicular/Axial	26	7.8
Carapace	3	1.1
Plastron	1	1.8
Carapace/Plastron	2	0.9
Total	**32**	**3.6**



Figrure 6.193. Digestive corrosion in chelonia parts from Profile Four

Table 6.112. Prevalence of digestive corrosion in chelonia appendicular and axial elements from Profile Four

	N	%
Coracoid	1	20
Humerus	1	2.4
Radius	1	4.8
Ilium	2	8.3
Pubis	1	25
Femur	1	3.1
Tibia	4	19
Fibula	1	5.3
Tarsal/carpal	1	50
Distal phalange	4	11.4
Phalange	8	11.6
Vertebra	1	7.1
Total	**26**	**2.9**

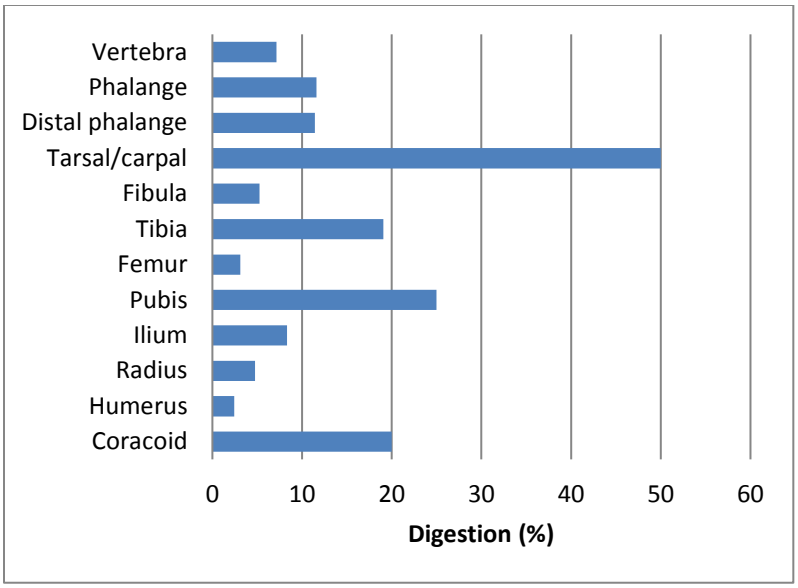


Figure 6.194. Digestive corrosion in chelonia appendicular and axial skeleton remains from Profile Four

Table 6.113. Digestion in body size class in chelonia shell remains from Profile Four

	N	%
Size Class 1	3	1.6
Size Class 2	12	5.8
Size Class 3	14	14.3
Size Class 4	3	5.2
Total	**32**	**3.6**

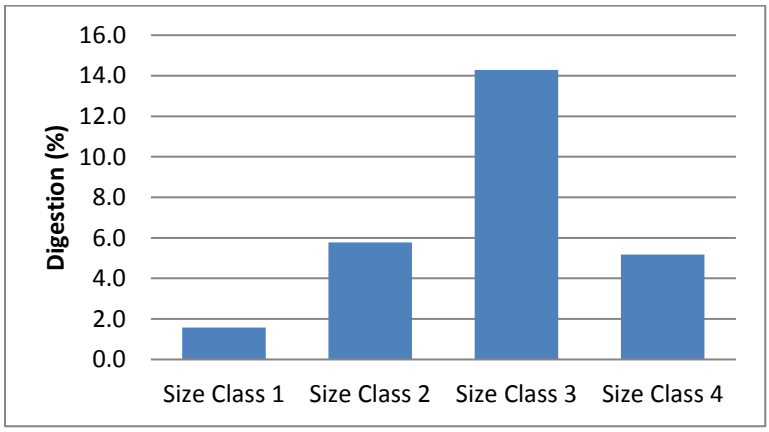


Figure 6.195. Digested remains with body size class in chelonia shell remains from Profile Four

Table 6.114. Root etching in chelonia parts from Profile Four

	Appendicular/Axial		Carapace		Plastron		Carapace/Plastron		Total	
	N	%	**N**	%	**N**	%	**N**	%	**N**	**%**
Stage 1	29	8.7	55	20.6	9	15.8	57	24.8	**150**	**16.9**
Stage 2	13	3.9	20	7.5	1	1.8	20	8.7	**54**	**6.1**
Stage 3	3	0.9	2	0.7	-	-	1	0.4	**6**	**0.7**
Total	**45**	**13.6**	**77**	**28.8**	**10**	**17.5**	**78**	**33.9**	**210**	**23.7**

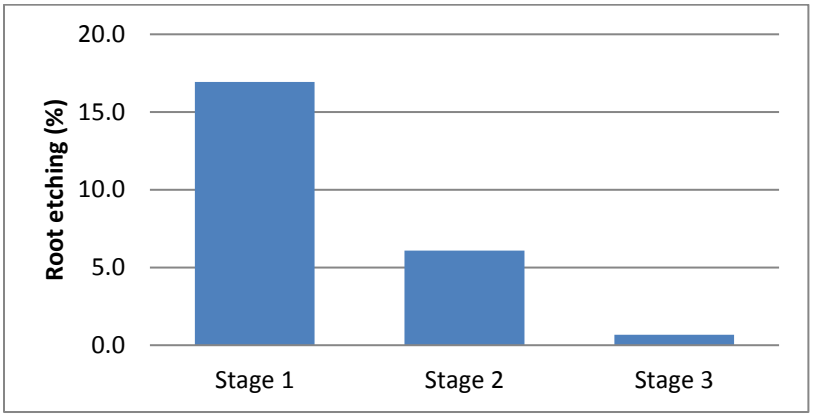


Figure 6.196. Root etching intensity in chelonia remains from Profile Four

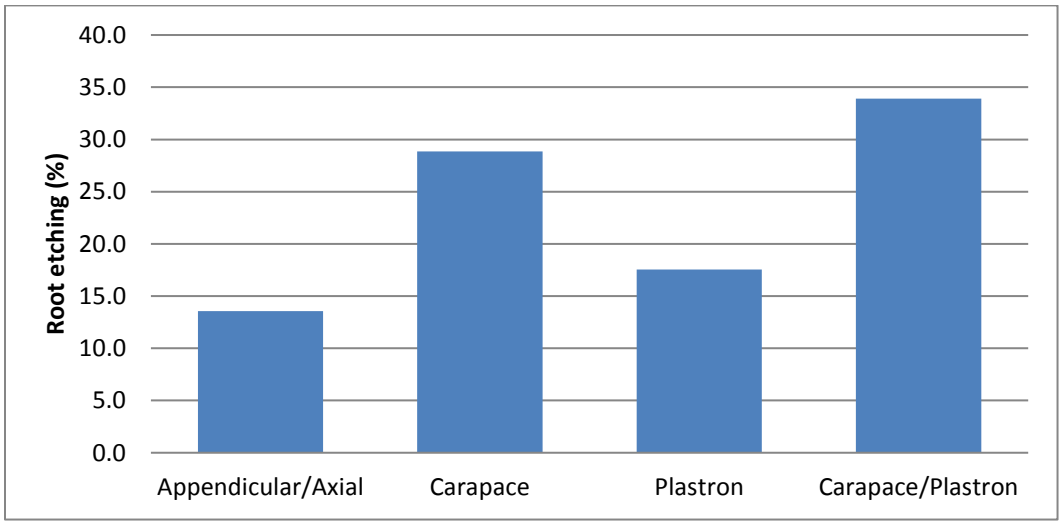


Figure 6.197. Root etching in chelonia parts from Profile Four

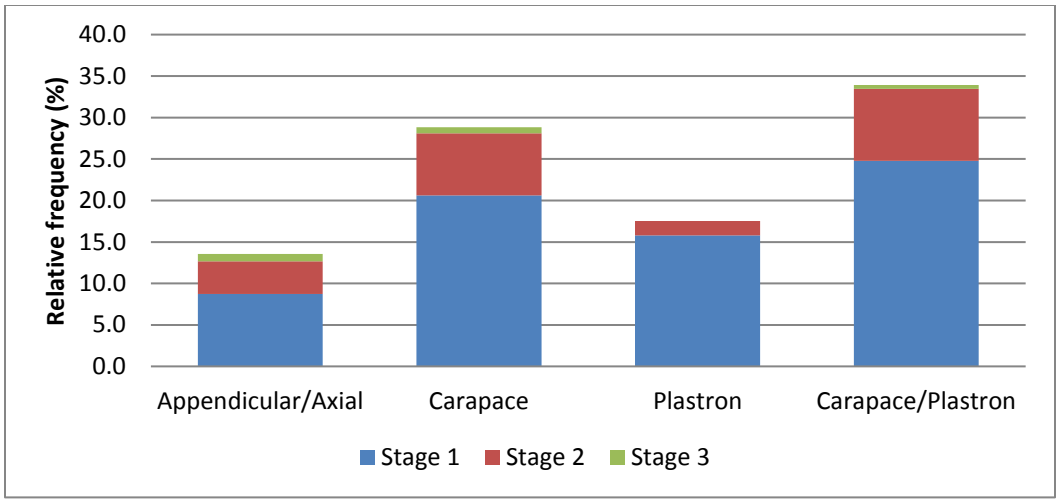


Figure 6.198. Root etching intensity in chelonia parts from Profile Four

Table 6.115. Root etching in chelonia appendicular and axial remains from Profile Four

	Stage 1		Stage 2		Stage 3		Totals	
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Coracoid	-	-	1	100	-	-	**1**	**20**
Scapula	3	100	-	-	-	-	**3**	**30**
Humerus	5	62.5	2	25	1	12.5	**8**	**19.5**
Radius	1	100	-	-	-	-	**1**	**4.8**
Ulna	1	50	1	50	-	-	**2**	**18.2**
Ilium	5	62.5	2	25	1	12.5	**8**	**33.3**
Ischium	1	50	1	50	-	-	**2**	**25**
Pubis	1	100	-	-	-	-	**1**	**25**
Femur	4	66.7	1	16.7	1	16.7	**6**	**18.8**
Tibia	2	40	3	60	-	-	**5**	**23.8**
Distal phalange	4	80	1	20	-	-	**5**	**14.3**
Phalange	1	50	1	50	-	-	**2**	**2.9**
Long bone fragment	1	100	-	-	-	-	**1**	**8.3**
Total	**29**	**8.7**	**13**	**3.9**	**3**	**0.9**	**45**	**13.6**

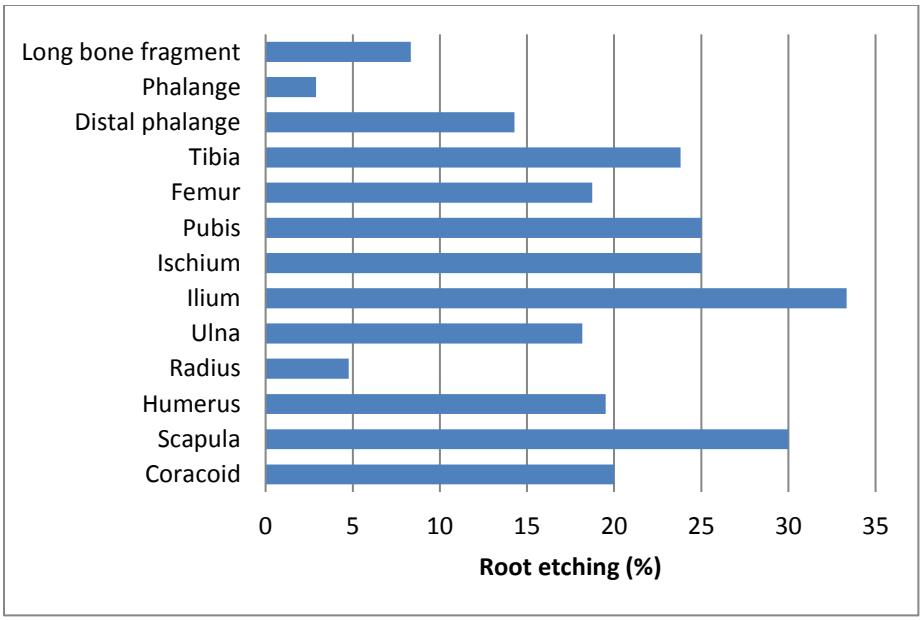


Figure 6.199. Relative frequency of root etching in chelonia appendicular and axial elements from Profile Four

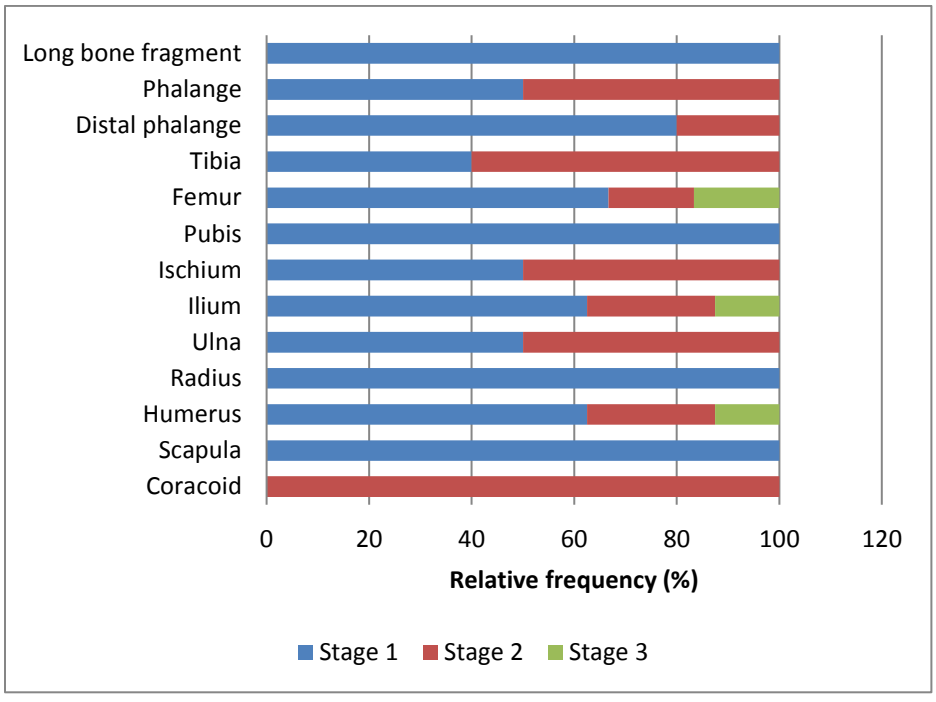


Figure 6.200. Intensity of root etching in chelonia appendicular and axial elements from Profile Four

Table 6.116. Root etching intensity and body size class in chelonia shell remains from Profile Four

	Size Class 1		Size Class 2		Size Class 3		Size Class 4		Total	
	N	%	**N**	%	**N**	%	**N**	%	**N**	%
Stage 1	35	18.4	41	19.7	33	33.7	12	20.7	**121**	**21.8**
Stage 2	8	4.2	23	11.1	4	4.1	6	10.3	**41**	**7.4**
Stage 3	-	-	1	0.5	2	2	-	-	**3**	**0.5**
Total	**43**	**22.6**	**65**	**31.25**	**39**	**39.8**	**18**	**31.0**	**165**	**29.8**

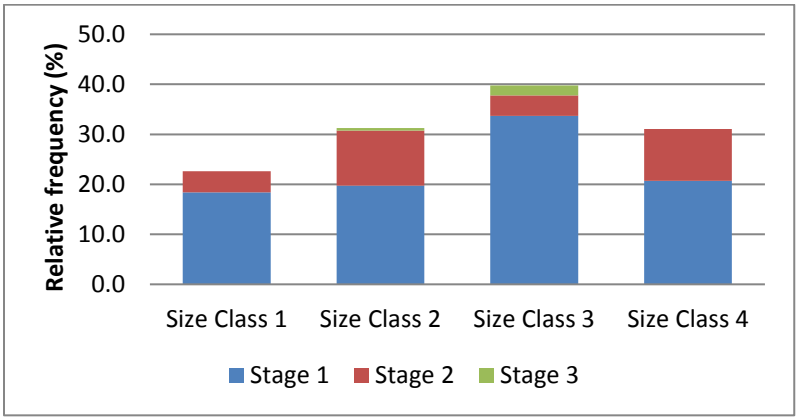


Figure 6.201. Root etching intensity by body size class in chelonia shell remains from Profile Four

Table 6.117. Species composition of aves from Profile Four

	Size Class 1		Size Class 2		Size Class 3		Size Class 4		Total	
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Ciconiidae	-	-	-	-	1	100	-	-	**1**	**2**
Phasianidae	-	-	-	-	4	100	-	-	**4**	**8.2**
Spheniscidae	-	-	-	-	-	-	1	100	**1**	**2**
Aves indet	3	7.0	10	23.3	20	46.5	10	23.3	**43**	**87.8**
Total	**3**	**6.1**	**10**	**20.4**	**25**	**51**	**11**	**22.4**	**49**	**3.1**



Figure 6.202. Relative frequency of body size class in avian remains from Profile Four

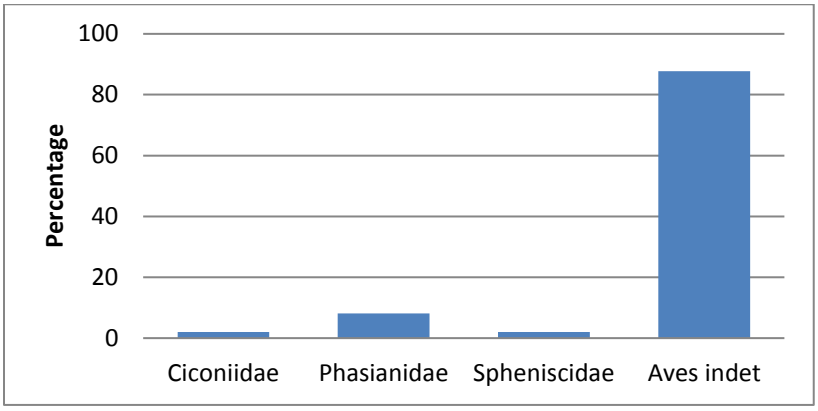


Figure 6.203. Relative frequency of avian species from Profile Four

Table 6.118. Species representation of avian remains by spit from Profile Four

	Spit2		Spit3		Spit4		Spit5		Spit6		Spit7		Spit8		Spit9		Spit10		Total	
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Ciconiidae	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	100	**1**	**2.1**
Phasianidae	-	-	-	-	2	50	-	-	-	-	1	25	-	-	1	25	-	-	**4**	**8.5**
Spheniscidae	-	-	-	-	-	-	-	-	-	-	-	-	1	100	-	-	-	-	**1**	**2.1**
Aves indet	1	2.3	6	14	6	14	8	18.6	2	4.7	4	9.3	10	23.3	4	9.3	2	4.7	**43**	**91.5**
Total	**1**	**2.1**	**6**	**12.8**	**8**	**17**	**8**	**17**	**2**	**4.3**	**5**	**10.6**	**11**	**23.4**	**5**	**10.6**	**3**	**6.4**	**49**	**3.1**

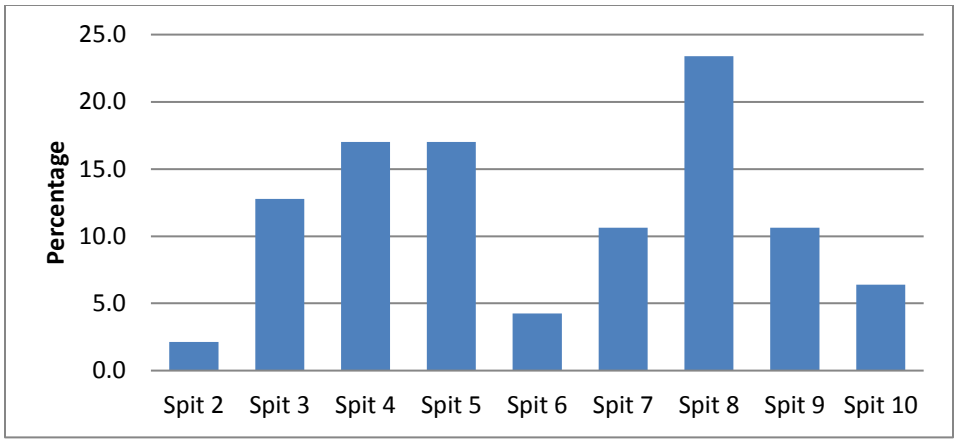


Figure 6.204. Relative frequency of avian remains by spit from Profile Four

Table 6.119. Skeletal element frequencies in avian remains from Profile Four

	Element	NISP	MNE	MAU	%MAU	MNI
Spheniscidae	Ulna	1	1	1	33.3	1
Ciconiidae	Tibia	1	1	1	33.3	1
Phasianidae	Coracoid	2	2	2	66.6	2
	Humerus	1	1	1	33.3	1
	Ulna	1	1	1	33.3	1
Aves indet	Coracoid	4	3	3	100	3
	Scapula	1	1	1	33.3	1
	Humerus	4	3	2	66.6	2
	Radius	2	2	2	66.6	2
	Ulna	3	2	3	100	3
	Innominate	1	1	1	33.3	1
	Tibiotarsus	7	3	2	66.6	2
	Tarsometatarsus	7	2	2	66.6	2
	Tarsal/Carpal	1	1	1	33.3	1
	Cervical vertebra	3	3	2	66.6	2
	Thoracic vertebra	2	2	2	66.6	2
	Synsacrum	1	1	1	33.3	1
	Vertebra	3	2	2	66.6	2
	Long bone fragment	4	2	2	66.6	2
	Total	**49**				**7**

Table 6.120. Anatomical composition of aves from Profile Four

		Size Class 1		Size Class 2		Size Class 3		Size Class 4		Total	
	Element	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Spheniscidae	Ulna	-	-	-	-	-	-	1	100	**1**	**2**
Ciconiidae	Tibia	-	-	-	-	1	100	-	-	**1**	**2**
Phasianidae	Coracoid	-	-	-	-	2	100	-	-	**2**	**4.1**
	Humerus	-	-	-	-	1	100	-	-	**1**	**2**
	Ulna	-	-	-	-	1	100	-	-	**1**	**2**
Aves indet	Coracoid	1	25	2	50	1	25	-	-	**4**	**8.2**
	Scapula	-	-	-	-	1	100	-	-	**1**	**2**
	Humerus	-	-	2	50	2	50	-	-	**4**	**8.2**
	Radius	-	-	-	-	1	50	1	50	**2**	**4.1**
	Ulna	-	-	-	-	1	33.3	2	66.6	**3**	**6.1**
	Innominate	-	-	1	100	-	-	-	-	**1**	**2**
	Tibiotarsus	-	-	3	42.9	3	42.9	1	14.3	**7**	**14.3**
	Tarsometatarsus	-	-	-	-	4	57.1	3	42.9	**7**	**14.3**
	Tarsal/Carpal	-	-	-	-	-	-	1	100	**1**	**2**
	Cervical vertebra	1	33.3	-	-	2	66.6	-	-	**3**	**6.1**
	Thoracic vertebra	-	-	1	50	1	50	-	-	**2**	**4.1**
	Synsacrum	-	-	-	-	1	100	-	-	**1**	**2**
	Vertebra	1	33.3	1	33.3	1	33.3	-	-	**3**	**6.1**
	Long bone fragment	-	-	-	-	2	50	2	50	**4**	**8.2**
	Total	**3**	**6.1**	**10**	**20.4**	**25**	**51.0**	**11**	**22.4**	**49**	

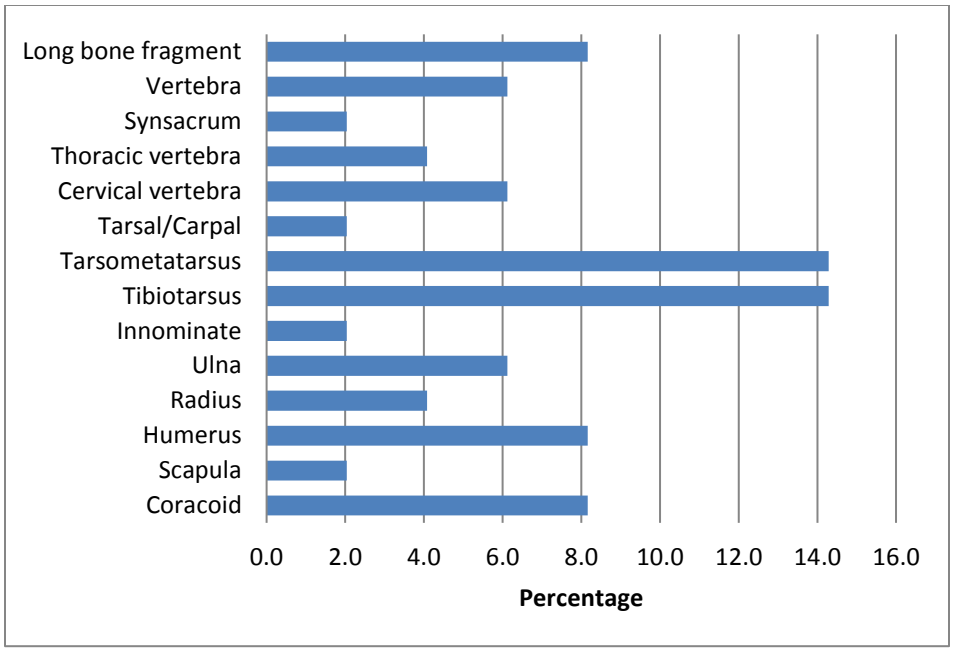


Figure 6.205. Relative frequency of skeletal elements in avian remains from Profile Four

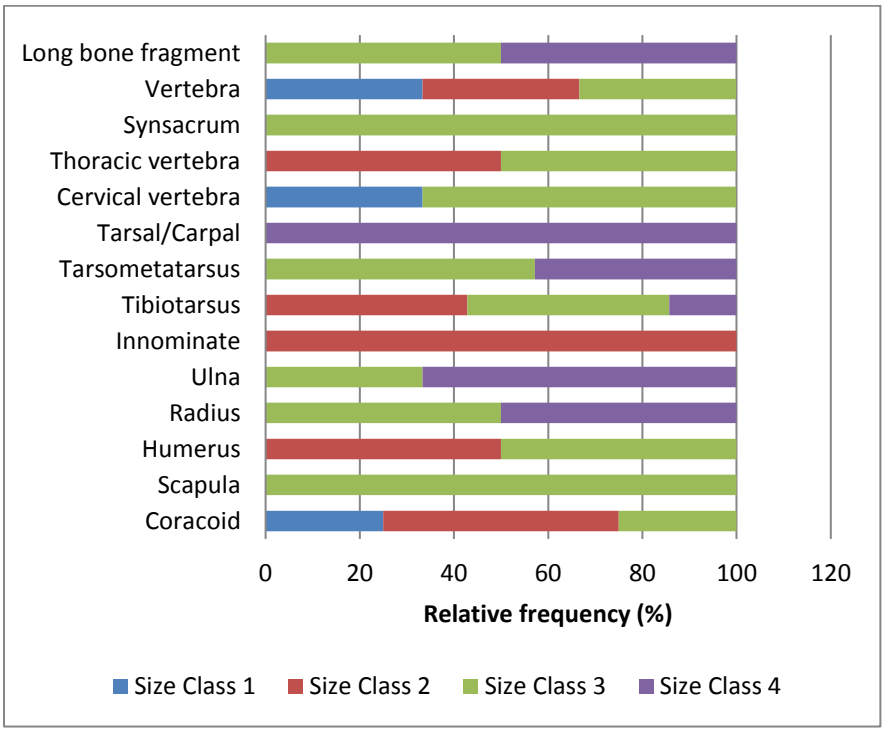


Figure 6.206. Body size class and skeletal element in aves remains from Profile Four

Table 6.121. Anatomical composition with spit in avian remains from Profile Four

		Spit 2		Spit 3		Spit 4		Spit 5		Spit 6		Spit 7		Spit 8		Spit 9		Spit 10		Total	
Taxon	**Element**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Spheniscidae	Ulna	-	-	-	-	-	-	-	-	-	-	-	-	1	100	-	-	-	-	**1**	**2**
Ciconiidae	Tibia	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	100	**1**	**2**
Phasianidae	Coracoid	-	-	-	-	2	100	-	-	-	-	-	-	-	-	-	-	-	-	**2**	**4.1**
	Humerus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	100	-	-	**1**	**2**
	Ulna	-	-	-	-	-	-	-	-	-	-	1	100	-	-	-	-	-	-	**1**	**2**
Aves indet	Coracoid	1	25	2	50	-	-	-	-	1	25	-	-	-	-	-	-	-	-	**4**	**8.2**
	Scapula	-	-	-	-	1	100	-	-	-	-	-	-	-	-	-	-	-	-	**1**	**2**
	Humerus	-	-	-	-	-	-	2	50	-	-	2	50	-	-	-	-	-	-	**4**	**8.2**
	Radius	-	-	-	-	-	-	-	-	-	-	-	-	1	50	1	50	-	-	**2**	**4.1**
	Ulna	-	-	-	-	2	66.6	-	-	-	-	-	-	-	-	-	-	1	33.3	**3**	**6.1**
	Innominate	-	-	1	100	-	-	-	-	-	-	-	-	-	-	-	-	-	-	**1**	**2**
	Tibiotarsus	-	-	-	-	2	28.6	1	14.3	1	14.3	-	-	3	42.9	-	-	-	-	**7**	**14.3**
	Tarsometatarsus	-	-	2	28.6	-	-	2	28.6	-	-	-	-	1	14.3	2	28.6	-	-	**7**	**14.3**
	Tarsal/Carpal	-	-	-	-	-	-	1	100	-	-	-	-	-	-	-	-	-	-	**1**	**2**
	Cervical vertebra	-	-	-	-	-	-	-	-	-	-	-	-	2	66.6	-	-	1	33.3	**3**	**6.1**
	Thoracic vertebra	-	-	-	-	-	-	1	50	-	-	1	50	-	-	-	-	-	-	**2**	**4.1**
	Synsacrum	-	-	-	-	-	-	-	-	-	-	-	-	1	100	-	-	-	-	**1**	**2**
	Vertebra	-	-	1	33.3	-	-	1	33.3	-	-	1	33.3	-	-	-	-	-	-	**3**	**6.1**
	Long bone fragment	-	-	-	-	1	25	-	-	-	-	-	-	2	50	1	25	-	-	**4**	**8.2**
	Total	**1**	**2**	**6**	**12.2**	**8**	**16.3**	**8**	**16.3**	**2**	**4.1**	**5**	**10.2**	**11**	**22.4**	**5**	**10.2**	**3**	**6.1**	**49**	

Table 6.122. Descriptive statistics of maximum specimen length in avian remains from Profile Four

N	47
Minimum	9
Maximum	44
Mean	18.4
Standard Deviation	7.95

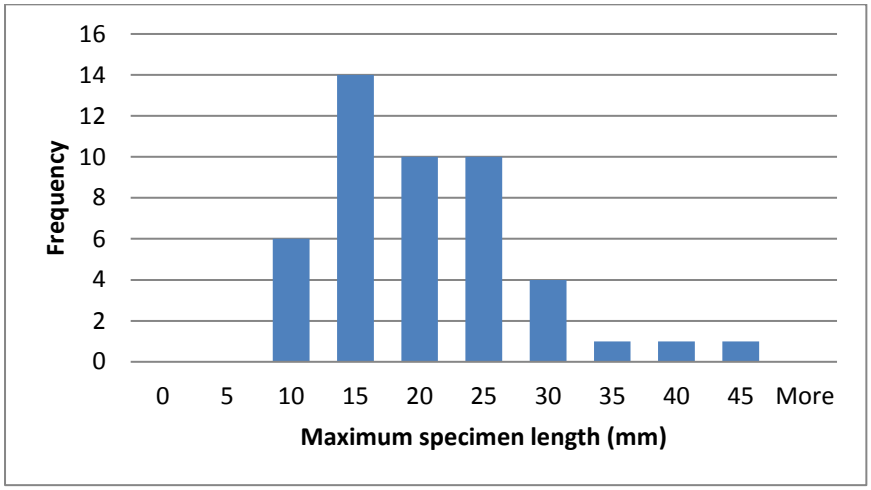


Figure 6.207. Histogram of maximum specimen length in avian remains from Profile Four

Table 6.123. Completeness in avian remains from Profile Four

	Size Class 3		Size Class 4		Total	
	N	**%**	**N**	**%**	**N**	**%**
Ulna	**-**	**-**	1	10	**1**	**33.3**
Tibia	1	100	-	**-**	**1**	**33.3**
Tarsal/Carpal	-	-	1	100	**1**	**33.3**
Total	**1**	**50**	**1**	**50**	**3**	**6.1**

Table 6.124. Breakage classes in avian remains from Profile Four

		Complete		Proximal		Shaft		Distal	
		N	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Spheniscidae	Ulna	1	100	-	-	-	-	-	-
Ciconiidae	Tibia	1	100	-	-	-	-	-	-
Phasianidae	Humerus	-	-	1	100	-	-	-	-
	Ulna	-	-	-	-	-	-	1	100
Aves indet.	Humerus	-	-	1	33.3	-	-	2	66.6
	Radius	-	-	2	100	-	-	-	-
	Ulna	-	-	-	-	1	33.3	2	66.6
	Tibiotarsus	-	-	1	14.3	3	42.9	3	42.9
	Tarsometatarsus	-	-	2	33.3	-	-	4	66.7
	Total	**2**	**8**	**7**	**28**	**4**	**16**	**12**	**48**

		Dorsal		Shaft	
		N	**%**	**N**	**%**
Phasianidae	Coracoid	2	100	-	-
Aves indet.	Coracoid	3	66.6	1	33.3
	Scapula	1	50	1	50
	Innominate	1	100	-	-
	Total	**7**	**77.8**	**2**	**22.2**

		Complete		Centrum		Fragmentary	
		N	**%**	**N**	**%**	**N**	**%**
Aves indet.	Cervical vertebra	1	100	-	-	-	-
	Thoracic vertebra	-	-	-	-	2	100
	Synsacrum	-	-	-	-	1	100
	Vertebra	-	-	1	33.3	2	66.6
	Total	**1**	**14.3**	**1**	**14.3**	**5**	**71.4**

		Complete		Fragmentary	
		N	**%**	**N**	**%**
Aves indet.	Tarsal/Carpal	1	100	-	-
	Long bone fragment	-	-	4	100
	Total	**1**	**20**	**4**	**80**

Table 6.125. Fracture outline in avian remains from Profile Four

	Spiral (fresh)		Transverse (dry)		Eroded		Total	
	N	%	N	%	N	%	N	%
Size Class 1	1	50	-	-	-	-	**1**	**50**
Size Class 2	7	50	-	-	1	7.1	**8**	**57.1**
Size Class 3	18	47.4	3	7.9	-	-	**21**	**55.3**
Size Class 4	8	40	1	5	-	-	**9**	**45**
Total	**34**	**87.2**	**4**	**10.3**	**1**	**2.6**	**39**	**52.7**

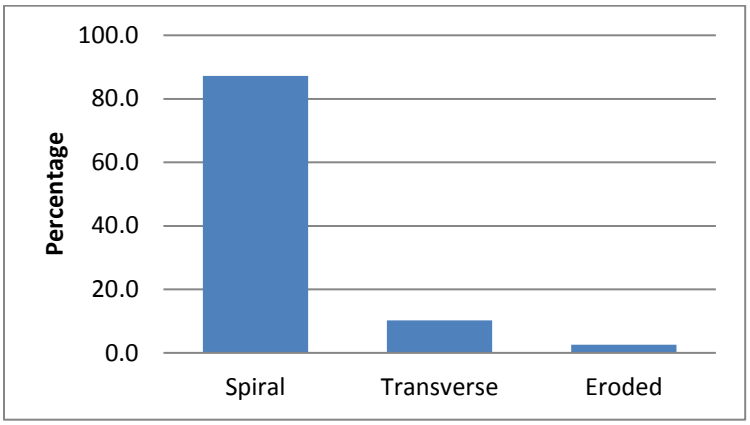


Figure 6.208. Fracture outline type in avian remains from Profile Four

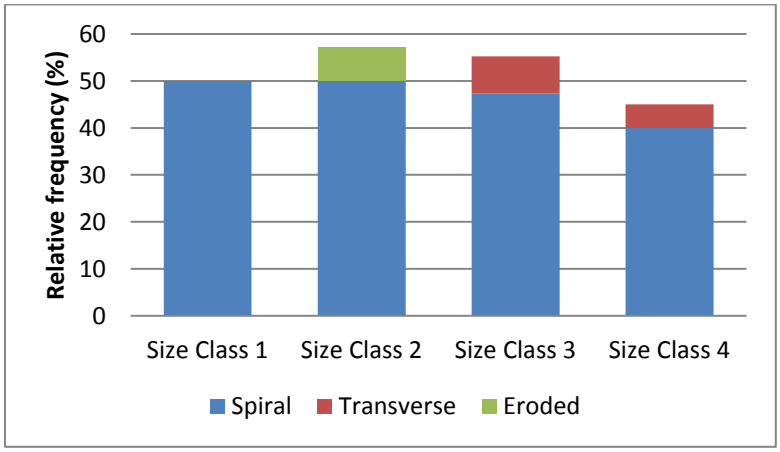


Figure 6.209. Fracture outline and body size class in avian remains from Profile Four

Table 6.126. Fracture outline and spit in avian remains from Profile Four

	Spiral (fresh)		Transverse (dry)		Eroded		Total	
	N	%	N	%	N	%	N	%
Spit 2	1	50	-	-	-	-	**1**	**50**
Spit 3	4	50	-	-	-	-	**4**	**50**
Spit 4	6	42.9	2	14.3	-	-	**8**	**57.1**
Spit 5	5	50	2	20	-	-	**7**	**70**
Spit 6	2	50	-	-	1	25	**3**	**75**
Spit 7	3	50	-	-	-	-	**3**	**50**
Spit 8	7	43.75	-	-	-	-	**7**	**43.8**
Spit 9	5	50	-	-	-	-	**5**	**50**
Spit 10	1	25	-	-	-	-	**1**	**25**
Total	**34**	**87.2**	**4**	**10.3**	**1**	**2.6**	39	

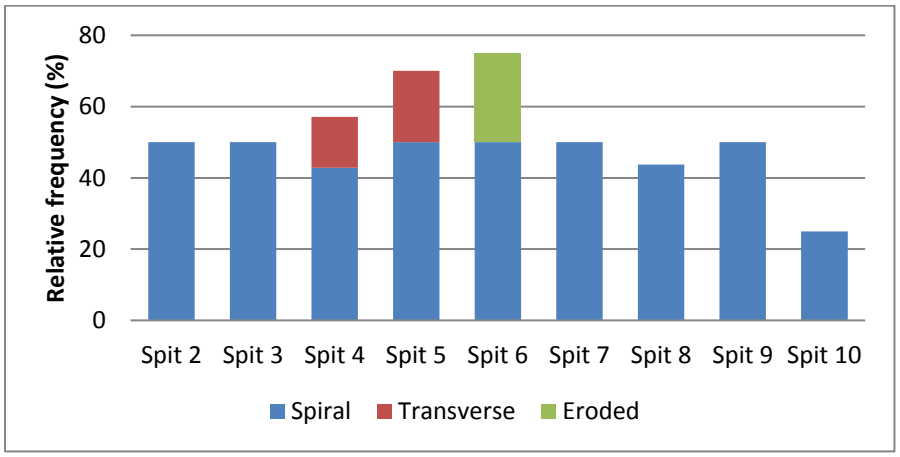


Figure 6.210. Fracture outline by spit in avian remains from Profile Four

Table 6.127. Fracture angle in avian remains from Profile Four

	Oblique		Right		Mixed		Total	
	N	%	N	%	N	%	N	%
Size Class 1	-	-	1	50	-	-	**1**	**50**
Size Class 2	4	28.6	1	7.1	3	21.4	**8**	**57.1**
Size Class 3	8	21.1	5	13.2	10	26.3	**23**	**60.5**
Size Class 4	-	-	2	10	8	40	**10**	**50**
Total	**12**	**28.6**	**9**	**21.4**	**21**	**50**	**42**	**56.8**

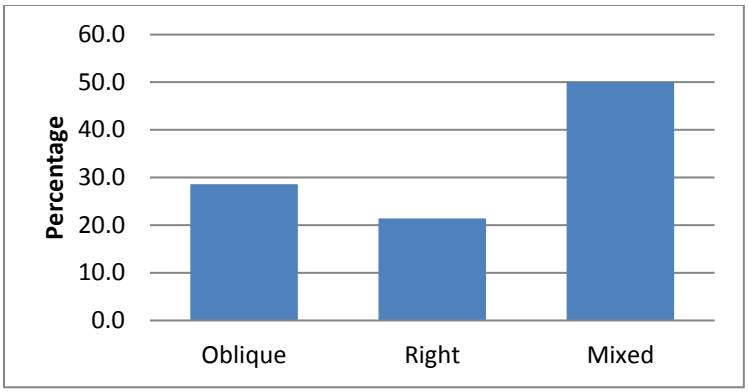


Figure 6.211. Fracture angle type in avian remains from Profile Four



Figure 6.212. Fracture angle and body size class in avian remains from Profile Four

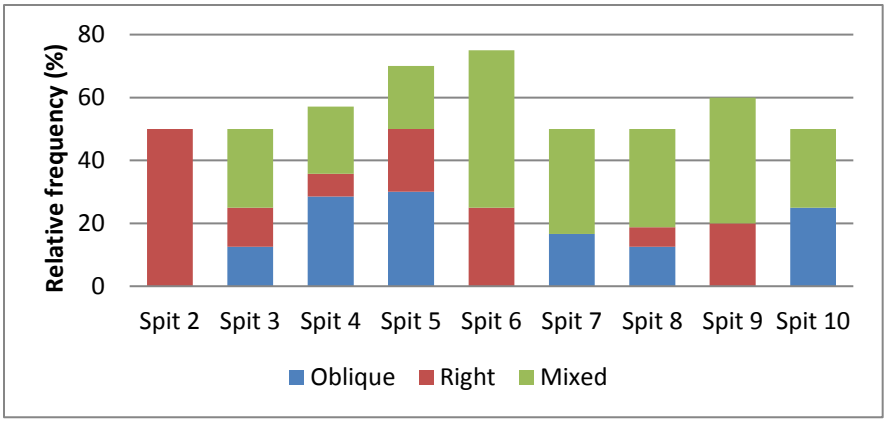


Figure 6.213. Fracture angle and spit in avian remains from Profile Four

Table 6.128. Staining in avian remains from Profile Four

	Size Class 1		Size Class 2		Size Class 3		Size Class 4		Total	
	N	%	**N**	%	**N**	%	**N**	%	**N**	%
Stage 1	1	33.3	-	-	4	16	-	-	**5**	**10.2**
Stage 2	-	-	2	20	3	12	1	9.1	**6**	**12.2**
Stage 3	-	-	4	40	2	8	3	27.3	**9**	**18.4**
Stage 4	-	-	-	-	2	8	-	-	**2**	**4.1**
Total	**1**	**33.3**	**6**	60	**11**	44	**4**	36.4	**22**	**44.9**

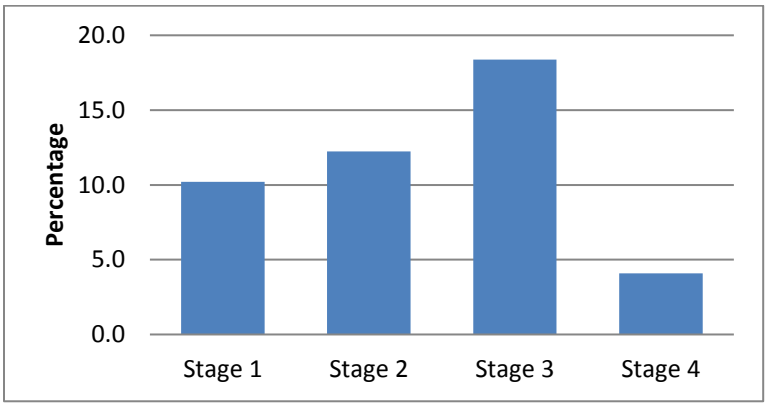


Figure 6.214. Intensity of staining in avian remains from Profile Four

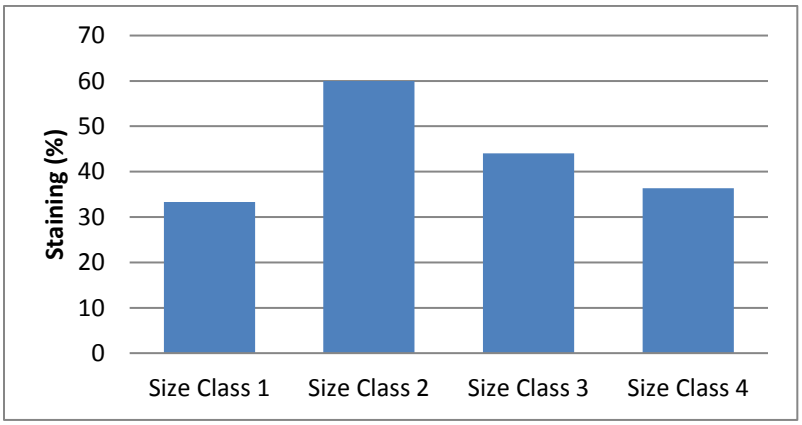


Figure 6.215. Relative frequency of staining by body size class in avian remains from Profile Four

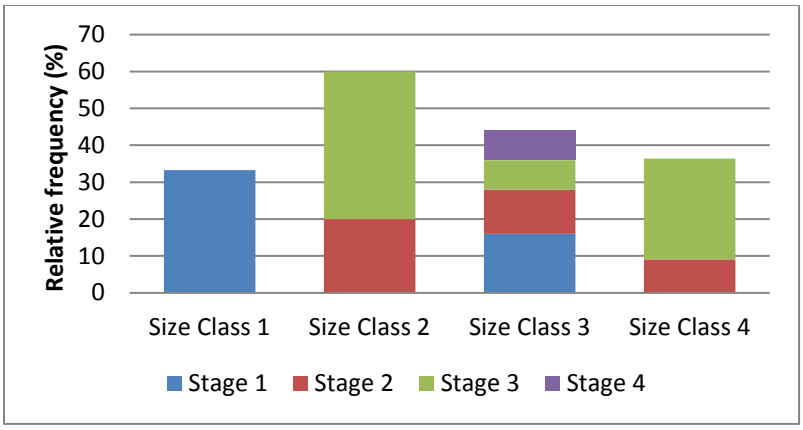


Figure 6.216. Intensity of staining by body size class in aves from Profile Four

Table 6.129. Abrasion in avian remains from Profile Four

	Size Class 2		Size Class 3		Size Class 4		Total	
	N	%	**N**	%	**N**	%	**N**	%
Stage 1	2	20	11	44	5	45.5	**18**	**36.7**
Stage 2	2	20	7	28	5	45.5	**14**	**28.6**
Stage 3	-	-	1	4	-	-	**1**	**2**
Total	**4**	**40**	**19**	**76**	**10**	**90.9**	**33**	**67.3**

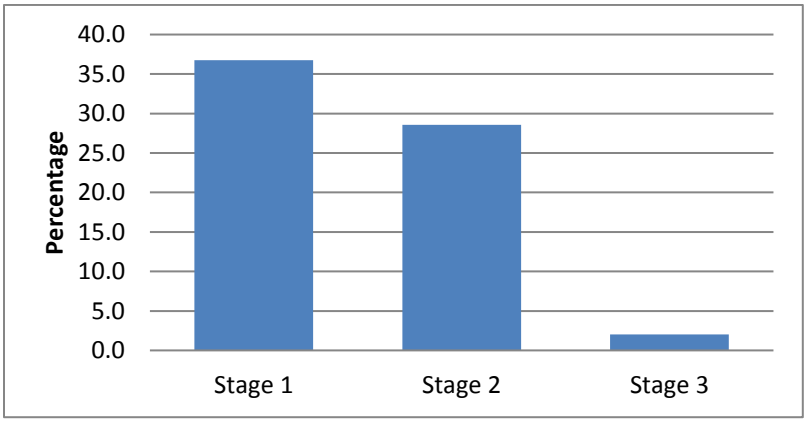


Figure 6.217. Abrasion intensity in avian remains from Profile Four

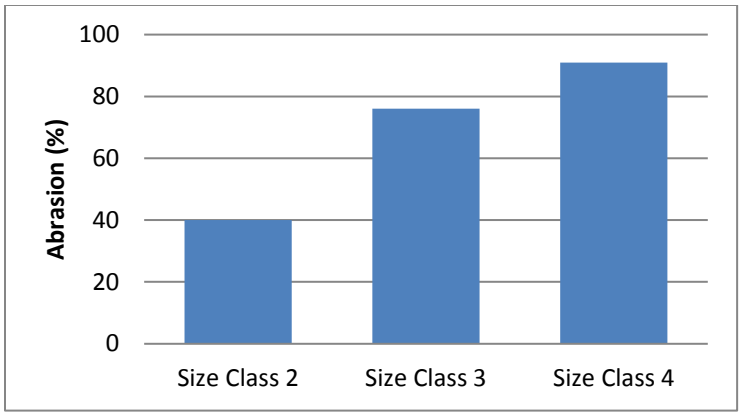


Figure 6.218. Abrasion by body size class in avian remains from Profile Four

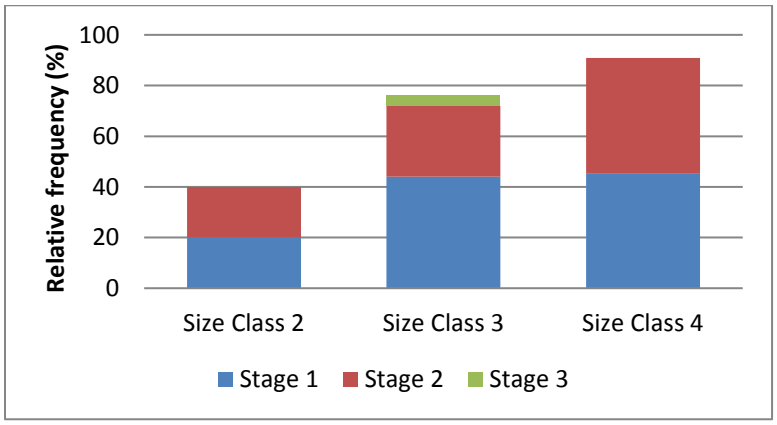


Figure 6.219. Intensity of abrasion by body size class in avian remains from Profile Four

Table 6.130. Sheen in avian remains for Profile Four

	Size Class 1		Size Class 2		Size Class 3		Size Class 4		Total	
	N	%	**N**	%	**N**	%	**N**	%	**N**	%
Stage 1	2	66.7	3	30	5	20	-	-	**10**	**20.4**
Stage 2	-	-	2	20	3	12	2	18.2	**7**	**14.3**
Stage 3	-	-	1	10	7	28	2	18.2	**10**	**20.4**
Total	**2**	66.7	**6**	60	**15**	60	**4**	36.4	**27**	**55.1**

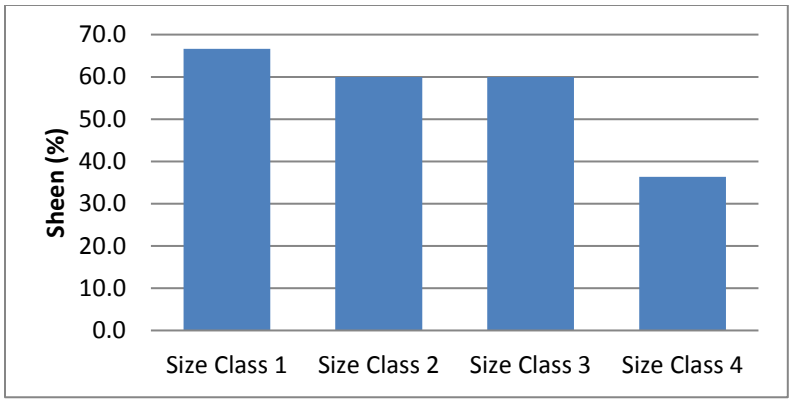


Figure 6.220. Sheen in avian remains with body size class from Profile Four

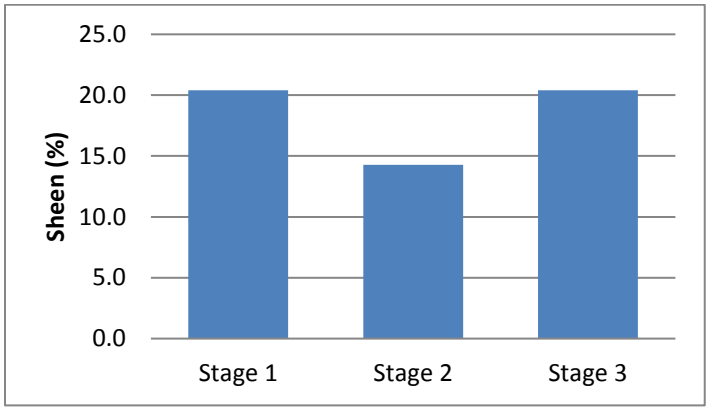


Figure 6.221. Sheen intensity in avian remains from Profile Four

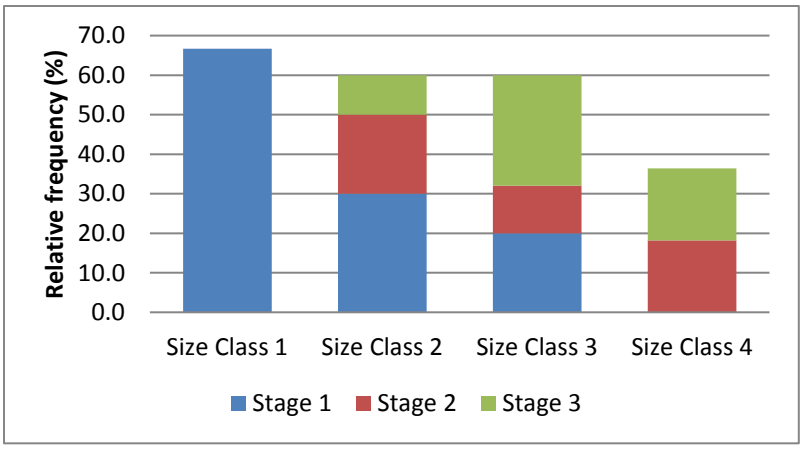


Figure 6.222.Intensity of sheen and body size class in avian remains from Profile Four

Table 6.131. Trampling in avian remains from Profile Four

	Size Class 2		Size Class 3		Size Class 4		Total	
	N	%	**N**	%	**N**	%	**N**	%
Stage 1	3	30	4	16	2	18.2	**9**	**18.4**
Stage 2	6	60	1	4	-	-	**7**	**14.3**
Total	**9**	**90**	**5**	**20**	**2**	**18.2**	**16**	**32.7**

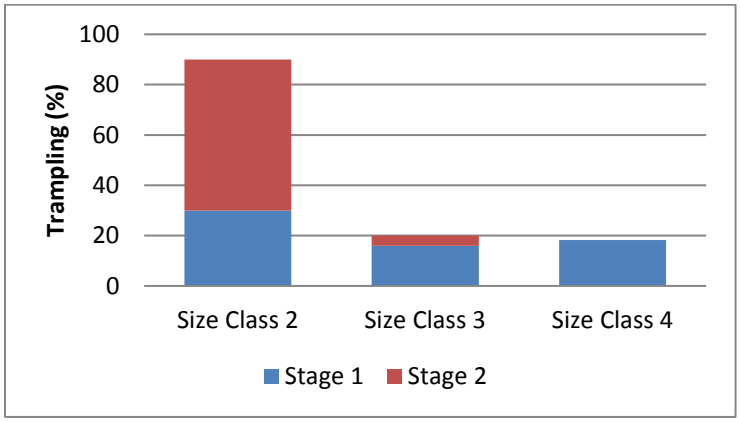


Figure 6.223. Trampling intensity in avian remains from Profile Four

Table 6.132. Tooth marked bones in the avian assemblage from Profile Four

		N	**%**
Ciconiidae	Tibia	1	100
Phasianidae	Coracoid	1	50
	Ulna	1	100
Aves indet.	Coracoid	1	25
	Tibiotarsus	1	14.3
	Tarsometatarsus	1	14.3
	Cervical vertebra	3	100
	Total	**9**	**18.4**

Table 6.133. Digestive corrosion in avian remains from Profile Four

		N	%
Ciconiidae	Tibia	1	100
Phasianidae	Coracoid	1	50
Aves indet.	Coracoid	1	25
	Cervical vertebra	1	33.3
	Vertebra	1	33.3
	Total	**5**	**10.2**

Table 6.134. Root etching in avian remains from Profile Four

	Size Class 1		Size Class 2		Size Class 3		Size Class 4		Total	
	N	%	**N**	%	**N**	%	**N**	%	**N**	%
Stage 1	1	33.3	1	10	1	4	1	9.1	**4**	**8.2**
Stage 2	-	-	-	-	1	4	1	9.1	**2**	**4.1**
Stage 3	-	-	1	10	-	-	-	-	**1**	**2**
Total	**1**	**33.3**	**2**	**20**	**2**	**8**	**2**	**18.2**	**7**	**14.3**

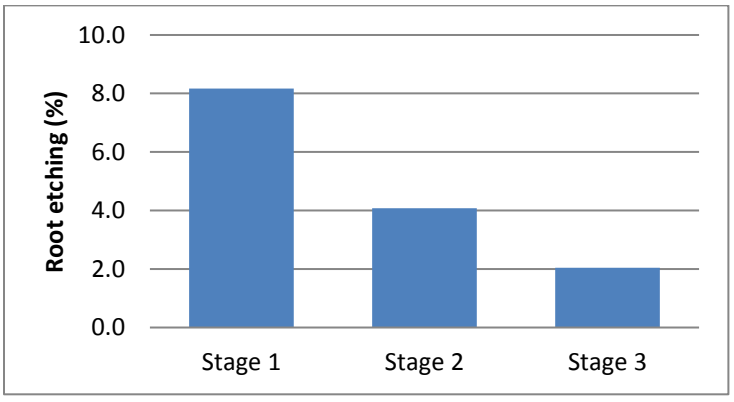


Figure 6.224. Root etching intensity in avian remains from Profile Four

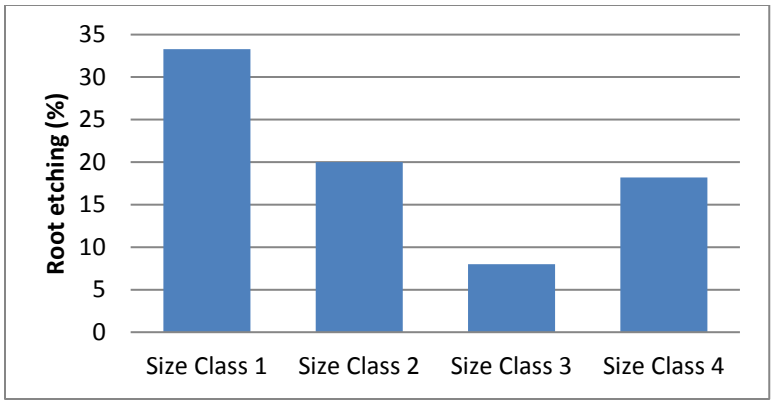


Figure 6.225. Root etching and body size class in avian remains from Profile Four

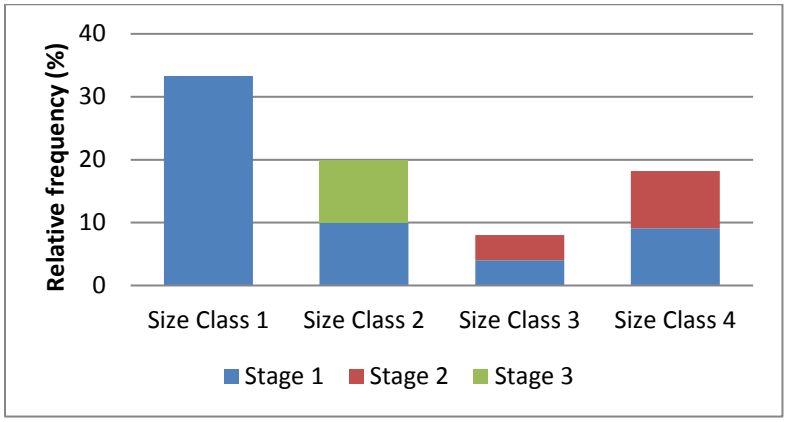


Figure 6.226. Intensity of root etching and body size class in avian remains from Profile Four

Table 6.135. Piscine remains with spit in Profile Four

	N	%
Spit 2	2	6.3
Spit 4	2	6.3
Spit 5	4	12.5
Spit 7	1	3.1
Spit 8	8	25
Spit 9	12	37.5
Spit 10	3	9.4
Total	**32**	

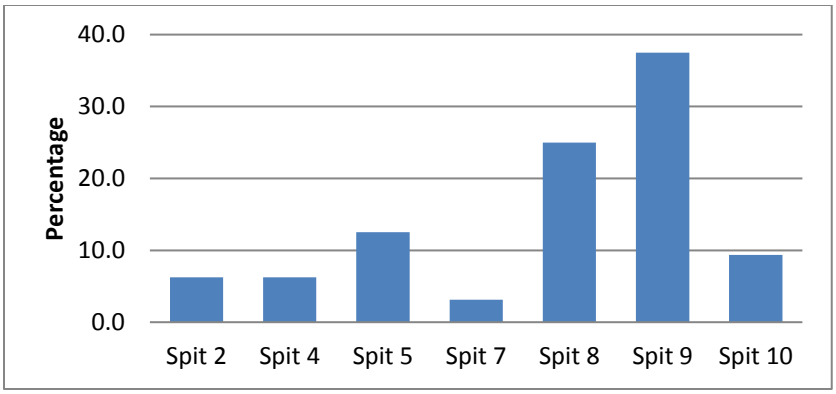


Figure 6.227. Relative frequency of Pisces remains with spit from Profile Four

Table 6.136. Anatomical composition of pisces from Profile Four

	Size Class 1		Size Class 2		Total	
Element	**N**	**%**	**N**	**%**	**N**	**%**
Maxilla	1	100	-	-	**1**	**3.1**
Mandible	-	-	1	100	**1**	**3.1**
Vertebra	15	50	15	50	**30**	**93.8**
Total	**16**	**50**	**16**	**50**	**32**	

Table 6.137. Anatomical composition by spit in pisces remains from Profile Four

	Spit 2		Spit 4		Spit 5		Spit 7		Spit 8		Spit 9		Spit 10		Total	
Element	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Maxilla	-	-	-	-	-	-	-	-	-	-	1	100	-	-	**1**	**3.1**
Mandible	-	-	-	-	-	-	-	-	-	-	1	100	-	-	**1**	**3.1**
Vertebra	2	6.7	2	6.7	4	13.3	1	3.3	8	26.7	10	33.3	3	10	**30**	**93.8**
Total	**2**	**6.3**	**2**	**6.3**	**4**	**12.5**	**1**	**3.1**	**8**	**25**	**12**	**37.5**	**3**	**9.4**	**32**	

Table 6.138. Descriptive statistics of maximum specimen length in pisces from Profile Four

N	32
Minimum	5
Maximum	17
Mean	7.4
Standard Deviation	2.5

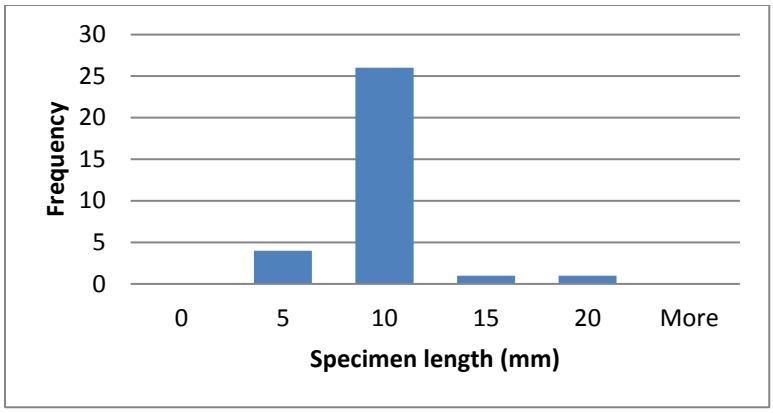


Figure 6.228. Histogram of maximum specimen length in piscine remains from Profile Four

Table 6.139. Staining in piscine remains with spit from Profile Four

	N	%
Spit 4	2	100
Spit 8	4	50
Spit 9	5	41.7
Spit 10	1	33.3
Total	**12**	

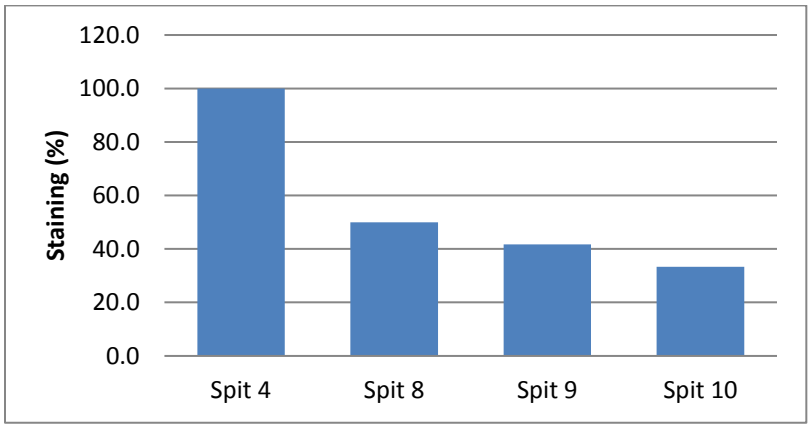


Figure 6.229. Staining by spit in piscine remains from Profile Four

Table 6.140. Abrasion in pisces from Profile Four

	Size Class 1		Size Class 2		Total	
	N	%	**N**	%	**N**	%
Stage 1	8	50	11	68.8	**19**	**59.4**
Stage 2	3	18.8	1	6.3	**4**	**12.5**
Stage 3	2	12.5	1	6.3	**3**	**9.4**
Total	**13**	**81.3**	**13**	**81.3**	**26**	**81.3**

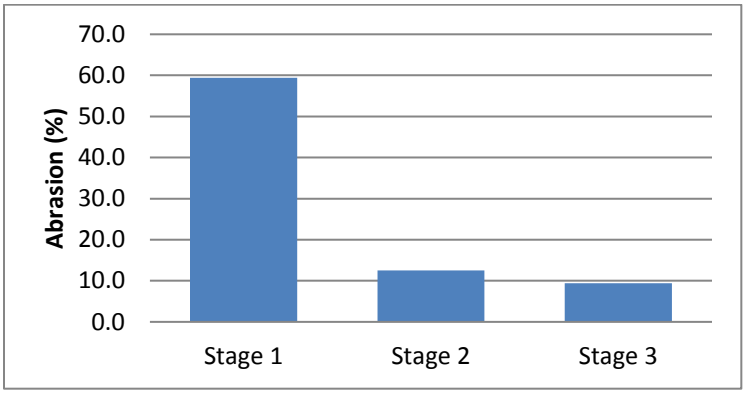


Figure 6.230. Abrasion intensity in piscine remains from Profile Four

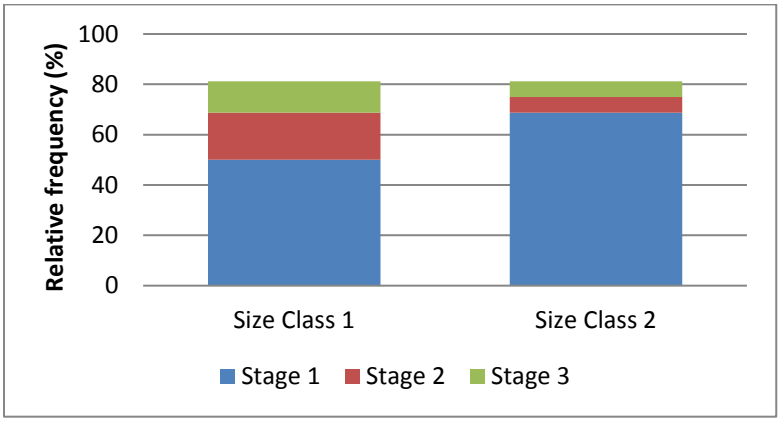


Figure 6.231. Intensity of abrasion and body size class in piscine remains from Profile Four

Table 6.141. Taxonomic composition of reptile remains from Profile Four

	Size Class 1		Size Class 2		Total	
	N	**%**	**N**	**%**	**N**	**%**
Lizard	6	100	-	-	**6**	**75**
Snake	1	50	1	50	**2**	**25**
Total	**7**	**87.5**	**1**	**12.5**	**8**	**0.5**

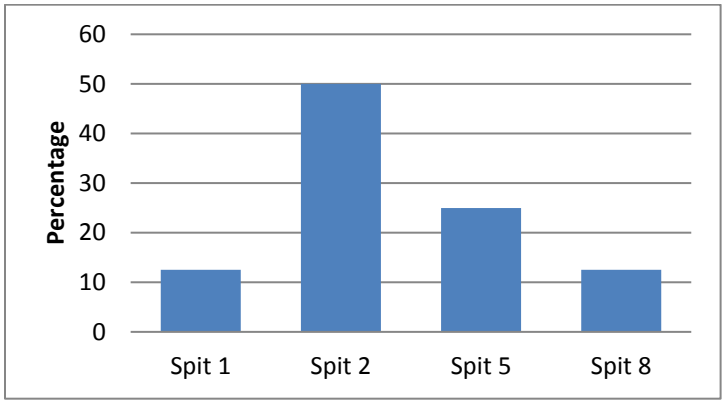


Figure 6.232. Reptile remains with spit from Profile Four

Table 6.142. Anatomical composition of reptile remains from Profile Four

		Size Class 1		Size Class 2		Total	
	Element	**N**	**%**	**N**	**%**	**N**	**%**
Lizard	Humerus	1	100	-	-	**1**	**12.5**
	Mandible	1	100	-	-	**1**	**12.5**
	Vertebra	4	100	-	-	**4**	**50**
Snake	Vertebra	1	50	1	50	**2**	**25**
	Total	**7**	**87.5**	**1**	**12.5**	**8**	

Table 6.143. Anatomical composition and spit in reptile remains from Profile Four

		Spit 1		Spit 2		Spit 5		Spit 8		Total	
	Element	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Lizard	Humerus	1	100	-	-	-	-	-	-	**1**	**12.5**
	Mandible	-	-	1	100	-	-	1	-	**2**	**25**
	Vertebra	-	-	3	100	-	-	-	-	**3**	**37.5**
Snake	Vertebra	-	-	-	-	2	100	-	-	**2**	**25**
	Total	**1**	**12.5**	**4**	**50**	**2**	**25**	**1**	**12.5**	**8**	

Table 6.144. Descriptive statistics of maximum specimen length in reptile remains from Profile Four

N	8
Minimum	9
Maximum	12
Mean	10.8
Standard Deviation	1.0

Table 6.145. Breakage categories in reptile remains from Profile Four

	Complete		Fragmented		Total	
	N	**%**	**N**	**%**	**N**	**%**
Humerus	1	100	-	-	**1**	**12.5**
Mandible	-	-	1	100	**1**	**12.5**
Vertebra	5	83.3	1	16.7	**6**	**75**
Total	**7**	**87.5**	**1**	**12.5**	**8**	

Table 6.146. Taxonomic comparison of taphonomic characters from Profile Four

	Mammal	Chelonia	Aves	Pisces	Reptile
N	614	886	49	32	8
%assemblage	38.6	55.8	3.1	2	0.5
Body Size Class	3/4	2	3	1/2	1
Depth	4	6	8	9	2
Avg length (mm)	31.5	17.5	18.4	7.4	10.8
Adult (%)	69	80.6	all	na	na
Completeness (%)	6.4	14.6	6.1	46.9	87.5
Fracture outline	Spiral	Spiral	Spiral	na	na
Fracture angle	oblique/right	oblique/right	Mixed	na	na
Weathering	22.6	15	6.1	9.4	na
Burning	1.8	7.6	8.2	3.1	12.5
Staining	79.5	37.8	44.9	37.5	87.5
Abrasion	87	82.1	67.3	81.3	87.5
Sheen	22.8	21.7	55.1	6.3	12.5
Trampling	30.9	28.2	32.7	3.1	na
Tooth marks	3.3	4	18.4	na	na
Digestion	2.3	3.6	10.2	na	na
Root etching	32.2	23.7	14.3	na	na

Table 6.147. Comparison of taphonomic characteristics in the MPPM and bonebed deposits from Profile Four

	MPPM	Bonebed
Spits	1-5	6-10
N	930	659
%assemblage	58.5	41.5
Mammal	528	86
Chelonia	364	522
Aves	23	26
Pisces	8	24
Reptile	7	1
Avg length (mm)	26	18
Completeness (%)	46	136
Fracture outline	Spiral	Spiral
Fracture angle	Oblique/right	Oblique
Weathering	18.5	16.1
Burning	2.3	9.6
Staining	73	33.8
Abrasion	90.4	73.7
Sheen	20.9	26.3
Trampling	29.5	27.8
Tooth marks	2.7	5.9
Digestion	1.5	6.2
Root etching	30.5	19.9

Table 6.148. Descriptive statistics of maximum specimen length in remains from the MPPM and the bonebed from Profile Four

	MPPM	Bonebed
N	929	658
Minimum	0	4
Maximum	117	100
Mean	26	18
Standard Deviation	14.1	13

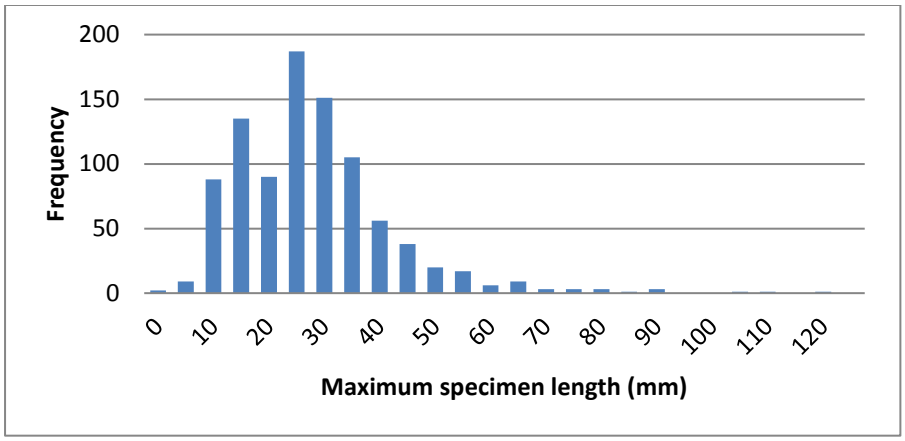


Figure 6.233. Histogram of maximum specimen length in remains from the MPPM of Profile Four

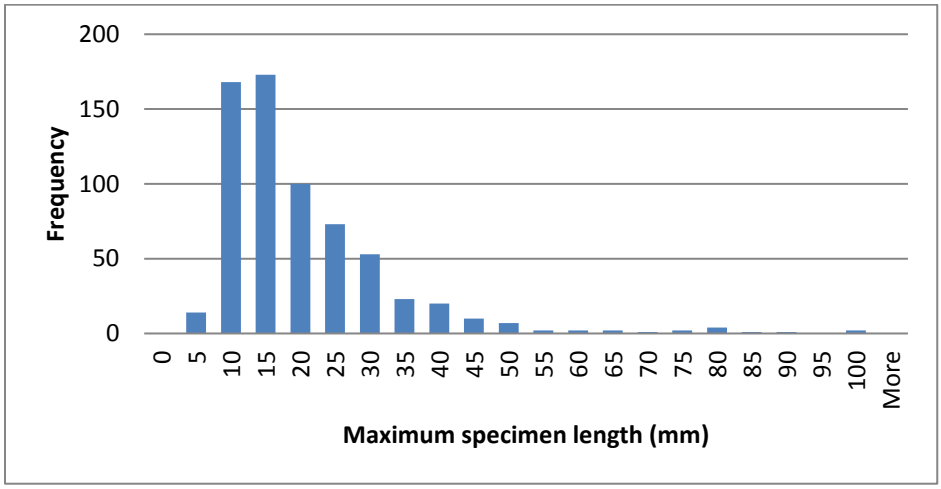


Figure 6.234. Histogram of maximum specimen length in remains from the Bonebed from Profile Four

Table 6.149. Fracture outline in the MPPM and the bonebed from Profile Four

	Spiral (fresh)		Transverse (dry)		Splintered		Eroded		Irregular		Total
	N	%	N	%	N	%	N	%	N	%	N
MPPM	421	65.3	117	18.1	82	12.7	3	0.5	22	3.4	645
Bonebed	161	73.2	21	9.5	8	3.6	8	3.6	22	10.0	220

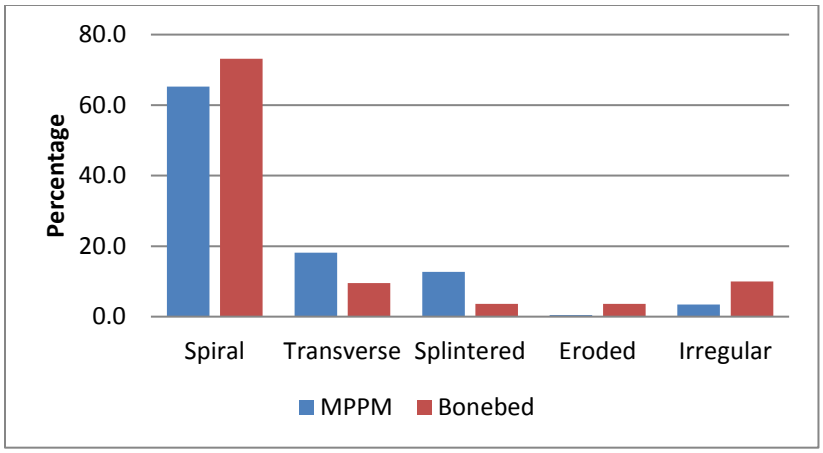


Figure 6.235. Fracture outline in the MPPM and bonebed from Profile Four

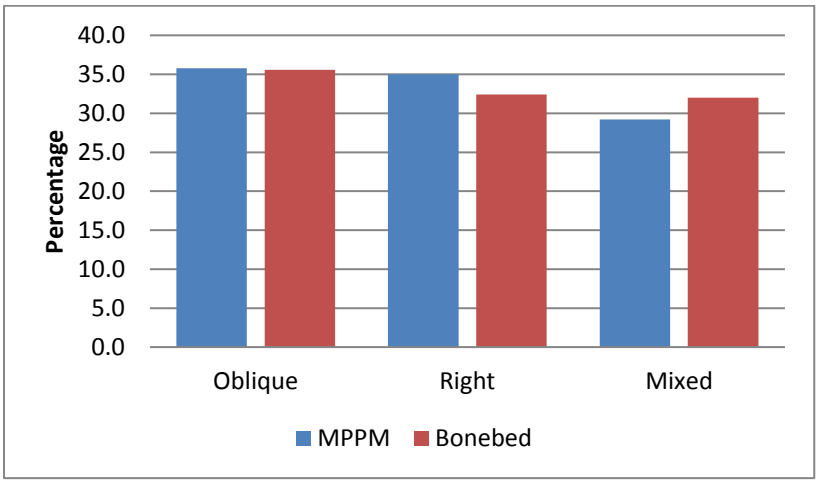


Figure 6.236. Fracture angle in the MPPM and bonebed from Profile Four

CHAPTER SEVEN

PROFILE TWO - RESULTS

7.1. SEDIMENTOLOGY

Profile Two was located in Hendey's 1976/2 excavation, now covered by the small agricultural tunnel. The original excavations were conducted in a series of six trenches orientated roughly east to west. The trenches were 5 m to 6 m long and each was separated by a narrow bulkhead of earth (Figure 7.1). After Hendey's excavations, this area was left exposed on the surface for decades before upgrades to the shelter over the bonebed lead to the covering of 1976/2. After excavations in the bonebed had begun it was decided to expand the grid system used in that area over the 1976/2 excavation, so that the latter may be incorporated into the global positioning grid (orientated to true north). Unfortunately, the original trenches do not align with the grid, but lie at a diagonal angle to it, which has made subsequent excavations in this area using the grid problematic. This area was last excavated briefly by Dr D. D. Stynder in 2009. Dr Stynder's excavations show that much of the MPPM has been stripped away in the trenches and that the contact with the LQSM is close to the current surface. The 1976/2 excavation sampled material from the bed 3aN deposit (Hendey 1980). It was considered an ideal location in which to excavate in this analysis as both MPPM and LQSM were likely to be encountered and the origins and depositional environment of the bed could be explored.

In this excavation I selected a square in the southern most trench.This square was selected as it displayed a large cross section through the southern wall of the old bulkhead and some bedding could be observed within that wall (Figure 7.2). In addition, other trenches at slightly higher elevations within 1976/2, intersected the MPPM-LQSM contact and it was believed that the contact should be found close to the surface in this square. This test pit was named Profile Two. The test pit was 1 m X 1 m in size and was excavated to a depth of 0.5 m, intersecting both the MPPM and the LQSM deposits.

7.1.1 Excavations

Overburden

Approximately 0.7 m of overburden can be observed rising over the initial surface of the test pit, on the southern side (Figure 7.2). This material displays intermittent fine laminae with a gentle drape (Figure 7.3). These fine laminations within the overburden could indicate deposition in a low energy environment; however, it is unclear how much, if any, of this material is still *in-situ*. Or how much was disturbed by the original excavation and by decades of weathering.

Spit One (0 – 10 cm)

Profile Two was excavated in 10 cm spits. The first spit displayed a great deal of colour mottling with grey, white and orange sediments visible. There was a dominance of orange, presumably iron-stained, material in this spit. There was root and insect activity throughout the spit and many localised differences in hardness, related to different colour sediments. By the end of the spit most of the orange sediments had been removed and the grey and white mottling continued. The grey sands are consistent with the MPPM. We would expect, given the age and exposure of this deposit, for the upper parts to be disturbed to some degree. Fossils observed in this spit appeared small, fragmented, and often soft to the touch.

Spit Two (10 cm – 20 cm)

Sediments were predominantly grey, with some white patches throughout. The grey sediments are sandy but appear to be lightly cemented and very firm, consistent with the MPPM. Excavation of the dry sediments with a trowel was difficult and damaging to fragile fossils. However soaking of sediments with water was very effective in relieving this problem. Fossil preservation improves in this layer with some complete elements recovered. Clusters of associated bone fragments or “exploded” bones were common in this spit and in the upper parts of spit four (Figure 7.4). This type of fracturing is consistent with calcite formation. In the lower part of spit two, associated teeth of a hyena (*Ikelohyeana abronia*; see section 7.3.1) were recovered, descending into the next spit (Figure 7.5).

Spit Three (20 cm – 30 cm)

Sediments in most of spit three continue to have the same texture, and display the same colour variations as spit two. The number of larger and more complete bones increases in spit three. Occasionally observable in spit three were veins of fine dark mud, likely root infillings and localised calcrete formations that appear post-depositional. Towards the end of the spit, the firm grey sediments (MPPM) appear to be replaced by white sandy sediments. These white sands are loose and soft with a coarse texure, similar to beach sands, and are consistent with the LQSM. They interfinger freely with the grey sediments (MPPM), both laterally and vertically (Figure 7.6). Occasional "puddle-like" structures of grey sediments were observed within the white sands.

Spit Four (30 cm – 40 cm)

There is a clear dominance of white LQSM sands but with the continued presence of grey MPPM sediments. Lateral and vertical interfingering continue, with the LQSM appearing as channel-like structures in the MPPM (Figure 7.7). Small clasts and rolled bones have become common. In the lower parts of the spit, a yellowed and slightly firmer sand was observed interfingering into the white sands. The contact between the two was not distinct but the yellow-sands appeared to have greater numbers of clasts and at times an almost a gravel-like consistency. Chelonian shell pieces were common in the yellow sands. Bones were fragile and many bones were surrounded by a halo of yellow-orange sediment staining.

Spit Five (40 cm – 50 cm)

White sands dominate but grey sediments continued to interfinger. It was not possible to excavate the two sediment types stratigraphically as they merged finely and often tended to extend vertically as well as laterally. Calcrete formations were common in the white sands and bone preservation was poor in these layers with no large identifiable remains observed. A photograph of the profile wall from the test pit is shown in Figure 7.8.

7.1.2. Sedimentological Analysis

MPPM

The MPPM sediments in Profile Two display a large amount of colour variation. Colour in the MPPM was predominantly pale to very pale brown (10YR 6/3 to 10YR 7/3 on the Munsell scale). Within the MPPM there are many fine lenses with slight to distinct colour changes (Figure 7.8). Sediments in the MPPM were firm, indurated, and weakly cemented. The MPPM sediments were grain supported and moderately to well sorted. Bed character as a whole appears wavy to irregular, with many gradational and irregular variations in colour within the MPPM itself. Large variations in colour in the MPPM of bed 3aN/S are described by Hendey in this field notes (section 3.6). Below the LQSM (in spit five) additional lenses of MPPM can be observed outcropping. The boundary between the MPPM and LQSM was clear (2-5 cm) to gradational (5-15 cm) in places. No sedimentary grading could be observed. In the east wall there appears to be two layers of MPPM, a darker and a lighter layer. The only difference between the two MPPM layers appears to be colour changes and LQSM intrusion. It is possible the lower part of the MPPM is paler in colour due to inclusions of LQSM sediments. The contact between them is distinct to in-distinct and displays some possible erosional features (micro scours). The upper parts of Profile Two display iron-staining. Spit one and spit two sample the MPPM deposit. Spit three represents the lower-most part of the MPPM with some inclusion of the LQSM.

Grain size distribution displays a bimodal pattern with high percentages of fine to very fine sands (Figure 7.9). The coarse fraction and coarse sands were rare (>10%), as were fine (silt and clay) grains which represented less than 1.5% of the sample mass (Figure 7.10). Despite the lack of grains at the small and large ends of the scale, Profile Two MPPM sediments compare favourably with previous findings and with the MPPM layers in Profile Four. The bedding features and colour variations in this profile, which have only previously been described by Hendey, are likely features linked to the contact with the LQSM. It has been suggested that the 1976/2 excavation (where Profile Two is located) is part of an overbank feature of the river channel bed 3aN, with lateral accretion of sedimentary material (Smith, personal communication). The MPPM sediments of Profile Two do not show any of the features typical of an overbank deposit. Lateral accretion on overbank deposits results in stacked upward fining sequences that typically display trough cross-bedding and other fluvial characters like ripple marks (Boggs 2011). None of this was observed in Profile Two. The features observed in the MPPM appear more likely erosional. It is not possible to rule out fluvial action in the 1976/2 bed from a single test pit and fluvial

action could account for the erosion and for the taphonomic characters observed in the bones (see below).

LQSM

The LQSM consisted of soft powdery quatzose sands, in character very much like beach sand. The LQSM sands were white (7.5 YR 8/1). Sediment fabric was grain supported and moderately sorted, displaying well rounded grains with high sphericity. The bed character was sharp and irregular, with frequent interfingering into the MPPM both laterally and vertically. The elongate 'tongues' of LQSM appear to display many of the characteristics of ripple and small channel fills. The boundary with the MPPM was abrupt to clear and irregular. No sedimentary grading was visible. Spit four and spit five sample mostly LQSM but some MPPM was also transected.

Within the LQSM were lenses of coarse yellowish sand which produced many small clasts and chelonia shell remains. These sands can be characterised as a very pale brown (10YR 8/3), and were observed in the lower parts of the profile. The yellow sands were well to moderately sorted. Sediments were grain supported with well rounded grains. Visible phosphate grains were observed. The yellow sands appeared as ripple fill lenses within the LQSM deposit. They were thin to medium in thickness with a clear (2-5 cm) and irregular boundary. Note however, that the yellow sands were difficult to distinguish from the LQSM due to the high similarlity in colour and texture. No sedimentary grading was visible. The majority of the yellow sands were observed in spit five.

The LQSM sediments display much the same grain size curve as the MPPM (Figure 7.11). Silts (0.038 mm) represent less 0.5% of the mass of the sample and no finer material was recovered (Figure 7.12). The sands have a bimodal distribution with a skew towards the very fine sands class. Coarse material (> 1 mm) made up less than 5% of the sediment. These results compare favourably with Roberts (2006b) description of the LQSM as a fine- to medium-grained, moderately sorted quartzose sand (80-100%). Hendey (1980) proposed that the MPPM river channel had eroded into LQSM flood plain deposits. Profile Two does not show any indication for a MPPM channel digging into the LQSM. Rather the interfingering of the deposits and the channel-like structures of LQSM, on top of MPPM suggest concurrent deposition, with some erosion. The channel-fill characters observed in the LQSM do indicate some fluvial action, probably with relatively low energy or a small water load. Perhaps these are runoff structures leading towards the main river channel.

7.2. TAXONOMY

A total of 4 094 bones were recovered from Profile Two (Table 7.1). A total of 202 (5.2%) of the 4 094 specimens were identifiable to element and family. This is a remarkably low percentage compared to the other test pit excavations. The remaining 3 874 specimens were unidentifiable and are hereafter excluded from analysis. Less than 20 microfaunal specimens were recovered from Profile Two, making up less than 1% of the total bone sample. This contrasts strongly with the other test pits which produced large numbers of microfauna. The frequency of specimens or bone density was low (<20% of remains) in the first three spits (MPPM) with spit three only producing 14 identifiable remains (Table 7.1). Specimen density however, increased dramatically in spit four (24.3%) and spit five (40.6%) (Figure 7.13). This would suggest that specimen density was greater in the LQSM than the MPPM, a finding also observed in Profile One (section 8.2).

7.2.1 Taxonomic Abundance in Profile Two

A total of 51 (25.2%) mammal remains, 148 (73.3%) chelonia and 3 (1.5%) aves were recovered from Profile Two (Table 7.2 and Figure 7.14). Mammals were well represented in spits one (48.6%), two (63.6%) and three (71.4%), and were the dominant taxonomic group in the latter two layers (Figure 7.15). In spits four and five mammals drop off dramatically (8.2%, 7.3%; respectively) and chelonia remains become profuse, accounting for 89.8% to 91.5% of the fossil material from those spits. Mammal and chelonia were equally represented in spit one. A single avian specimen was recovered each from spits one, four and five.

7.3 TAPHONOMY

7.3.1 Bone size frequency distribution and fragmentation patterns

The smallest bone specimen recovered from Profile Two was 4 mm in length, while the largest specimen recovered was 67mm (Table 7.3). Mean specimen length in bones from Profile Two was 17.36 mm. Profile Two specimens display a spread from 5 mm to 45 mm with some outliers in the 65 – 70 mm range. Maximum length displays a skew towards smaller sized bones with a peak around 15 mm. (Figure 7.16).

7.3.2 Bone Surface Modifications

Bone Weathering

Weathering was observed in 39 (19.3%) specimens out of the entire Profile Two assemblage (Table 7.4). Weathering in Profile Two was limited to stage one (16.3%) or stage two (3%) (Figure 7.17). Weathering occurred in 27.5% of mammal remains and 16.9% of chelonia, but was absent in birds (Figure 7.18). Stage two weathering was only observed in spits four (4.1%) and five (4.9%) (Table 7.5 and Figure 7.19). Weathering was particularly pervasive in spit three, where fully 50% (7) of remains were weathered to stage one (Figure 7.20).

Burning

Burning was scarce in Profile Two, occurring on 17 (8.4%) of remains (Table 7.6). A total of only 3.9% of mammal bones and 10.1% (15) of chelonian bones displayed burning (Figure 7.21). Avian bones did not display burning. Severe burning, stages five and six, were absent in remains from Profile Two. The most common stages of burning were stage one (4.5%) and stage three (2.5%) (Figure 7.22). Stage two was observed on a single (0.5%) specimen. Burning prevalence appears to increase with spit depth, becoming more common in the LQSM than the MPPM (Table 7.7). Burning was absent in spit one, and occurred on a single (4.5%) remain in spit two and on 2 (14.3%) remains in spit three (Figure 7.23). The number of burnt bones increases in spit four and spit five; however, the percentage of remains from the spit that display burning remains low (12.2%, 9.8%; respectively). Figure 7.24 displays the burning intensity within each spit. Note that all burning, at any given intensity, made up less than 15% of the total sample from the spit. No bones within spit one were burnt. Burning in spit two was limited to stage one. Burning in spit three displayed a high prevalence of stage three and stage four (7.1%, respectively). Spit four displayed stage one (6.1%) and stage three (6.1%) burning. Spit five displayed a high prevalence of stage one (6.1%) burning, but isolated occurrences of stages two, three and four (1.2%, respectively) were also observed.

Colour Mottling and Staining

A total of 119 (58.9%) of remains from Profile Two displayed staining (Table 7.8). Staining was prevalent in mammals (80.4%) and chelonia (50.7%) (Figure 7.25). All avian remains displayed staining. Bones from Profile Two displayed stage one, two and three staining. Figure 7.26 displays how staining was predominantly of a light intensity with stage one (40.1%) most common, followed by stage two (14.9%) and stage three (4%) was minimal. Staining was highly prevalent in spit one (94.3%) and spit two (95.5%), possibly reflecting the high numbers of mammal remains from these spits (Figure 7.27). Stage one staining was the most common type in all spits (Figure 7.28). In spit one, stage two and three staining were equally abundant (22.9%) (Table 7.9). Spit one was the only spit in which stage three was observed (22.9%). Stage two staining was also observed in spit two where it made up 27.3% (6) of the remains, spit four (6.1%) and spit five (15.9%).

A number of different colours of bone staining were observed in Profile Two. The different colours relate to different chemical precipitates or processes of dissolution, and are addressed in greater detail in Chapter Nine. Four colours were observed, brown, purple, black and orange. Orange staining is likely the result of iron precipitation from the surrounding sediments. Brumfit *et al*. (2013) has indicated that the black staining is the result of Manganese (Mn) precipitating in oxygenated conditions. The purple staining is likely derived from apatite (Brumfitt *et al.* 2013). Brown was the most common type of staining in Profile Two, occurring on 74.8% (89) of the assemblage (Table 7.10). Orange staining was observed on 21% (25) of remains. Purple (2.5%) and black (1.7%) staining were scarce (Figure 7.29). Figure 7.30 displays how staining type (colour) is affected by intensity. Most brown staining was of stage one (68.5%) intensity, although stage two (24.7%) and occasional stage three (6.7%) brown staining was also observed. Two-thirds of purple staining in Profile Two was stage three, the remainder was stage one. All black staining was stage one. Most orange staining was stage one (68%), the remainder was stage two (32%). Brown staining occurs in all spits (Table 7.11), purple staining is limited to spit one, black staining to spit five and three, while orange staining was observed in spits one, four and five (Figure 7.31).

Abrasion

A total of 189 (93.6%) specimens from Profile Two display abrasion damage (Table 7.12). Abrasion was greater in Profile Two than in the other test pits excavated, suggesting that bones from Profile Two either experienced a greater degree of transport and/or were deposited in a higher energy environment. Abrasion was extensive in chelonia (95.9%) and mammal (86.3%) remains and all avian specimens displayed abrasion (Figure 7.32). Stage three (33.7%) and stage two (31.7%) abrasion were most common; stage four (5.4%) abrasion was rare (Figure 7.33). Abrasion was extremely abundant in spit five where all but one specimen (1.2%) were abraded (Table 7.13). Spit three (92.9%) and spit two (90.2%) also show high levels of abrasion (Figure 7.34), suggesting bones in the LQSM experienced greater travel or a more energetic environment. Stage one (31.4%) was the most common stage of abrasion in spit one, followed by stage three (28.6%) and stage two (22.9%); stage four was rare (5.7%) (Figure 7.35). In spit two, on the other hand, stage two (54.5%) was the most prevalent type of abrasion, followed by stage three (22.7%) and stage one (13.6%). Stage four abrasion was absent from spit two, which was the only spit from which stage four was absent. In spit three, there was a particularly high number of stage one (50%) abrasion, followed by stage three (28.6%). In spit three stage two and stage four abrasion were found sporadically (7.1%, respectively). Spit four produced the largest numbers of stage four (10.2%) remains, but was otherwise dominated by stage two (40.8%). Spit five produced the highest percentage of stage three (46.3%) remains and the lowest percentage of stage four (3.7%). Thus we can conclude that there is no pattern between spit depth and *intensity* of abrasion.

Sheen and Polish

A total of 68 specimens, representing 33.7% of the Profile Two accumulation, displayed sheen (Table 7.14). Stage one (17.8%) and stage two (10.9%) sheen were most common, while stage three (5%) was relatively rare (Figure 7.37). Mammal fossils were strongly affected by sheen with 51% of the mammal assemblage modified (Figure 7.37). A total of 28.4% of chelonia displayed sheen which was absent in avian remains. Most of the polished bones were observed in the LQSM; spit four (44.9%) and spit five (34.1%) (Table 7.15 & Figure 7.38). Most of the sheen observed in spit one was stage two (17.1%) in intensity, with stage three (2.9%) observed on only one specimen (Figure 7.39). In spit two, stage one (13.6%) was the most common modification, although stage two (9.1%) and stage three (4.5%) were also occasionally observed. Stage two (14.3%) and stage three (7.1%) were the only stages of sheen observed in spit three. Spit four displays greater numbers of all sheen intensities with a strong dominance of stage one (26.5%) over stages two (10.2%) and three (8.2%). In spit five there is a strong

domination of stage one (22%), and occasional representation of stage two (8.5%) and stage three (3.7%). I should note that some specimens, particularly chelonia shell remains, appear to display natural polish on the inner surface. It is unknown, at this stage, why these bones appear shiny and polished or how to differentiate this from post-depositional polish or sheen. In many cases this natural shininess is scoured away by the forces of abrasion, but it is a factor that should be considered in future analyses.

Trampling

There were 52 specimens representing 25.7% of the Profile Two accumulation that displayed trampling marks (Table 7.16). Profile Two displayed the lowest relative frequency of bones with trampling modification; however, the percentage is only slightly smaller than in Profile Four. Of the 52 specimens, only 3 (2%) displayed more than occasional (stage two) marks (Figure 7.40). Trampling was observed in 25.5% of mammal remains and 26.4% of chelonia remains, suggesting that there was no particular preference for, or susceptibility to, trampling in either vertebrate class (Figure 7.41). Trampling was absent from avian remains. Trampling was most common in spit five (32.9%), spit three (28.6%) and spit one (28.6%) (Table 7.17); but was relatively rare in spit two (9.1%) (Figure 7.42). Stage two trampling was observed in spits one (2.9%), four (2%) and five (1.2%) but was in all cases exceptional (Figure 7.43). Table7.18 displays the types of trampling marks observed in Profile Two. Note that some specimens display more than one kind of mark (example, pits and scores), thus the number of marks (61) exceeds the number of bones (52) with trampling marks. Trampling marks observed in Profile Two include pits, scores, notches and scratching. Scores (57.4%) and pits (36.1%) were the most common modification (Figure 7.44), the remaining trampling marks occur at low frequencies (2 notches and 2 scores). Certain types of trampling marks were found associated. Pits and scores were often (7) found on the same bone. Pits and notches, and scores and scratches were also observed together (1 specimen, respectively). Experimental work on trampling in sandy sediments has found that the mark categories described here can be regarded as arbitrary classifications steming from a continuous pedoturbationary process (Reynard 2014).

Carnivore modifications

Carnivore modifications were only observed in chelonian remains from Profile Two and are discussed in section 7.4.4.

Root Etching

Root etching was observed on 80 (39.6%) remains from Profile Two (Table 7.19). It was most common in mammals (52.9%), but was also observed in numerous (35.1%) chelonia and even a single (33.3%) aves specimen (Figure 7.45). The majority of root marking was light, stage one (25.2%) or stage two (11.9%); but occasional heavy, stage three (2.5%) root marking was also observed (Figure 7.46). Root marks were observed in all spits (Table 7.20). Root marking was most common in spit two (54.5%) and spit one (45.7%) and least common in spit three (28.6%) (Figure 7.47). Stage three root marking was always uncommon (>10%) and was observed in all levels except spit three (Figure 7.48). Spit three displayed only stage one root marking.

Other Surface Modifications

Insect modifications were absent from Profile Two.

7.4. MAMMAL TAXONOMY AND TAPHONOMY

7.4.1. Taxonomic Abundance of mammals

A total of 51 remains identifiable to the class mammalia were recovered from Profile Two, representing 25.2% of the total assemblage from Profile Two (Table 7.2). Table7.21 displays a breakdown of the mammal families recovered by depth. The majority (58.8%) of the mammal remains were not identifiable to the family level (Figure 7.49). Of the material that was identifiable, bovids (27.5%) were the most common family, followed by carnivores (9.8%) and rodents (3.9%) (Figure 7.49). This pattern was consistently observed in test pit excavations in this study. A further breakdown of individual families is given below. The estimated minimum number of individuals (MNI) for mammals was six (Table 7.22). No remains from megamammals (size class five) were recovered from Profile Two (Table 7.2). The majority of mammals from Profile Two were large bodied; size class four (47.1%) or size class three (35.3%) (Figure 7.50). Figure 7.51 plots mammal size classes against spit depth. There is no clear correlation between size class and spit for mammals. Size class one is observed in spits one (20%), three (20%), four (20%) and five (40%). Size class two occurred in spits one (25%), three (25%) and four (50%). Size class three was observed in spits one (44.4%), two (27.8%) and three (27.8%).

Bovidae

A total of 14 bovid specimens, representing 27% of mammalian remains were recovered from Profile Two (Table 7.21). The majority of the bovid remains were recovered from spit two (57.1%), and the remainder from spits one and three (21.4%, respectively) (Figure 7.52). Bovid remains in Profile Two were limited to size class four (85.7%) and size class three (14.3%) (Table 7.23 and Figure 7.53). None of the bovid material was identifiable below the family level. The MNI for Bovidae was three based on molar remains (Table 7.22).

Carnivora

Remains from two carnivorans were recovered in Profile Two, representing 9.8% of the identifiable mammalian assemblage (Table 7.2). One of the carnivores, a small hyaena (body size class three), is represented by associated dentition. It will be discussed in more detail below. The remaining specimen

is a small carnivore (size class one) recovered in spit one. Thus, each species is represented once in the assemblage, and the total carnivore MNI in this profile is two. Carnivore remains were recovered from spit one (5.9%), spit two (14.3%) and spit three (20%). The material from spits two and three appear to be associated with the same skeleton (see below) (Figure 7.52).

Rodentia

Two incisor remains consistent in size with a large rodent like the mole rat were recovered from Profile Two. These represent almost 4% of mammals from Profile Two. Both remains were recovered from spit five (Figure 7.52). MNI based on the partial rodent dentition recovered is one. Porcupine and mole-rats have been recovered from Langebaanweg previously, and the latter is an abundant taxon.

Mammal Indeterminate

The majority (58.8%) of the mammal remains from Profile Two are not identifiable to family group, but can none-the-less be differentiated from chelonia or aves remains (Figure 7.50). Most (40%, respectively) of these remains are size class three or size class four mammals (Figure 7.53). The majority of the unidentifiable mammal remains were recovered from spit one (Figure 7.52). Reitz and Wing (1999) recommend calculating skeletal frequencies for the lowest taxonomic class possible and caution against applying those methods to higher taxonomic classes where those elements could relate to lower taxa. Following this, MNI is not calculated for indeterminate mammal remains. It should be noted that even if MAU were to be estimated in this group, the value would only be one individual, thus suggesting that removal of this material from the analysis has not adversely affected MNI calculations for mammals.

7.4.2. Anatomical Composition of Mammals

Bovidae

Bovids were represented by cranio-dental remains in the form of molar, premolar and other tooth fragments, an isolated partial maxilla and a horncore (Table 7.24). No postcranial material attributable

to bovids was recovered in Profile Two. Molar (35.7%) and other tooth fragments (42.9%) were the most common bovid specimens (Figure 7.54); other elements were isolated occurrences. The horncore and a single tooth fragment were derived from a size class three bovid, while the remaining material originated from size class four individuals. All (83.3%) but one of the tooth fragments (the size class three specimen) were recovered from spit two. Molar remains were recovered from spit two (40%) and spit three (60%) (Table 7.25). All remaining bovid material was recovered from spits one and two. An MNI of three was estimated based on molar remains and body size classes. Isolated tooth fragments were also prevalent in the sample, but these remains lacked landmarks useful for identification even to body size, and were thus excluded from skeletal frequency analysis.

Carnivora

Carnivoran remains in Profile Two are limited to craniodental and a single postcranial remain (Table 7.26). The extinct hyena *Ikelohyaena abronia* was represented by a complete set of upper dentition (Figure 7.5). Some of the teeth are isolated while others were recovered *in-situ* with associated fragmentary bone from the maxilla and premaxilla. These two bones and their associated dentition were added to the taphonomic database and analysed as a single unit. Two additional remains, a premolar and an incisor, were recovered in the lower levels of the overlying spit. These compare favourably with the *Ikelohyaena abronia* material, in terms of morphology, and are considered to be associated with this specimen. However as this material was recovered from a different spit, it was analysed separately. In addition to the *Ikelohyaena abroniaI* material, a single phalange of a small (size class one) carnivore was recovered from spit one (Table 7.27). Thus at least two carnivore individuals are represented in Profile Two. *Ikelohyaena abronia* is well known from Langebaanweg (Werdelin 2006; Stynder *et al.* 2012; Hartstone-Rose & Stynder 2013).

Rodentia

Two large rodent incisors were recovered from spit five of Profile Two. This material was consistent in size with a size class one mammal, and most strongly resembled the modern dune mole rat (*Bathyergus suillus*). However given the small sample, it was decided to leave the identification at the family level. Both the incisors were partial fragments, and as they were recovered from the same spit and are of a

similar size, they cannot be ruled out as belonging to the same individual, thus the MNI for rodents is one.

Mammal Indeterminate

A large number (30 specimens) of remains were recovered in Profile Two, that while identifiable to element, could not be attributed to any particular mammalian class and were thus left as mammal indeterminate (Table 7.28). Among these remains were 18 (60%) long bone fragments; small compact bones like phalange, sesamoid and carpal/tarsal, vertebral fragments (3.3%, respectively) and some isolated and fractured dentition (20%) (Figure 7.55). Dental remains were limited to size class three and size class four mammals. Dental remains were recovered from spits one, two and five. Vertebrae were recovered from size class one and size class four. Vertebra elements were recovered from spits two and three. Compact bones represented size class one, two and three. Compact bones were recovered from spits two, three and four. The number of long bone fragments increased with body size; thus there are 8 (44.4%) size class four long bone fragments, 6 (33.3%) size class three and 4 (22.2%) size class two. This is likely an effect of decreased robusticity and bone density with decreasing body size. The majority of long bone fragments were derived from spit one (55.6%), the remainder were recovered in spit three (22.2%), spit four (11.1%) and spit five (11.1%).

7.4.3. Body size frequency distribution and fragmentation pattern of mammals

Maximum Length

The smallest mammal bone recovered from Profile Two was 4 mm in length, while the largest specimen was 65 mm (Table 7.30). Mean specimen length in mammals was 25.73 mm. The mean length in size class one was particularly low (12 mm). The combined mammal sample displays a spread of specimen sizes between 5-50 mm, with an outlier in the 60-65 mm size range (Figure 7.56). The most common sizes were between 20-25 mm and 30-35 mm. Mammal size classes one and two had small sample sizes and were restricted to the smaller size range of mammal specimens; below 20 mm and below 40 mm, respectively (Figure 7.57 and Figure 7.58). Size class three specimens likewise range between 5-35 mm, with a size of 25-30 mm being most common (Figure 7.59). It was from size class three that the large

outlier was recorded. Specimens from size class four were similarly sized between 15-50 mm, with most falling within the range 35-40 mm (Figure 7.60).

Epiphyseal Fusion

Fusion or age could be determined in just three (5.9%) mammal specimens, all from size class one. A single juvenile, subadult and adult could be identified. All mammal dental remains were from adults.

Completeness

A total of 8 (15.7%) mammalian bones were recovered complete (Table 7.31). Complete mammal bones in Profile Two include small dense bones like phalange and sesamoid, as well as dentition. Dental remains (62.5%) were the most common elements in the mammal assemblage recovered complete, followed by phalange (25%). Complete elements were recovered from all size classes with size class four producing most (37.5%) of the complete remains.

Breakage Patterns

Overall fragmentation was high in mammalian remains. Table 7.32 displays a break-down of skeletal element parts recovered in Profile Two. Compact bones as noted previously, were all recovered complete. Long bone fragments and the horncore were represented by shaft fragments. The majority (66.6%, respectively) of the incisors and premolars were fragmented, as well as all unidentifiable tooth fragments. Molar remains on the other hand were more often recovered complete (60%), than fragmented (40%). Maxilla and premaxilla remains were always fragmentary. Vertebra, on the other hand, were represented by the vertebral arch and the vertebral body (centrum).

Fracture Outline

Fracture shape was only analysed in long bones. Each specimen can present two fracture shapes, one proximal and one distal. Within the mammal sample there are a total of 18 long bone fragments, thus

there is a potential total of 36 fracture outlines. In some cases it was not possible to identify the fracture outline and these are excluded from analysis. Fracture shape was recorded in a total of 16 (15.7%) bone ends within the mammal sample (Table 7.33). Fracture outlines could be observed in size class two (25%), size class three (16.7%) and size class four (16.7%) mammals. The vast majority of fracture outlines in mammals were spiral (93.8%). A single (6.3%) size class three specimen displayed a transverse fracture. This suggests that most of the sample was modified while the bones were fresh and unweathered. Fracture outlines were discernable in all spits, although spit one (32.4%) produced a particularly large sample (Table 7.34). In total, 90.9% of the spit one sample displayed spiral fractures with a single (9.1%) transverse break also recovered in spit one. All other spits produced spiral fractures.

Fracture Angle

A total of 22 (21.6%) fracture angles were classified in mammalian long bones from Profile Two (Table 7.35). Oblique (50%) breaks were the most common, with right (27.3%), and mixed (27.7%) breaks also occurring. This would suggest that most bones were fractured while fresh, but results are far from conclusive. Fracture angles were observed in size class two (37.5%), three (22.2%) and four (22.9%) mammalian remains. In all size classes, oblique fractures were the most common breakage angle. Fracture angles were observed in spits one, three, four and five but not in spit two (Table 7.36). Oblique fractures were observed in all the above mentioned spits. Right angled fractures were observed in spit one (33.3%) and spit five (25%). Mixed angled fractures were observed in spit one (20%), four (50%) and five (25%). Spit three displayed only oblique fractures. In all but spit four, oblique was the dominant fracture type. Spit one displayed the highest density (44.1%) of positive fracture angles.

7.4.4. Surface Modifications in Mammals

Bone Weathering

A total of 14 (27.5%) mammalian remains displayed weathering in Profile Two (Table 7.37). Weathering in mammals was limited to stage one (27.5%) (Figure 7.61). Carnivore (60%) remains were most strongly affected by weathering. In total, 35.7% of bovid and 22.2% of unidentifiable mammalian bones were modified; although weathering was absent in rodent remains (Figure 7.62). This would suggest that the

carnivore remains suffered longer sub-aerial exposure that other mammal groups. Although, possible reasons for this are unclear.

Burning

A total of two (3.9%) mammalian remains displayed burning (Table 7.38). Burning in the mammalian sample was equally split between stage one and stage four. The burnt mammalian remains were from the unidentifiable group. Burning in mammals was observed on a caudal vertebra and a long bone fragment, from size class one and two respectively.

Staining

A total of 41 (80.4%) mammalian specimens displayed staining (Table 7.39). Stage one (56.1%) staining was the most common and stage three (14.6%) staining least common (Figure 7.63). Unidentifiable mammals (92.6%) were the most susceptible to staining but all families show a high (>50%) incidence of modification (Figure 7.64). Bovids sustained stage one or stage two (35.7%, respectively) staining, although stage three (7.1%) was also occasionally observed (Figure 7.65). Staining in carnivores was limited to stage one (60%) and stage three (20%). Staining (stage one) was observed in a single rodent bone. Like bovids, unidentifiable mammalian remains displayed mostly stage one (51.9%) or stage two (25.9%) staining, with some stage three (14.8%). Almost all staining in mammals was brown (95.1%) in colour, except for a single purple (2.4%) and a single black (2.4%) specimen, from a carnivore and an unidentifiable mammal respectively (Table 7.40). Orange staining was absent.

Abrasion

Abrasion was observed in 86.3% (44) of mammal remains (Table 7.41). All rodent and unidentifiable mammal material was abraded (Figure 7.66). Similarly the majority (approximately 80%) of bovid and carnivore specimens displayed abrading. Most abrasion in mammals was stage one (43.1%) or two (25.5%), although stages three (13.7%) and four (3.9) were also observed infrequently (Figure 7.67). Indeed in all mammalian families except bovids, stage one was the most common stage of abrasion (Figure 7.68). In bovids, stage two (50%) abrasion was the most common, followed by stage one (21.4%)

and a single specimen (7.1%) with stage three abrasion. Carnivores displayed stage one (60%) and stage two (20%) abrasion. Unidentifiable mammals were the only group to display specimens with stage four (7.4%) abrasion; otherwise stage one (51.9%) and stage three (22.2%) abrasion were the most common in this group.

Sheen and polish

Sheen or polishing was observed in 51% (26) of mammalian remains in Profile Two (Table 7.42). The majority of mammal remains with polishing display stage two (25.5%) or stage one (19.6%) damage, although some stage three (5.9%) damage was also recorded (Figure 7.69). Sheen was observed in all rodent remains, 55.6% of unidentifiable mammals, 50% of bovids and 40% of carnivore specimens (Figure 7.70). Bovids displayed stage two (21.4%), stage one and stage three (14.3%, respectively) sheen (Figure 7.71). Carnivore (40%) and rodent (100%) remains displayed only stage two sheen. Unidentifiable mammals displayed mostly stage one (29.6%) and stage two (22.2%) sheen.

Trampling

Trampling was observed in 25.5% (13) of mammalian remains (Table 7.43). All trampling on mammal bones was limited to stage one. All rodent remains exhibited trampling; trampling was otherwise observed on a small percentage of unidentifiable mammal (29.6%) and bovid (21.4%) remains (Figure 7.72). Carnivore remains lacked trampling. Mammalian remains display pitting (13.7%), notching (2%) and scoring (15.7%), but scratches were not observed (Table 7.44; Figure 7.73). Pits were observed in rodent (28.6%) and unidentifiable mammal (71.4%) remains (Table 7.45). A single (100%) unidentifiable mammal specimen displayed notching (Figure 7.74). Score marks were observed in bovids (37.5%) and unidentifiable mammal (62.5%) remains.

Root Etching

A total of 52.9% (27) of mammal remains displayed root marks (Table 7.46). The majority of root marking in mammals was stage one (27.5%) and stage two (21.6%) with only occasional stage three (3.9%) markings (Figure 7.75). A large percentage of carnivore (60%) and unidentifiable mammal (59.3%)

remains displayed root etching (Figure 7.76). A total of 50% of bovid and rodent remains displayed root etching. Bovid remains displayed stage one (28.6%), stage two (14.3%) and stage three (7.1%) root etching (Figure7.77). Carnivores were dominated by stage one (40%) root etching, although stage three (20%) was also observed in this family. A single (50%) rodent specimen displayed stage two root etching. Finally unidentifiable mammals displayed equal proportions of stage one and stage two root etching (29.6%, respectively).

Pathology

A single (2%) mammal specimen, an unidentified premolar, displayed a potential pathology on one side. This specimen was from a size class three mammal and was recovered in spit one. The type of pathology and potential cause was unknown.

7.5 CHELONIA TAXONOMY AND TAPHONOMY

7.5.1 Taxonomic Abundance of Chelonia

A total of 148 remains, representing almost three-quarters of the total assemblage, were identified as chelonia (Table 7.2 and Figure 7.14). The most common tortoises in Profile Two are size class two (66.2%) and size class one (24.3%) individuals (Table 7.47). The very large (size class four) tortoise makes up only 3.4% of the chelonian assemblage (Figure 7.78). Fully half of the tortoise remains were recovered from spit five (Figure 7.79). A further 30% were recovered from the overlying spit four. Spits two and three display scant tortoise remains. It should be noted that while the number of tortoise remains (NISP) is high, the MNI is low (Table 7.48). The most common appendicular element in the tortoise assemblage was the humerus (5), which had a MNE of four and produced a MNI of two individuals. Shell remains were abundant, but much of this material could only not be assigned to specific element or even to carapace or plastron, and is thus excluded from skeletal frequency analysis. The most common shell elements are marginals (35). A living tortoise commonly contains 22 marginals, 11 on each side on the carapace. Using this value to estimate the MAU of tortoises indicates that at least two individuals contributed to the assemblage.

7.5.2 Anatomical Composition of Chelonia

Table 7.49 displays the chelonia elements collected from Profile Two. Of the 148 tortoise specimens collected from Profile Two, only 12.2% was identified to the appendicular or axial skeleton, the remaining 87.8% are shell fragments from the carapace or plastron. Almost a third of tortoise remains from Profile Two were derived from size class two (66.2%), with size class one (24.3%) remains also fairly common (Figure 7.80). Size class three (6.1%) and size class four (3.4%) remains were rare. The majority of chelonian remains from Profile Two were recovered from spit five (50.7%) and spit four (29.7%) (Table 7.50 and Figure 7.81). Chelonia remains were rare in spit two (5.4%) and spit three (2.7%). By far the most common body size of tortoise remains from Profile Two was size class two (66.2%).

Chelonia appendicular and axial remains

A total of 18 (12.2%) appendicular and axial elements were recovered from tortoises in Profile Two. Chelonia appendicular and axial elements recovered include the scapula, humerus, radius, femur, ilium, phalange, vertebra and even a long bone fragment (Table 7.49). The most commonly recovered appendicular elements were the humerus (27.8%), ilium (22.2%), and femur (16.7%) (Figure 7.82). Most chelonia appendicular and axial material came from size class two (77.8%) individuals, although occasional size class three (5.6%) and size class four (16.7%) remains were also recovered (Figure 7.83). No size class one appendicular or axial elements were recovered from Profile two. This is particularly interesting given the large sample of size class one shell remains (see below). It is possible that size class one tortoise appendicular and axial remains are being included in the microfaunal sample and thus being overlooked from this analysis. A future investigation in the microfauna recovered in this study will be beneficial in identifying whether size class one appendicular tortoise remains are being lost from the system. All scapula, radius, femur, ilium and phalange remains were derived from size class two tortoises (Figure 7.82). Most (80%) humeral remains were derived from size class two, although a single (20%) size class four humerus was also recovered. Other size class four remains included the long bone fragment and a single (50%) vertebra specimen. Size class three was represented by a single (50%) vertebra specimen. Tortoise skeletal elements were recovered from all spits, however spit four (38.9%) and spit five (27.8%) produced most of the tortoise skeletal material (Figure 7.84). Humeral remains were recovered from spits one (20%), two (40%), three (20%) and five (20%) (Figure 7.85). The femur was recovered from spit two, spit four and spit five (33.3%, respectively). The ilium and vertebra were recovered from spits four and five and spits four and one, respectively. The scapula, radius and ilium elements were only recovered from spit four.

Chelonia Shell

The majority (87.8%, 130) of tortoise material recovered in Profile Two was assorted shell specimens (Table 7.49). Tortoise shell material can be broken down into plastron and carapace remains and from there into individual shell elements. A great deal of chelonia material could not be assigned to either carapace or plastron and were thus recorded as shell indeterminate. In Profile Two a total of 36 (27.7%) carapace elements, 5 (3.8%) plastron elements and 89 (68.5%) chelonia shell remains were recovered (Figure 7.86). The carapace was represented mostly by marginals (97.2%) and a single (2.8%) neural

fragment (Figure 7.87). Within the carapace of a tortoise the marginals can be considered the most conspicuous and most easily recognisable elements. Even small and highly fragmented marginals can be readily identified. In addition, marginals have the highest density bone of any element in the carapace. The plastron was represented by fragments from the hypoplastron (40%), epiplastron (20%) and indeterminate plastron (40%) (Figure 7.87). Most (64.6%) tortoise shell material was produced by size class two individuals (Figure 7.88). Size class one (27.7%) shell remains were common, while size class three (6.2%) and size class four (1.5%) were rare. Size class four material was limited to indeterminate shell remains (Figure 7.89). The majority of the carapace material was derived from size class one (54.3%,) and size class two (34.3%) tortoises. Spit five (53.8%), spit four (28.5%) and to a lesser extent spit one (11.5%) produced the majority of the tortoise shell material. Spits four and five were particularly dominated by marginals (25.7%, 65.75%; respectively) and indeterminate shell (30.3%, 51.7%; respectively) remains.

7.5.3 Bone Size Frequency Distribution and Fragmentation Pattern of Chelonia

Maximum Length

Table 8.51 displays the mean, minimum, maximum and standard deviation of the maximum length of tortoise specimens from Profile Two. Maximum length was assessed by size class as well as a single combined sample. The minimum size of tortoise remains recovered from Profile Two was 6 mm in length. The maximum length was 67 mm. There is a distinct difference in mean length from size class one and two to size class three and four. The histograms (Figure 7.90 – Figure 7.94) explore this difference in maximum length according to the size class in greater detail. The majority of remains in the tortoise assemblage displayed maximum length between 5-10 mm, 10-15 mm and 15-20 mm (Figure 7.100). There is an absence of remains between the sizes of 45-60 mm. Size class one tortoises did not exceed 25 mm in length (Figure 7.91). The bulk of the size one sample was below 20 mm in length. Maximum length increaseed in size class two with a greater representation of remains above 20 mm (Figure 7.92), however the average length was very similar to the size one sample. Size class three displayed a single very large (>65 mm) specimen, a couple moderately sized specimens (30-45 m) and an absence of any material less than 10 mm in length (Figure 7.93). The vast majority of material in size class three was between 15 mm and 20 mm in size. Size class four material was grouped between 15

mm and 35 mm, with a single outlier (>60 mm) (Figure7.94). The small sample size of class four must however be noted.

Completeness

Only 3 (2%) out of 148 chelonia specimens were recovered complete (Table 7.53). Complete tortoise remains include a single size class two shell element from the carapace and two skeletals; a humerus and a phalange, both from large (size class four) tortoises. The smaller, size class two remains were more commonly complete (66.6%) than the size class 4 (33.3%).

Fragmentation Patterns

Table 7.54 displays the breakage classes observed in tortoise appendicular elements. Humeral remains were evenly distributed between complete specimens, proximal end and proximal, distal and middle shaft remains (20%, respectively). The radius was represented by the proximal end. Femoral remains included proximal shaft, distal shaft, and an incomplete distal end (33.3%, respectively). Long bone fragments were represented by the middle shaft. The most common portion of the ilium recovered was the proximal shaft (50%), while the distal shaft (25%) and a portion containing the acetabulum (25%) were also recovered. The scapula was represented by the distal-most end of the blade where it attaches to the shell. Vertebra were all represented by the body.

Fracture Outline

Chelonia appendicular elements

A total of 17 (47.2%) fracture outlines on tortoise long bones were classified in Profile Two (Table 7.55). As noted earlier, all tortoise long bones in Profile Two were derived from size class two or size class four tortoises, with size class two dominating the assemblage. Fracture outlines were observed in 50% (14, 3; respectively) of remains from size classes two and four. The majority of tortoise remains display spiral (76.5%) fractures, although transverse breaks are observed in 23.5% of remains (Figure 7.95). The majority of size class two remains displayed spiral breaks (78.6%) with transverse breaks appearing

occasionally (21.4%) (Figure 7.96). In size class four tortoise remains, spiral breaks occurred on two thirds of remains. Table 7.56 displays an outline of fracture angles observed in tortoise long bones. Transverse breaks were observed in femur (40%), ilium (25%) and long bone fragments (66.6%). Most fracture outlines were observed from spit five (70%), spit two (66.7%) or spit three (50%). Transverse breaks were only observed in spit two (25%), spit four (25%) and spit five (28.6%). The majority of tortoise bones were fractured while fresh.

Chelonia Shell

Fracture angle and outline are normally applied only to long bones in fossil assemblages. However in this investigation I attempted to apply these criteria also to tortoise shell elements, as this material greatly outnumbers the skeletal elements in most samples. A total of 150 (57.7%) fracture outlines were recorded for Profile Two (Table 7.57). This is greater than the total number of shell elements in the assemblage. The reason for this is that every (shell) element analysed is presumed to have two sides, a distal and a proximal (as in long bones). Effectively the 150 fractures in this sample reflects 57.7% of possible fractured edges that could be analysed. Two thirds (66.7%) of the assemblage showed spiral breaks, 30% had transverse breaks and eroded edges were occasional (3.3%) (Figure 7.98). In all size classes approximately 50% to 60% of remains displayed fracture outlines (Figure 7.99). Eroded breaks were only observed in size class one (5.3%) and size class two (3%) (Figure 7.100). Transverse breaks were observed in size classes one (15.8%), two (34.7%) and three (44.4%). Spiral breaks were observed in all size classes and were always the most common fracture outline. Size class four produced only spiral breaks. All spits showed more than 50% of tortoise shell remains displayed fracture outlines, except spit three which displayed 33.3% outlines (Figure 7.101). Eroded breaks were observed in spit one (10.5%), spit four (2.2%) and spit five (2.5%) (Figure 7.102). Transverse breaks were observed in spits one (36.8%), two (20%), four (35.6%) and spit five (26.6%). Spiral breaks were dominant in all spits and were the only fracture outlines observed in spit three. Shell remains concur with appendicular elements that the majority of the chelonid assemblage was fractured while bone was fresh.

Fracture Angle

Chelonia appendicular elements

A total of 19 fracture angles were classified in tortoise long bones, representing 52.8% of all possible long bone breakages (Table 7.58). The most common fracture angle in tortoise appendicular elements was oblique (47.4%), followed by mixed (31.6%) and right (21.1%) angled fractures (Figure 7.103). Most (50%) size class two tortoise appendicular elements display oblique fractures (Figure 7.104). Size class four remains are evenly distributed between the three fracture angle types. Table 7.59 displays fracture angles observed on tortoise long bones. Oblique fractures were observed on humerus (66.7%), femur (25%), ilium (75%) and long bone fragments (50%) (Figure 7.105). Right angle breaks were observed on femur (25%), ilium (25%) and long bone fragments (50%). Mixed breaks were observed on scapula (100%), humerus (33.3%), radius (100%) and femur (50%) elements. Oblique fractures were dominant in humerus (66.7%) and ilium (75%). Mixed fractures were dominant in scapula (100%), radius (100%) and femur (50%) elements. Fracture angles were observed and classified in all spits (Table 7.60), but were particularly predominant in spit five (80%) and spit two (66.7%) (Figure 7.106). Oblique fractures were observed in all spits, except spit three. Right angled fracture angles were observed in spits two (25%), four (20%) and five (25%) (Figure 7.107). Mixed fractures were observed in spits three (100%), four (60%) and five (25%). Thus, spit one displayed only oblique fractures and spit three displayed only mixed fractures. Oblique breaks were the dominant fracture angle in remains from spits one, two and five. Mixed breaks were the dominant fracture angle in spits three and four.

Chelonia Shell

A total of 146 tortoise shell specimens displayed fracture angles, representing 56.2% of all possible identifications (Table 7.61). Right (42.5%) fracture angles were the most common, followed by oblique (30.8%), and mixed (26.7%) (Figure 7.108). All size classes were represented but fracture angles were particularly prevalent in size class four (75%) (Figure 7.109). Oblique fracture angles were dominant (50%) in size class one, while right fracture angles were dominant in size class two (47.4%) (Figure 7.110). Both oblique and right fractures angles were pervasive in size class three. All fracture angles were equally represented in size class four. Fracture angles were observed and classified in all spits (Table 7.62), but were particularly prevalent in spits one (63.3%) and four (60.8%). All spits presented all fracture types except spit three which lacked mixed fractures (Figure 7.111). Oblique breaks are most

prevalent (40%) in spit four. Right angled breaks are most prevalent in spits one (57.9%) and five (45.3%). While mixed breaks are most prevalent in spit two (60%).

7.5.4. Surface Modifications of Chelonia

Bone Weathering

A total of 25 (16.9%) chelonia remains were weathered (Table 7.63), of which only six (4.1%) specimens were weathered beyond stage one (Figure 7.112). The plastron (40%) appears to have been the most susceptible tortoise element to weathering (Figure 7.113). Weathering was observed in appendicular elements (27.8%), shell (14.6%) and carapace (13.9%) remains. Stage two weathering was observed on appendicular elements l (11.1%) and shell (4.5%) remains (Figure 7.114). Weathering was observed in humerus (2), femur (2) and ilium (1) remains. Stage one weathering was observed in femur and humerus, stage two in ilium and femur elements (Figure 7.115). Size class three displays the highest prevalence of weathering with a third of the assemblage affected (Table 7.64). Stage two weathering was only observed in size class two (Figure 7.116).

Burning

Burning damage was observed on 10.1% (15) of chelonia remains (Table 7.65). The majority of burning in tortoise remains was stage one (5.4%) or stage three (3.4%) in intensity (Figure 7.117). Most of the burning was observed on tortoise plastron (20%) and carapace (16.7%) elements (Figure 7.118). Chelonia appendicular (11.1%) and plastron (20%) elements were only burnt to stage one (Figure 7.119). Stage two (8.3%) burning was only observed in the carapace. Stage three burning was observed in the carapace (40%) and shell (60%). Stage four was only observed in shell remains. In the carapace, stage one (8.3%) and stage three (5.6%) were the most common burning. In shell elements, stage three (3.4%) and stage one (2.2%) were the most common damage. Burning in appendicular elements was limited to humerus and radius (one each). Burning was only observed on size class one and size class two tortoises (Table 7.66), with most of the burning having occurred on the size class one (19.4%) remains (Figure 7.120). Stage two (2.8%) burning was only observed in size class one remains, while stage four (1.2%) burning was only observed in size class two remains. Note that these correlate to a carapace and a shell specimen, respectively. Stage one (11.1%) and stage three (5.6%) were the most common degrees of

burning in size class one tortoises, although stage two (2.8%) was also observed. On the other hand, stages three (3.6%), one (2.4%) and four (1.2%) were observed in size class two. A total of 13 (86.7%) tortoise shell and skeletal elements displayed burning all over (Table7.67), that is to say, on the inner and outer surface or on the proximal and distal ends (Figure 7.121). A single (6.7%) carapace remain was burnt along one edge, suggesting prior disarticulation. A single shell element (6.7%), displayed burning on the inner surface only, which could suggest burning after disarticulation of the shell. No remains displayed burning on the outer surfaces only.

Staining

In contrast to the mammal assmblage, where 80% of the sample was stained, staining was observed in just over half (57) of the chelonia assemblage (Table 7.68). The plastron (80%) displays a stronger tendency towards staining (Figure 7.122) than any other tortoise element. Stage one (37.2%) staining was most prevalent in tortoises, while stage three was rare (1.2%) (Figure 7.123). Most chelonia skeletals were stained to stage one (27.8%) and stage two (16.7%), with a single stage three (5.6%) specimen (Figure 7.124). Carapace elements displayed stage one (30.6%) and stage two (19.4%) staining. A total of 60% (3) of the plastron assemblage was stained to stage one, and a single remain displayed stage three (20%) modification. Chelonia shell elements were mostly stained to stage one (40.4%) with a few (9%) stage two specimens.Staining in tortoise skeletals was observed in humerus, femur, ilium, vertebra and long bone fragments (Figure 7.125). The humerus and long bone fragments displayed stage one staining on respectively 60% (3) and 100% (1) of specimens. Femoral remains were equally split between stage one (33.3%) and stage two (33.3%) staining. Half of the ilium remains displayed stage two staining, while half of the vertebrae displayed stage three staining. All staining in the tortoise skeletal was brown coloured, save for a single purple stainined vertebra and an orange stained long bone fragment. Staining was observed in size class one (50%), two (52.4%) and three (50%) shell remains (Table 7.69 and Figure 7.126). The majority of staining in size class one remains was stage one (27.8%) and stage two (19.4%), however a single specimen (2.8%) displayed stage three staining (Figure 7.127). Stage three staining was only observed in size class one remains. Staining in size class two and three was limited to stage one and stage two and in both cases the former made up a substantially greater proportion of the sample than the latter (44% to 8.3% and 37.5% to 12.5%, respectively). The majority of staining in tortoise shell remains was brown (62.1%) and orange (34.8%) with sporadic purple (1.5%) and black (1.5%) staining (Table 7.70). Brown stained bones were recovered from all body size classes,

although the bulk (73.2%) of the sample came from size class two remains (Figure 7.128). Purple bones were recovered from a single size class two tortoise. Similarly black staining was observed in a single size class one specimen. Orange staining was observed in all size classes, but was most common in size class two (56.5%) and size class one (34.8%) remains.

Abrasion

A total of 95.9% (142) of chelonia bones from Profile Two were abraded (Table 7.71). Most abrasion in tortoise remains was stage three (39.9%) and stage two (34.5%) in intensity, with infrequent stage four (6.1%) also observed (Figure 7.129). The greatest frequency of abrasion was observed in shell (97.8%), carapace (97.2%) and appendicular elements (94.4%) elements (Figure 7.130). In comparison, the plastron showed relatively little (60%) abrasion, perhaps indicating some resistance to this type of modification. Appendicular elements were most commonly abraded to a stage two (55.6%) degree (Figure 7.131). Occasional examples of stage one and stage three (16.7%, respectively) were also recorded, along with a single (5.6%) stage four specimen. Carapace elements displayed mostly stage three (50%) and stage two (30.6%) abrasion, with the remainder displaying stage one (16.7%). The plastron was equally (20%, respectively) represented by stages one, two and three; stage four was absent. Stage three (41.6%) and stage two (32.6%) were most abundant in shell elements, which additionally displayed stage one (14.6%) and occasional stage four (9%). All but one appendicular specimen (a femur) displayed abrasion, mostly stage two in intensity (Figure 7.132). Stage one abrasion was observed in vertebra and femur specimens, incidentally these were the only elements not to display stage two abrasion. Stage three abrasion was observed in vertebra and ilium remains, while stage four was observed in humerus only. All size class three and four remains were abraded (Table 7.72). Size class one showed the smallest percentage of abraded bones, although this was still 91.7% of the sample (Figure 7.133). Size class one tortoise shell displayed stage two (38.9%), stage one (27.8%), stage three (22.2%) and infrequent stage four (2.8%) abrasion (Figure 7.134). Size class two likewise displayed all stages of abrasion, but was dominated by stage three (47.6%) modification. Stage four was absent from size class three, and size class four only displayed stage three abrasion.

Sheen and polish

Sheen was observed on 28.4% (42) of tortoise remains from Profile Two (Table 7.73). The majority of chelonia remains displayed stage one sheen (17.6%), with stage two and three occurring on less than 10% of remains (Figure 7.135). Sheen in tortoise elements varies between 40% and just under 30% of remains displaying modification, with the plastron (40%) and appendicular elements (33.3%) appearing most affected (Figure 7.136). Appendicular elements display a very distinct pattern from other chelonia material, in being heavily dominated by stage three (27.8%) sheen and with a lack of stage two (Figure 7.136). The carapace and shell elements display stage one (16.7%, 20.2%; respectively), stage two (8.3%, 5.6%) and stage three (2.8%, 1.1%) sheen. The plastron displayed equal numbers of stage one (20%) and stage two (20%) sheen and lacked any stage three remains. Sheen was absent in tortoise radius, phalange, vertebra and long bone fragments. Sheen was observed on scapula (100%), humerus (20%), femur (66.6%) and ilium (50%) elements (Figure 7.137). Sheen in the scapula was stage one, the remaining elements all displayed stage three sheen. Sheen was most prevalent in size class four (50%) and size class one (33.3%) shell remains (Table 7.74). Size class three was least affected (Figure7.138). Stage three sheen was only observed on size class one (2.8%) and two (1.2%) shell remains (Figure 7.139). Stage two sheen was observed in size class one (5.6%), two (7.1%) and three (12.5%) and was the only sheen observed in the latter. Size class four remains display only stage one (50%) sheen.

Trampling

Trampling was observed in 26.4% (39) of chelonia remains in Profile Two (Table 7.75). Trampling in chelonia was limited to stage one (24.3%) and very occasionally stage two (2%) modification (Figure 7.140). Trampling was common on carapace (36.1%) elements but was also observed on appendicular elements (22.2%) and shell remains (24.7%); it was absent on plastron remains (Figure 7.141). Stage two trampling was limited to three (3.4%) shell remains. Trampling in the appendicular skeleton was observed in humerus (60%) and vertebra (50%) remains. Size class four (50%) shell remains displayed the highest percentage of trampling, followed by size class two (28.6%) (Table 7.76 and Figure 7.142). Trampling marks observed in chelonia remains include pits (10.1%), notching (0.7%), scores (18.2%) and scratching (1.4%) (Table 7.44 and Figure 7.73). Table 7.77 and Figure 7.143 display the types of trampling marks observed in chelonia elements. Pit marks were observed in shell (46.7%), carapace (33.3) and appendicular elements (20%). A single skeletal displayed notching and two shell elements displayed

scratching. Scores were observed on shell (59.3%), carapace (37%) and a single (3.7%) appendicular element. Pits were observed in size class one (20%), two (73.3%) and size class three (6.7%) tortoise shell remains. Notching was observed in a single size class four remain and scratching in two size class two remains. Scores were observed in size class two (66.7%), size class one (22.2%), size class three (7.4%) and size class four (3.7%).

Carnivore Tooth Marks and Digestion

A total of two (1.4%) chelonia specimens displayed carnivore tooth marks, these were the only tooth marked bones in the Profile Two assemblage. All tooth marks observed in spit two consisted of pit marks. Tooth marked bones displayed only occasional (stage one) marks. Tooth marks were observed in size class two (100%) remains only. Tooth marks were observed in remains from spit four (50%) and spit five (50%). Digestion was observed on a single (0.7%) chelonid remain in Profile Two. The digested bone was not tooth marked. Digestion in Profile Two consisted of stage two pitting and surface etching. It was observed in a size class four tortoise from spit five. Profile Two displayed the lowest relative frequency of tooth marked bone, but note the low prevalence of this modification throughout all test pits excavated.

Root Etching

A total of 52 (35.1%) chelonia specimens from Profile Two display root etching (Table 7.78). Of these, the majority (24.3%) of remains displayed stage one marking, with stage two (8.8%) and stage three (2%) occurring more infrequently (Figure 7.144). Root marking occurred extensively in plastron (40%) and shell (42.7%) remains (Figure 7.145). Appendicular elements (27.8%) and carapace (17.4%) elements were less heavily modified by roots. Appendicular elements are characterised by a low incidence of stage one (5.6%) root etching and equal occurrences of stage two and three etching (11.1%, respectively) (Figure 7.146). Carapace elements displayed stage one (19.4%) etching exclusively. In the plastron stage one and stage two appeared with equally low (20%) incidence. The majority of shell elements display stage one (30.3%) etching with some stage two (11.2%) and sporadic stage three (1.1%) modification. Root etching was absent in scapula, phalange, vertebra and long bone fragments. Root marking was observed in humerus (20%), radius (100%), femur (33.3%) and ilium (50%) remains

(Table 7.79). Stage one etching was observed in ilium remains (25%), stage two in ilium (25%) and radius (100%) and stage three in humerus (20%) and femur (33.3%) elements. Root etching was absent from size class four remains (Table 7.80), it was observed in 38.1% (3) of size class two remains, 37.5% (32) of size class three and 33.3% (12) of size class one (Figure 7.147). The majority of size class one and two remains displayed stage one etching (27.8%, 27.4%; respectively) (Figure 7.148). Size class three remains displayed stage one (25%) and stage three (12.5%) etching.

Other surface modifications

No other surface modifications were observed in Chelonia remains from Profile Two.

7.6 AVIAN TAXONOMY AND TAPHONOMY

7.6.1 Taxonomic Abundanceof Aves

A total of three aves specimens (Table 7.81), representing 1.5% of the assemblage were recovered in Profile Two. Birds in Profile Two include representation from size class two, three and four. Birds were recovered in spits one, four, and five. Profile Two produced the lowest relative frequency of avian remains in this study.

7.6.2 Anatomical Compositionof Aves

A total of three avian remains were recovered from Profile Two. These included a size class two humerus from spit one, a second phalange (from the wing) of a large bird (size class four) from spit four and an size class two ulna from spit five (Table 7.82).

7.6.3. Bone Size Frequency Distribution and Fragmentation Profile of Aves

Maximum Length

Maximum length in avian remains was 15 mm in the humerus, 10 mm in the ulna and 11 mm in the second phalange. Average specimen size in the bird sample was 12 mm.

Epiphyseal Fusion

All three bird remains displayed fusion on at least one end consistent with adult specimens.

Completeness

There were no complete bird remains in Profile Two.

Breakage Patterns

All bird remains were represented by incomplete proximal ends (Table 7.82).

Fracture Outline

Fracture outlines were classified on two (33.3%) specimens in the bird assemblage; namely in the humerus and the ulna. In both cases the breaks were spiral.

Fracture Angle

Fracture angles were observed in two (33.3%) bird remains from Profile Two. The bird humerus displayed a mixed fracture angle and the ulna an oblique fracture angle.

7.6.4. Surface Modification of Aves

Sub-aerial weathering, burning, polishing, trampling, insect modifications and carnivore modifications were absent in avian remains from Profile Two.

Staining

Staining was observed in all three bird remains (Table 7.8). All staining in birds was stage one. A total of 66.6% of staining in birds was brown, the remaining specimen (wing phalange) was stained orange (Table 7.83).

Abrasion

All bird remains displayed abrasion (Table 7.12). Abrasion in birds was limited to stage one (humerus, 33.3%) and stage three (66.65%) modification (Table 7.84 and Figure 7.149).

Root Etching

A single (33.3%) aves specimen displayed stage one root etching (Table 7.19). Root etching appeared on the size class three humerus, recovered from spit one.

7.7. DISCUSSION

7.7.1 Taxonomic Comparison

Taxonomic composition

A total of 202 identifiable remains were collected from Profile Two, representing only six mammal and two chelonian individuals. This represents a low overall specimen density compared to the other test pits excavated in this analysis. Profile Two displayed the lowest relative frequency of identifiable bones in this study. The high proportion of unidentifiable bones is linked to high fragmentation, which suggests that bones underwent transport and/or were deposited in a high energy environment. In total, mammals contributed to only a quarter of the assemblage but this is consistent with the other test pits, for example, mammals represent only 10% of the Profile One sample (see Chapter Eight).

Chelonia were the most commonly occurring taxonomic group in Profile Two. Very little of the Profile Two material could be identified below the family level, and the most commonly occurring mammal families were bovids and carnivores. These patterns are observed in all the test pits excavated in this analysis. Profile Two had the lowest frequency of avian remains of any of the test pits. Fragile avian remains can be expected to suffer heavy destruction in a high energy depositional environment, which may be the cause of the low frequency of these remains. It is also possible that Profile Two is sampling from an environment where birds are scarce, although given the frequency of birds in the other test pits and the proximity of this site to the bonebed, this is unlikely.

Fragmentation Pattern

Fossil material from Profile Two displays a high level of fragmentation, with the largest bone collected measuring only 65 mm. Average size was greater in mammalian remains than chelonian, although both taxonomic groups display large outliers, for reasons unknown. Body size in mammals and chelonian was small; there were no megamammals (size class five) recovered (despite the proximity of Profile Two to the megamammal bonebed) and the vast majority of chelonian remains were size class one and two. The numbers of complete remains were low in mammals and tortoises and mostly limited to small compact bones. No mammal long bones were recovered intact. There does not appear to be any correlation between breakage and bone density. Fusion, fracture outline and fracture angle could only be assessed on a small sample of the assemblage due to the high degree of breakage. Fracture outlines

and fracture angles in both the mammal and chelonia samples indicate that most of the fragmentation occurred while the bones were fresh.

The chelonia assemblage was dominated by shell elements. This pattern is typical of many archaeological tortoise assemblages (Klein & Cruz-Uribe 1983; Sampson 1998; Thompson & Henshilwood 2014; Reynard *et al*. 2015). The high frequency of chelonian shell elements is an artefact of the higher abundance of these elements in a typical tortoise skeleton (see Chapter Nine for further discussion). There is a dominance of size class two chelonia remains. As noted in the methodology, size in chelonia was estimated by eye in a wholly subjective manner. In addition, chelonia size classes are arbitrary and may not represent a distinct taxon. Thus, it is unclear what chelonian species the size class two remains represent; or whether this material was derived from adult or subadult individuals. In the appendicular skeleton in reptiles fusion of the epiphyses does not play a role in juvenile development (Gerlach 2012; Farke & Distler 2015). Klein & Cruz-Uribe (1983, 1987) advocate the use of the humeral or femoral distal width to give an indication of the living size (mass) of the tortoise. The area required for measuring was not preserved or was only partially preserved in both the chelonian humerus and femur recovered from Profile Two, thus it was not possible to assess size class based on appendicular metrics in this analysis. Additionally, this method can only be applied where the chelonid species is known.

Surface Modifications

Surface modifications were common in mammals and chelonia from Profile Two. The most commonly occurring modifications were abrasion, staining and root etching (Figure 7.150). These were, in addition, the only surface modifications observed in the avian sample (Table 7.85). All surface modifications observed in Profile Two displayed light to moderate damage, with the exception of abrasion which displayed predominantly moderate to heavy damage. Biological modifiers and accumulating agents (like carnivores) do not appear to have had a large role in accumulating the Profile Two sample. The lack of weathering and insect modifications suggests quick burial with little surface exposure for the bones. The low numbers of burnt bones support this. The very high numbers of abraded bones together with the occurrence of polishing (sheen) suggests either transport from elsewhere into the depositional environment of Profile Two, or may reflect movement of fluids or sediments within the system itself. While indications are that bones were covered or buried quickly, the high prevalence of trampling marks

suggests that bones were subjected to a great deal of movement (possibly within the sediment) before final burial. The high numbers of stained and root etched bones indicates strong post-depositional processes. It is unclear how much of the root etching observed on remains from Langebaanweg is ancient and how much might be the result of modern roots, which have gained access to the deposits due to mining stripping away protective overlying sediments. Modern root traces were observed occasionally in all excavated Profiles so the effects of modern roots can not be ruled out.

7.7.2 Comparison between the MPPM and LQSM

There is a distinct change in overall specimen density and taxonomic composition that reflects the transition from the MPPM to the LQSM. Mammals were the dominant taxon in spits one, two and three; however there is a sudden change over in taxonomic composition in spits four and five where chelonia remains (89.8%, 91.5%; respectively) are vastly dominant. This pattern contrasts strongly with Profile One, where the LQSM layers preserve less bones with fewer chelonian remains. The sudden change over in taxonomic composition could be an indication of a change in depositional environment or ecology between the MPPM and the LQSM in Profile Two. Spit three produced particularly low numbers of bones. The reason for this is unclear, but could be an artefact of its position at the contact between the MPPM and LQSM.

The MPPM displayed higher levels of staining, weathering and root etching than the LQSM (Table 7.86; Figure 7.151). Part of this may be a factor of the higher number of mammal remains in the MPPM, particularly in the case of staining and root etching. But it otherwise suggests that bones in the MPPM may have been exposed for longer on the surface before being buried, and may have undergone different or more extensive post-depositional alteration.

7.7.3 Depositional environment

There is a distinct change in overall specimen density and taxonomic composition that reflects the transition from the MPPM to the LQSM. Mammals were the dominant taxon in spits one, two and three; however there is a sudden change over in taxonomic composition in spits four and five where chelonia remains (89.8%, 91.5%; respectively) are vastly dominant. This pattern contrasts strongly with Profile One, where the LQSM layers preserve less bones with fewer chelonian remains. The sudden change over

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Figure 7.1. View of the 1976/2 excavation facing north. Note the horizontal trenches and the diagonal lines of the grid squares.



Figure 7.2. View of the Profile Two excavation facing south. Note the bulkhead material against the south wall and colour mottling of the surface sands



Figure7.3. Fine laminations in the overburden wall from Profile Two



Figure 7.4. Example of an exploded bone in Profile Two



Figure 7.5. *Ikelohyaena abronia* associated upper dentition viewed *in-situ*



Figure 7.6. Interfingering of MPPM and LQSM sediments in Profile Two



Figure 7.7. Continued fine interfingering of the MPPM and LQSM in Profile Two

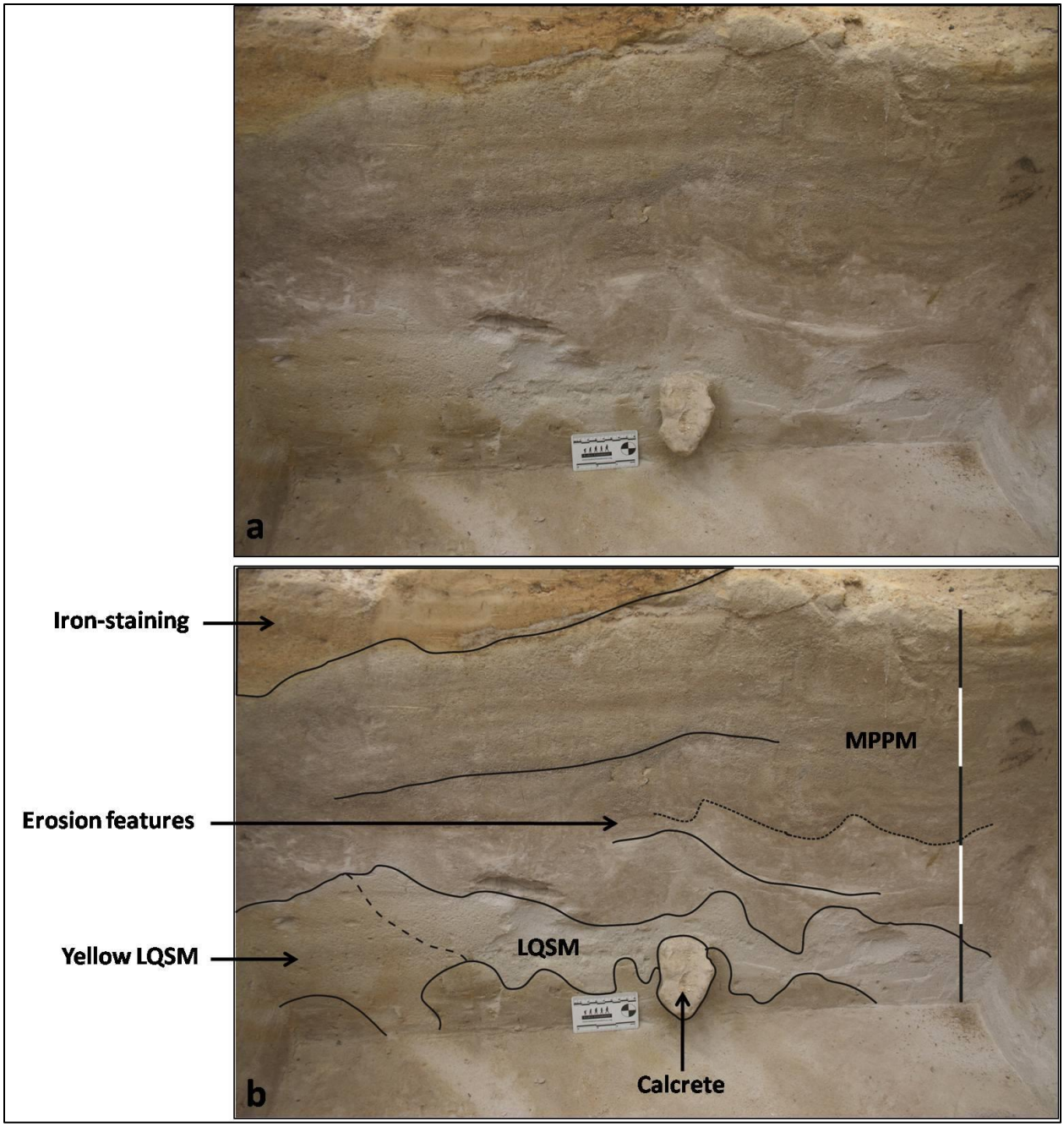


Figure 7.8. Profile wall in Profile Two. (a) original image, (b) annotated image showing relative positions of the MPPM and LQSM

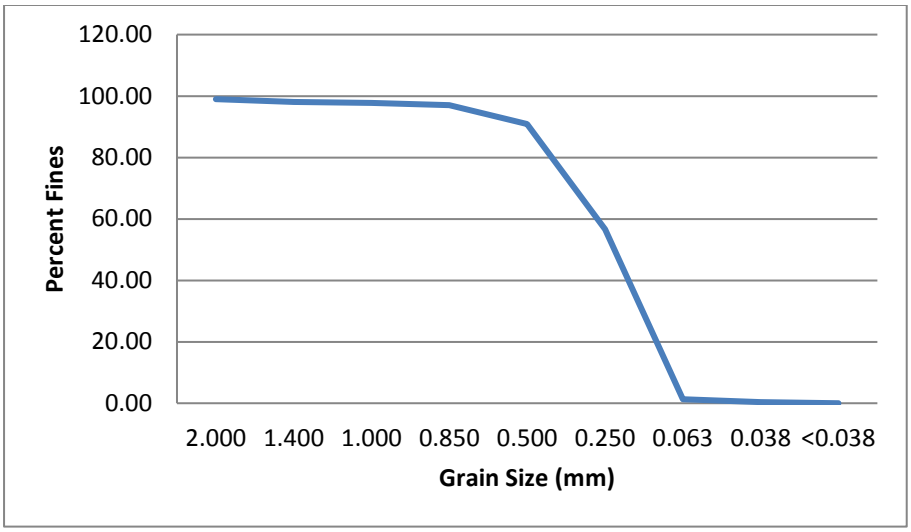


Figure 7.9. Cumulative percentage curve of grain size in the MPPM of Profile Two

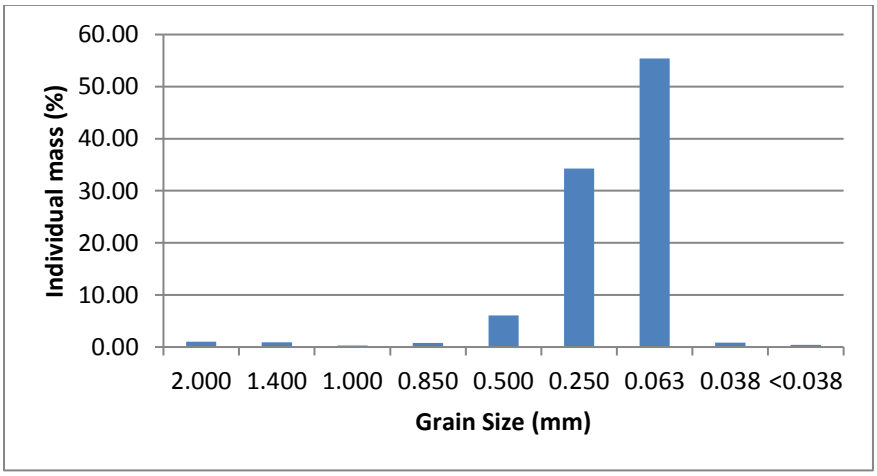


Figure 7.10. Relative frequencies of grain size in the MPPM from Profile Two

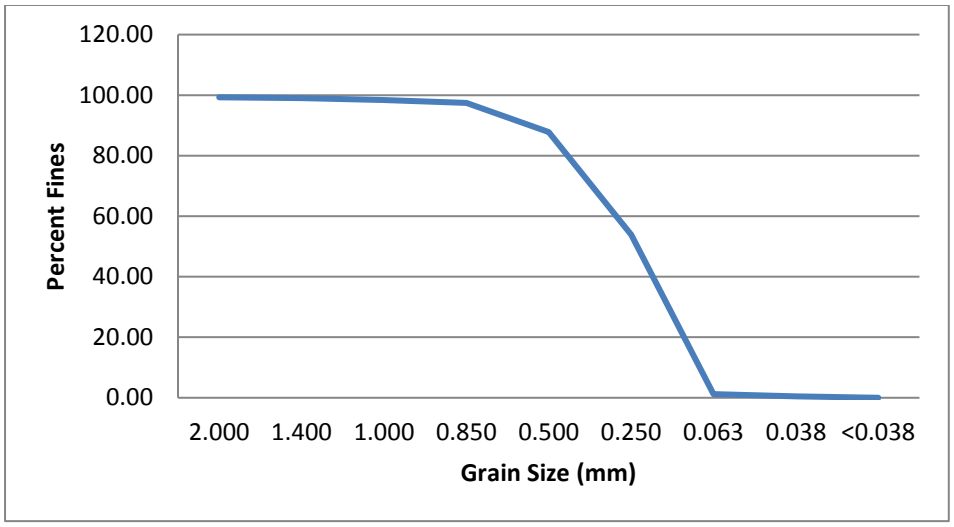


Figure 7.11. Cumulative percentage curve of grain size in the LQSM of Profile Two

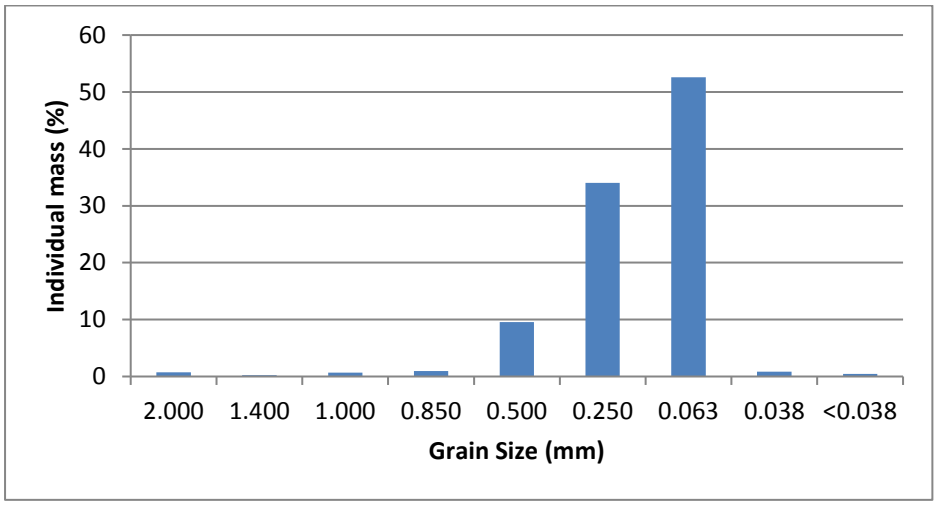


Figure 7.12. Relative frequencies of grain size in the LQSM from Profile Two

Table 7.1. Identifiable (NISP) bones by spit in Profile Two.

	NISP	%
Spit 1	35	17.3
Spit 2	22	10.9
Spit 3	14	6.9
Spit 4	49	24.3
Spit 5	82	40.6
Total	202	

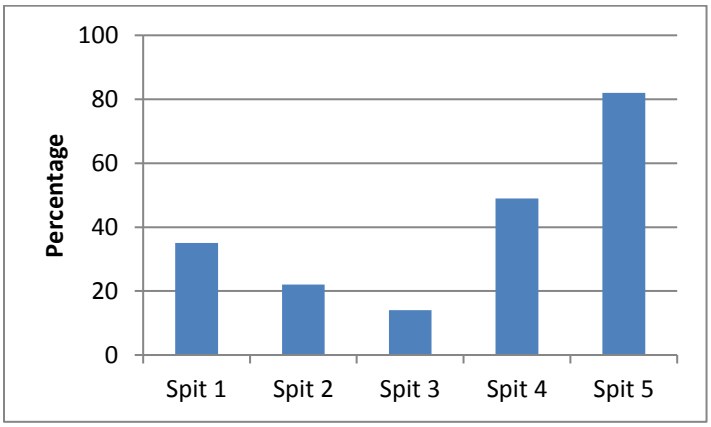


Figure 7.13. Specimen density by spit from Profile Two

Table 7.2. Taxonomic representation of specimens and spit from Profile Two

	Mammal		Chelonia		Aves		Total	
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Spit 1	17	48.6	17	48.6	1	2.9	**35**	**17.3**
Spit 2	14	63.6	8	36.4	-	-	**22**	**10.9**
Spit 3	10	71.4	4	28.6	-	-	**14**	**6.9**
Spit 4	4	8.2	44	89.8	1	2	**49**	**24.3**
Spit 5	6	7.3	75	91.5	1	1.2	**82**	**40.6**
Totals	**51**	**25.2**	**148**	**73.3**	**3**	**1.5**	**202**	

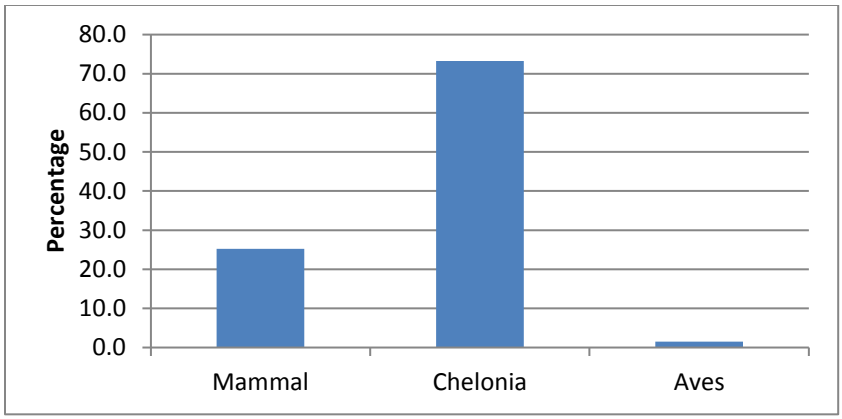


Figure 7.14. Relative frequency of taxonomic groups in Profile Two

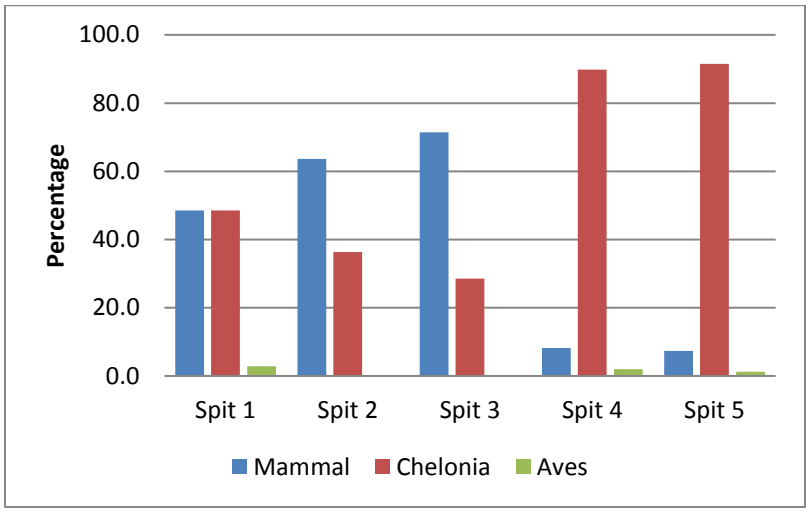


Figure 7.15. Comparison of the relative frequencies of taxonomic groups by spit in Profile Two

Table 7.3. Descriptive statistics of maximum length in combined Profile Two Sample

NISP	202
Minimum	4
Maximum	67
Mean	17.36
Standard Deviation	9.77

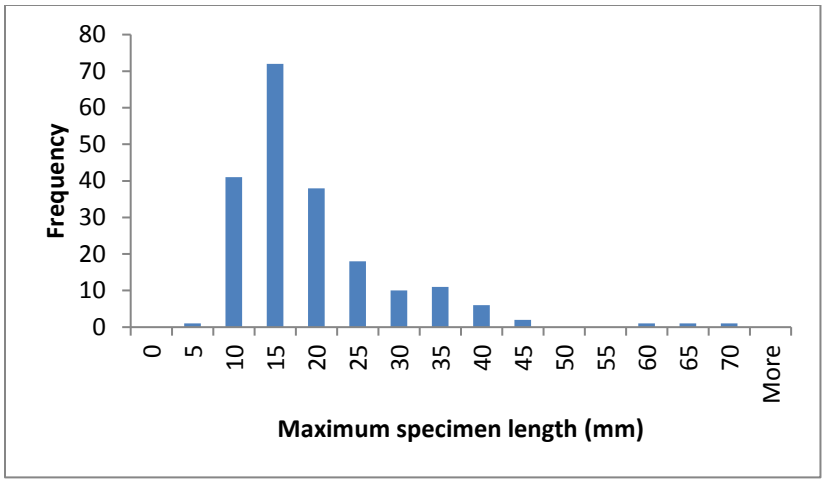


Figure 7.16. Histogram of maximum specimen length in combined Profile Two sample

Table 7.4. Weathering in Profile Two

	Mammals		Chelonia		Aves		Totals	
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Stage 1	14	27.5	19	12.8	-	-	**33**	**16.3**
Stage 2	-	-	6	4.1	-	-	**6**	**3**
Totals	**14**	**27.5**	**25**	**16.9**	**-**	**-**	**39**	**19.3**

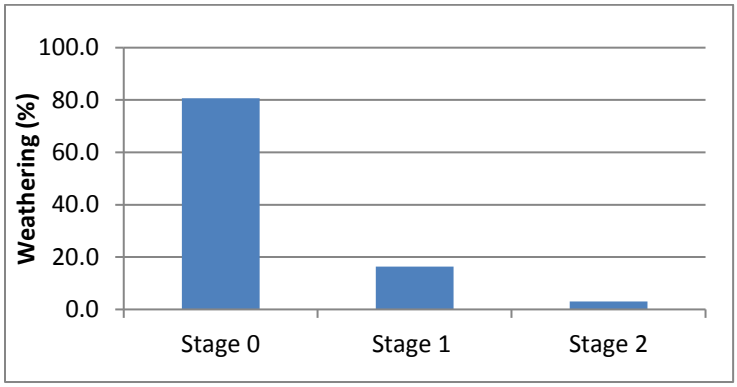


Figure 7.17. Weathering intensity from Profile Two

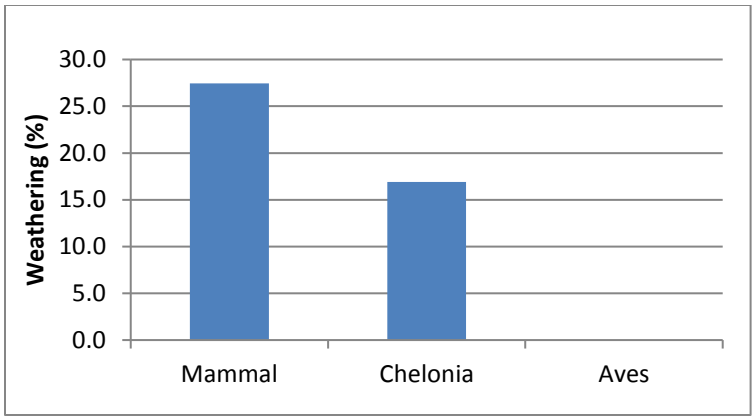


Figure 7.18. Weathering by taxonomic group in Profile Two

Table 7.5. Weathering by spit in Profile Two

	Spit 1		Spit 2		Spit 3		Spit 4		Spit 5		Totals	
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Stage 0	28	80	17	77.3	7	50	43	87.8	68	82.9	**163**	**80.7**
Stage 1	7	20	5	22.7	7	50	4	8.2	10	12.2	**33**	**16.3**
Stage 2	-	-	-	-	-	-	2	4.1	4	4.9	**6**	**3**
	7	**20**	**5**	**23**	**7**	**50**	**6**	**12.2**	**14**	**17.1**	**39**	**19.3**

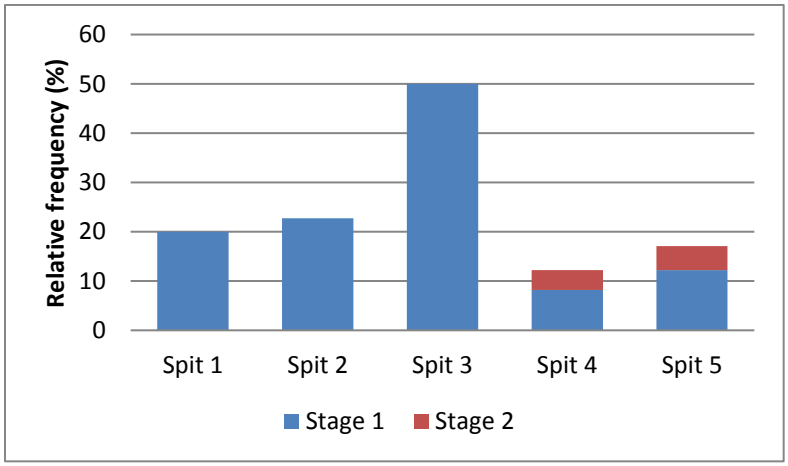


Figure 7.19. Weathering intensity with depth in Profile Two

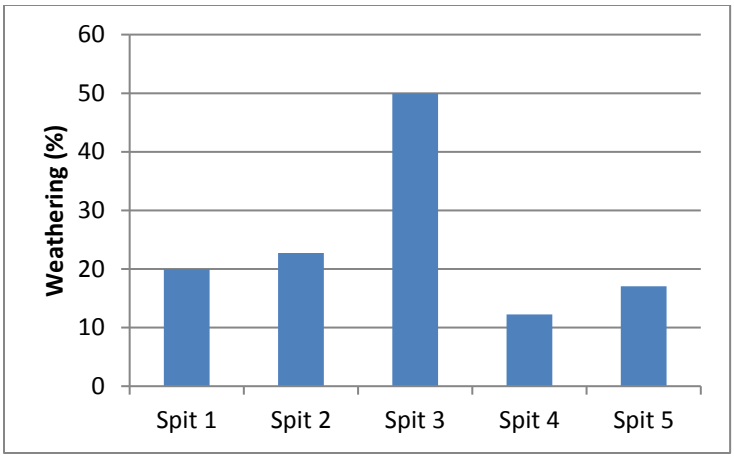


Figure 7.20. Weathering by spit from Profile Two

Table 7.6. Burning in Profile Two

	Mammals		Chelonia		Aves		Totals	
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Stage 1	1	2	8	5.4	-	-	**9**	**4.5**
Stage 2	-	-	1	0.7	-	-	**1**	**0.5**
Stage 3	-	-	5	3.4	-	-	**5**	**2.5**
Stage 4	1	2	1	0.7	-	-	**2**	**1**
Totals	**2**	**3.9**	**15**	**10.1**	**-**	**-**	**17**	**8.4**

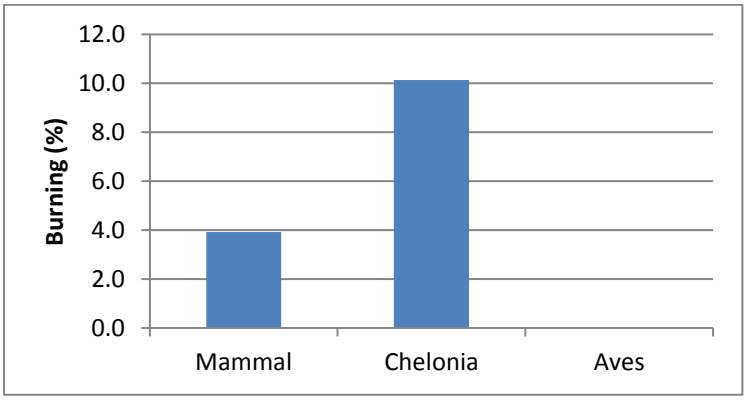


Figure 7.21. Burning by taxonomic group in Profile Two

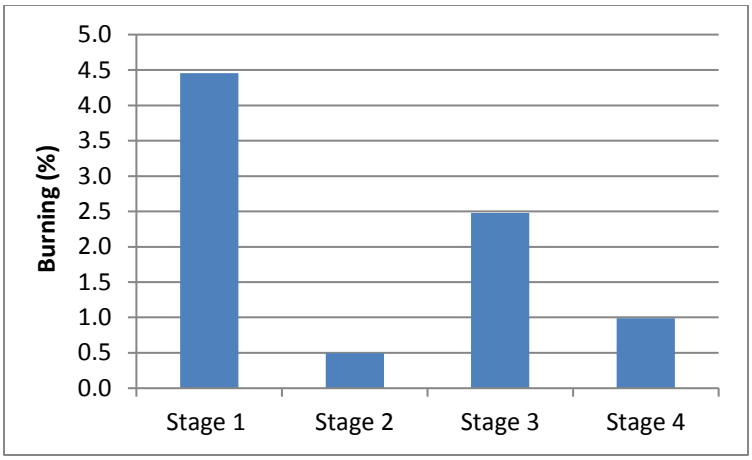


Figure 7.22. Burning intensity in Profile Two

Table 7.7. Burning by spit in Profile Two

	Spit 1		Spit 2		Spit 3		Spit 4		Spit 5		Totals	
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Stage 1	-	-	1	4.5	-	-	3	6.1	5	6.1	**9**	**4.5**
Stage 2	-	-	-	-	-	-	-	-	1	1.2	**1**	**0.5**
Stage 3	-	-	-	-	1	7.1	3	6.1	1	1.2	**5**	**2.5**
Stage 4	-	-	-	-	1	7.1	-	-	1	1.2	**2**	**1**
Totals	**-**	**-**	**1**	**4.5**	**2**	**14.3**	**6**	**12.2**	**8**	**9.8**	**17**	**8.4**

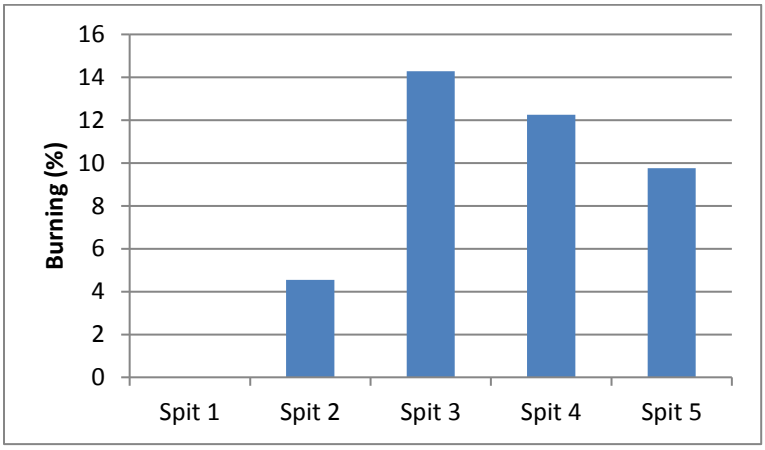


Figure 7.23. Relative frequency of burning by spit in Profile Two

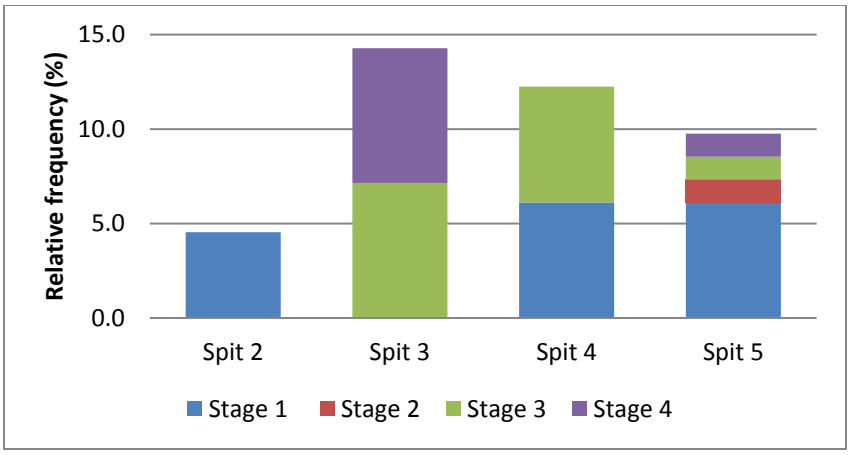


Figure 7.24. Burning intensity with depth in Profile Two

Table 7.8. Staining in Profile Two

	Mammals		Chelonia		Aves		Totals	
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Stage 1	23	45.1	55	37.2	3	100	**81**	**40.1**
Stage 2	12	23.5	18	12.2	-	-	**30**	**14.9**
Stage 3	6	11.8	2	1.4	-	-	**8**	**4**
Totals	**41**	**80.4**	**75**	**50.7**	**3**	**100**	**119**	**58.9**

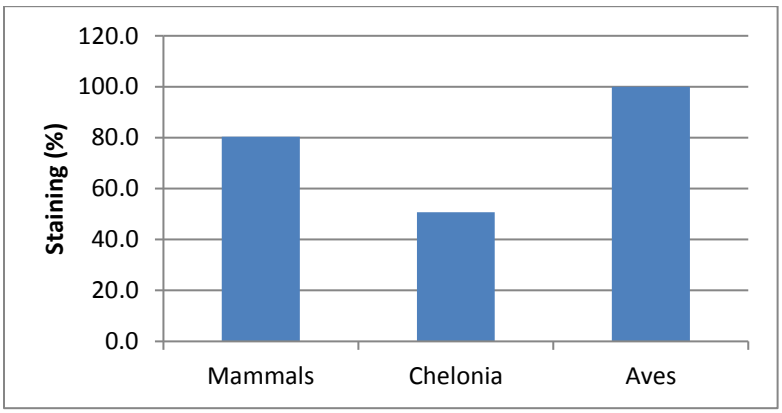


Figure 7.25. Relative frequency of staining by taxonomic group in Profile Two

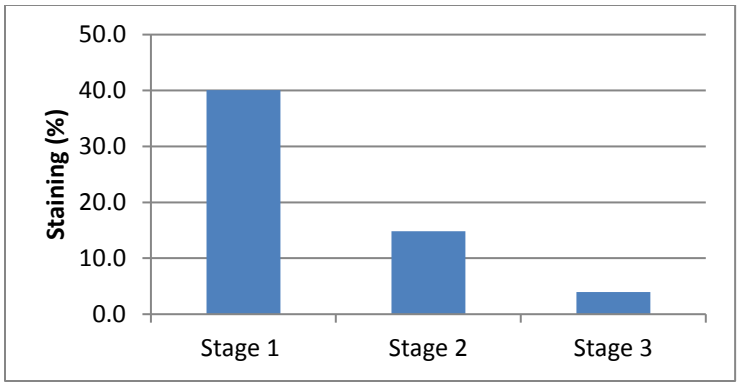


Figure 7.26. Staining intensity in Profile Two

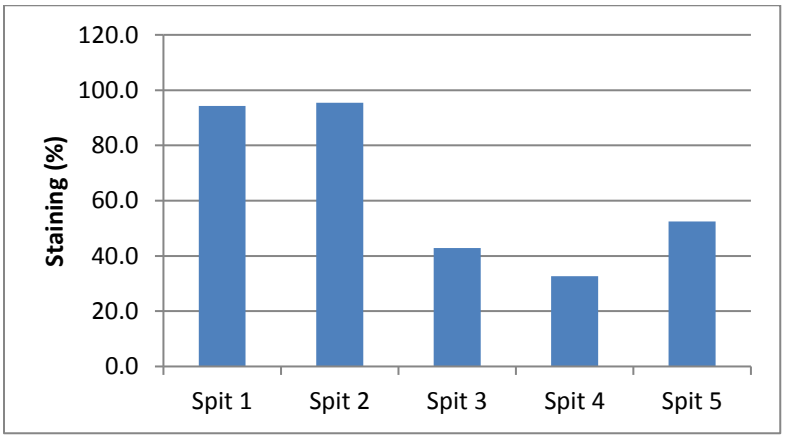


Figure 7.27. Relative frequency of staining by depth in Profile Two

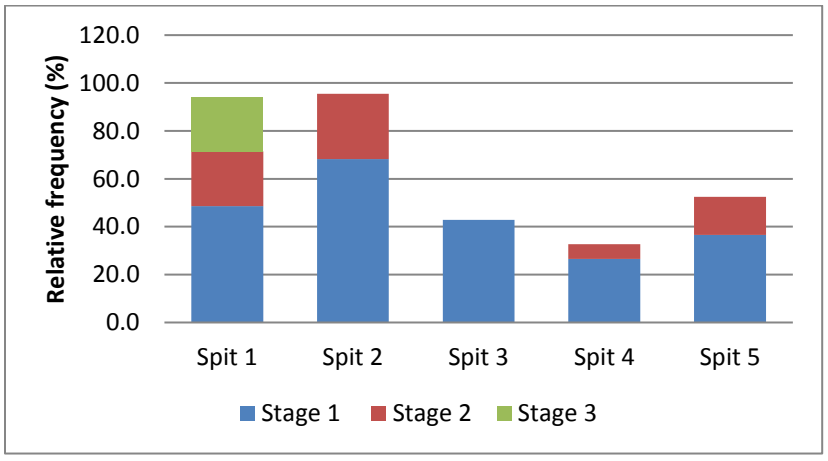


Figure 7.28. Staining intensity by spit from Profile Two

Table 7.9. Staining by spit in Profile Two

	Spit 1		Spit 2		Spit 3		Spit 4		Spit 5		Total	
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Stage 1	17	48.6	15	68.2	6	42.9	13	26.5	30	36.6	**81**	**40.1**
Stage 2	8	22.9	6	27.3	-	-	3	6.1	13	15.9	**30**	**14.9**
Stage 3	8	22.9	-	-	-	-	-	-	-	-	**8**	**4**
Totals	**33**	**94.3**	**21**	**95.5**	**6**	**43**	**16**	**32.7**	**43**	**52.4**	**119**	**58.9**

Table 7.10. Staining colour in Profile Two

	Brown		Purple		Black		Orange		Total	
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Stage 1	61	68.5	1	33.3	2	100	17	68	**81**	**68.1**
Stage 2	22	24.7	-	-	-	-	8	32	**30**	**25.2**
Stage 3	6	6.7	2	66.6	-	-	-	-	**8**	**6.7**
Total	**89**	**74.8**	**3**	**2.5**	**2**	**1.7**	**25**	**21**	**119**	**58.9**

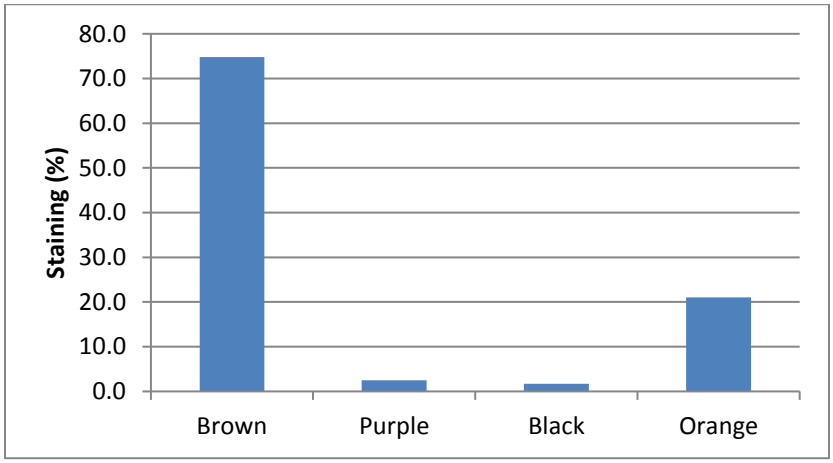


Figure 7.29. Relative frequency of staining colour in Profile Two.

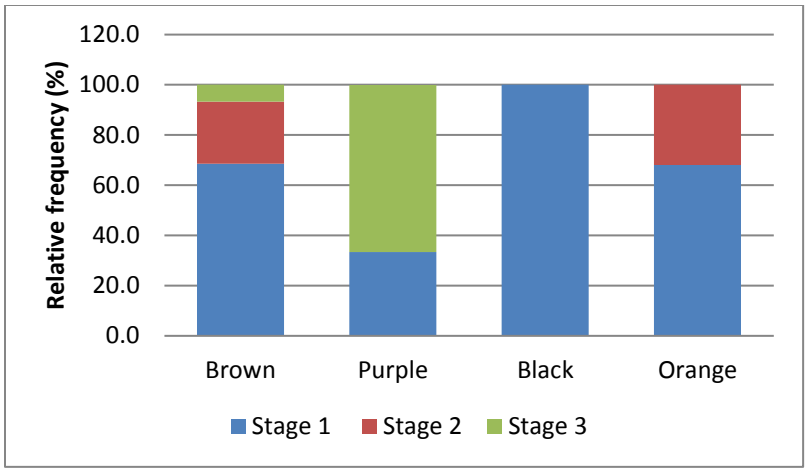


Figure 7.30. Staining colour and intensity from Profile Two

Table 7.11. Staining colour by spit from Profile Two

	Brown		Purple		Black		Orange		Total	
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Spit 1	28	31.5	3	100	-	-	2	8	**33**	**27.7**
Spit 2	21	23.6	-	-	-	-	-	-	**21**	**17.6**
Spit 3	5	5.6	-	-	1	50	-	-	**6**	**5**
Spit 4	10	11.2	-	-	-	-	6	24	**16**	**13.4**
Spit 5	25	28.1	-	-	1	50	17	68	**43**	**36.1**
Total	**89**	**74.8**	**3**	**2.5**	**2**	**1.7**	**25**	**21**	**119**	**58.9**

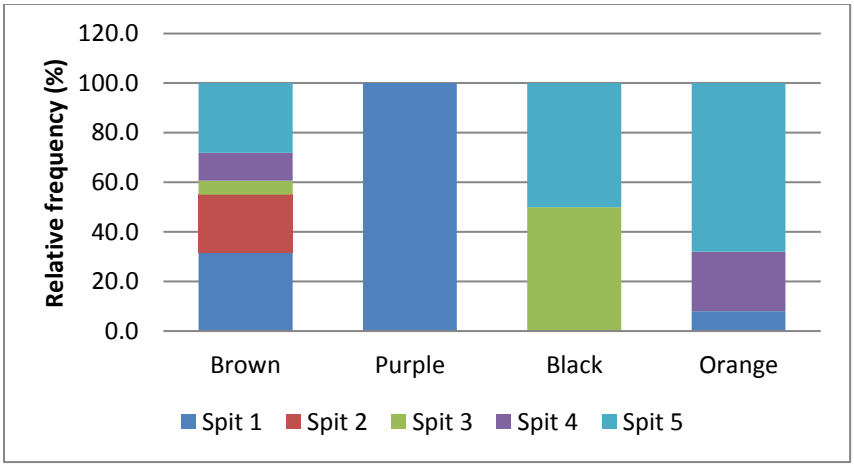


Figure 7.31. Staining colour with depth from Profile Two

Table 7.12. Abrasion in Profile Two

	Mammals		Chelonia		Aves		Totals	
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Stage 1	22	43.1	23	15.5	1	33.3	**46**	**22.8**
Stage 2	13	25.5	51	34.5	-	-	**64**	**31.7**
Stage 3	7	13.7	59	39.9	2	66.6	**68**	**33.7**
Stage 4	2	3.9	9	6.1	-	-	**11**	**5.4**
Totals	**44**	**86.3**	**142**	**95.9**	**3**	**100**	**189**	**93.6**

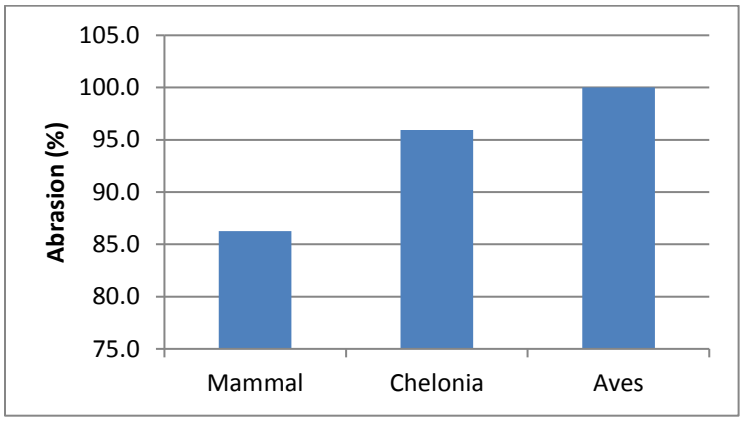


Figure 7.32. Abrasion by taxonomic group from Profile Two

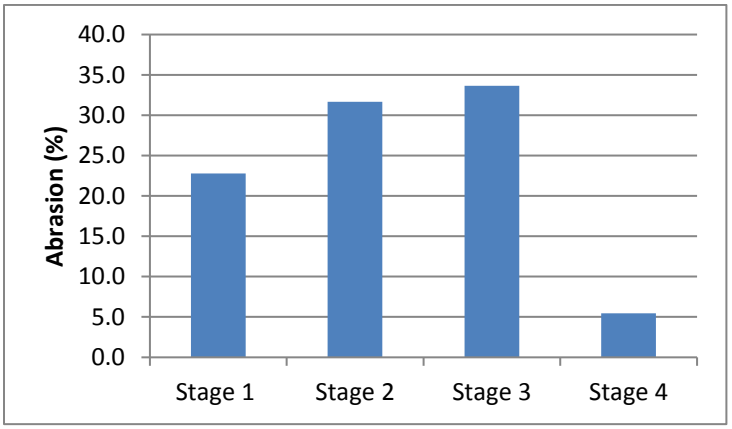


Figure 7.33. Abrasion intensity in Profile Two

Table 7.13. Abrasion by spit in Profile Two

	Spit 1		Spit 2		Spit 3		Spit 4		Spit 5		Total	
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Stage 1	11	31.4	3	13.6	7	50	8	16.3	17	20.7	**46**	**22.8**
Stage 2	8	22.9	12	54.5	1	7.1	20	40.8	23	28	**64**	**31.7**
Stage 3	10	28.6	5	22.7	4	28.6	11	22.4	38	46.3	**68**	**33.7**
Stage 4	2	5.7	-	-	1	7.1	5	10.2	3	3.7	**11**	**5.4**
	31	**88.6**	**20**	**90.9**	**13**	**92.9**	**44**	**89.8**	**81**	**98.8**	**189**	**93.6**

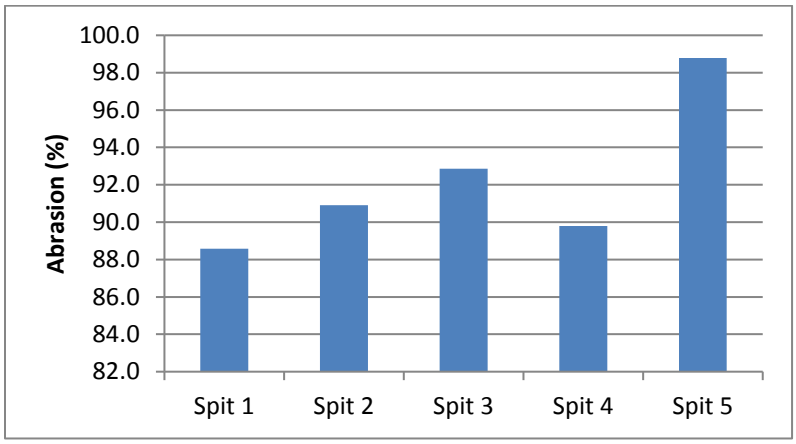


Figure 7.34. Abrasion and spit depth from Profile One

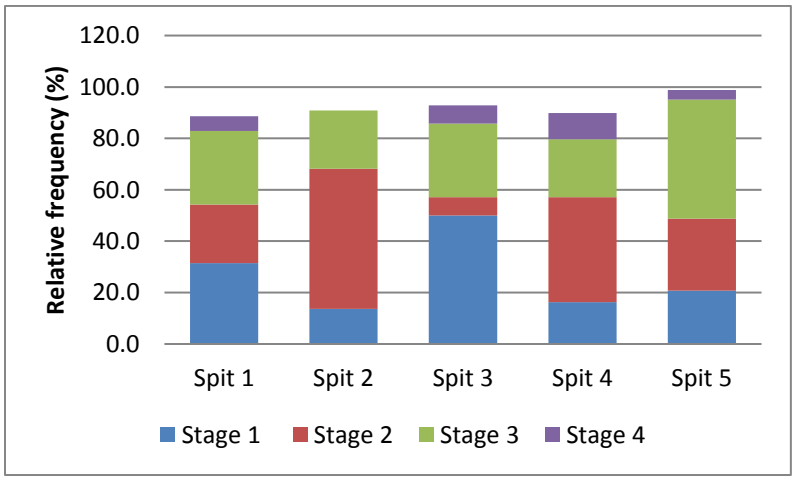


Figure 7.35. Abrasion intensity with depth from Profile Two

Table 7.14. Sheen in Profile Two

	Mammal		Chelonia		Aves		Total	
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Stage 1	10	19.6	26	17.6	-	-	**36**	**17.8**
Stage 2	13	25.5	9	6.1	-	-	**22**	**10.9**
Stage 3	3	5.9	7	4.7	-	-	**10**	**5**
Total	**26**	**51**	**42**	**28.4**	**-**	**-**	**68**	**33.7**

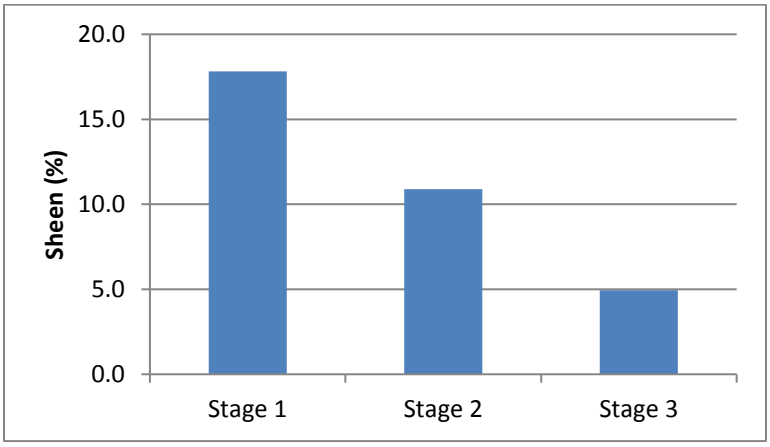


Figure 7.36. Sheen in Profile Two

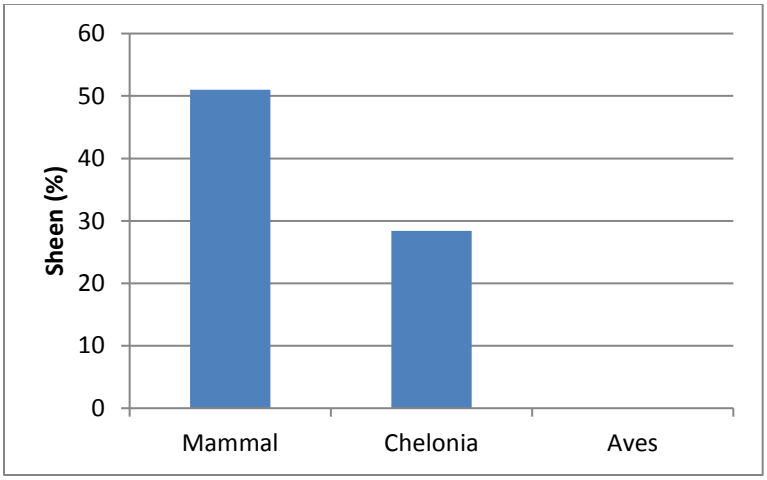


Figure 7.37. Sheen by taxonomic group from Profile Two

Table 7.15. Sheen with spit depth in Profile Two

	Spit 1		Spit 2		Spit 3		Spit 4		Spit 5		Total	
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Stage 1	2	5.7	3	13.6	-	-	13	26.5	18	22	**36**	**17.8**
Stage 2	6	17.1	2	9.1	2	14.3	5	10.2	7	8.5	**22**	**10.9**
Stage 3	1	2.9	1	4.5	1	7.1	4	8.2	3	3.7	**10**	**5**
Total	**9**	**25.7**	**6**	**27.3**	**3**	**21.4**	**22**	**44.9**	**28**	**34.1**	**68**	**33.7**

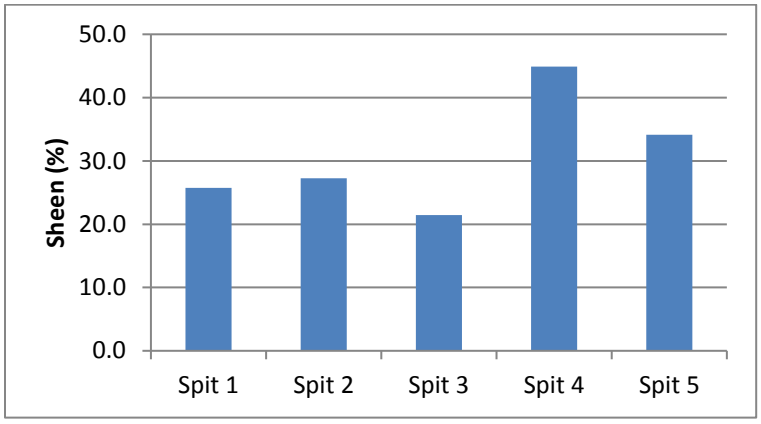


Figure 7.38. Sheen and spit from Profile Two

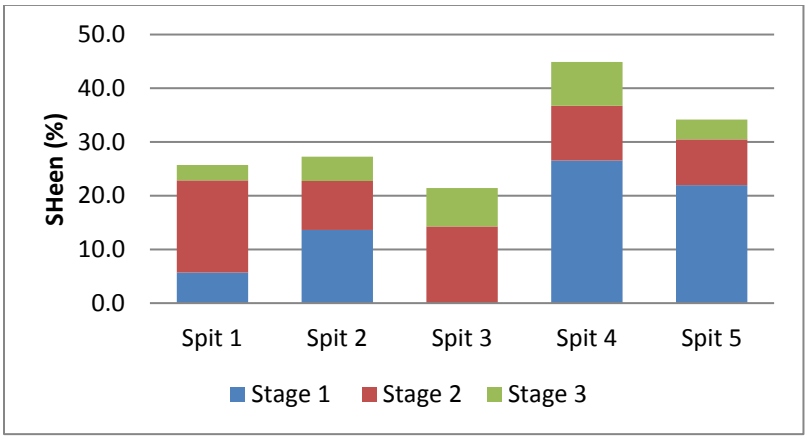


Figure 7.39. Sheen intensity and spit from Profile Two

Table 7.16. Trampling in Profile Two

	Mammals		Chelonia		Aves		Totals	
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Stage 1	13	25.5	36	24.3	-	-	**49**	**24.3**
Stage 2	-	-	3	2	-	-	**3**	**1.5**
Totals	**13**	**25.5**	**39**	**26.4**	**-**	**-**	**52**	**25.7**

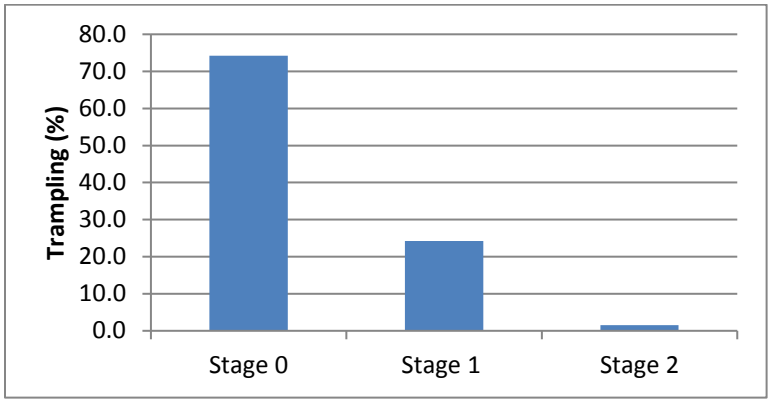


Figure 7.40. Trampling intensity in Profile Two

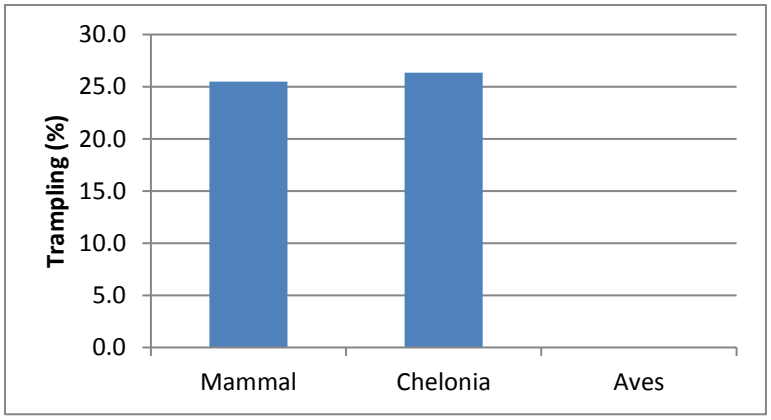


Figure 7.41. Trampling by taxonomic group from Profile Two

Table 7.17. Trampling and spit from Profile Two

	Spit 1		Spit 2		Spit 3		Spit 4		Spit 5		Total	
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Stage 1	9	25.7	2	9.1	4	28.6	8	16.3	26	31.7	**49**	**24.3**
Stage 2	1	2.9	-	-	-	-	1	2	1	1.2	**3**	**1.5**
	10	**28.6**	**2**	**9.1**	**4**	**28.6**	**9**	**18.4**	**27**	**32.9**	**52**	**25.7**

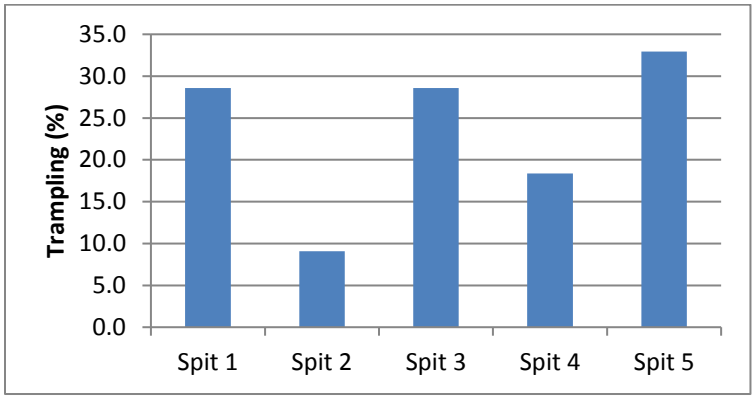


Figure 7.42. Relative frequency of trampling by spit from Profile Two

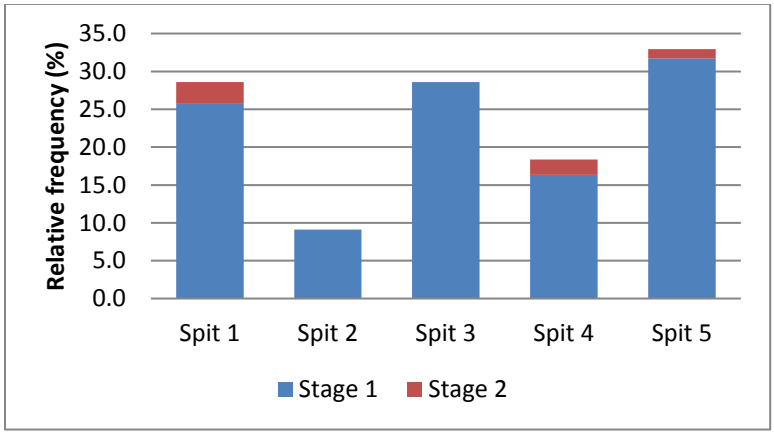


Figure 7.43. Trampling intensity with depth in Profile Two

Table 7.18. Trampling type in Profile Two

	Pit		Notch		Score		Scratch		Total	
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Stage 1	21	34.4	2	3.3	33	54.1	1	1.6	**57**	**93.4**
Stage 2	1	1.6	-	-	2	3.3	1	1.6	**4**	**6.6**
Totals	**22**	**36.1**	**2**	**3.3**	**35**	**57.4**	**2**	**3.3**	**61**	

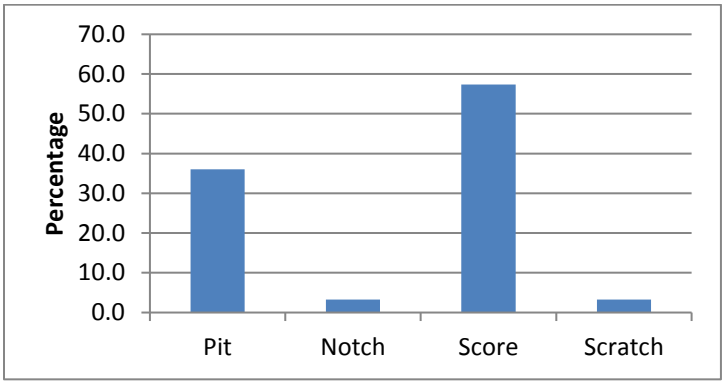


Figure 7.44. Relative frequency of trampling type in Profile Two

Table 7.19. Root etching in Profile Two

	Mammals		Chelonia		Aves		Totals	
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Stage 1	14	27.5	36	24.3	1	33.3	**51**	**25.2**
Stage 2	11	21.6	13	8.8	-	-	**24**	**11.9**
Stage 3	2	3.9	3	2	-	-	**5**	**2.5**
Totals	**27**	**52.9**	**52**	**35.1**	**1**	**33.3**	**80**	**39.6**

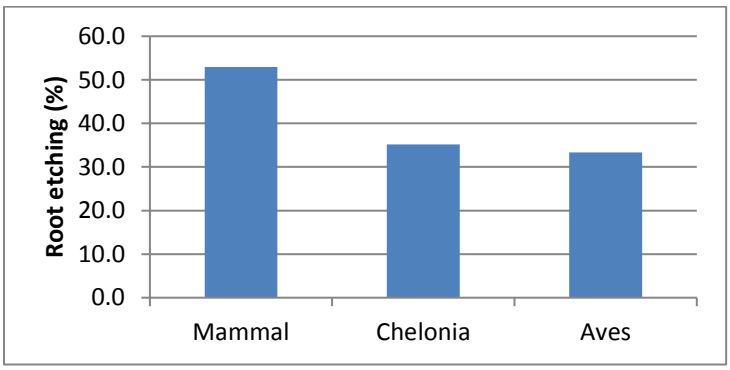


Figure 7.45. Root etching by taxonomic group from Profile Two

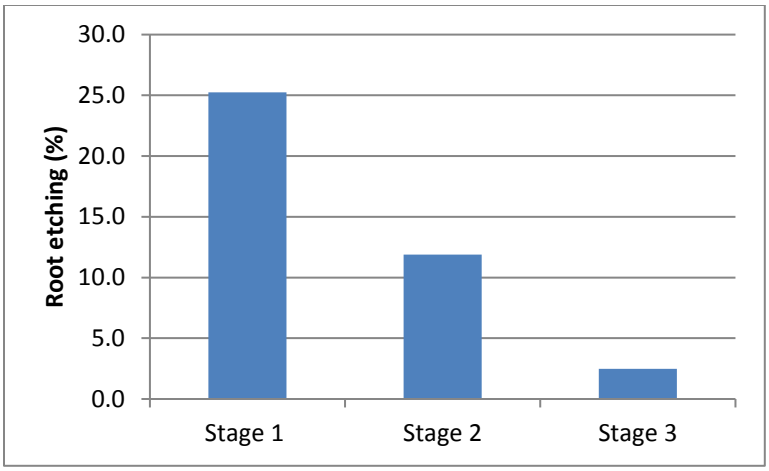


Figure 7.46. Root etching intensity from Profile Two

Table 7.20. Root etching and spit from Profile Two

	Spit 1		Spit 2		Spit 3		Spit 4		Spit 5		Total	
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Stage 1	8	22.9	5	22.7	4	28.6	10	20.4	24	29.3	**51**	**25.2**
Stage 2	7	20	5	22.7	-	-	6	12.2	6	7.3	**24**	**11.9**
Stage 3	1	2.9	2	9.1	-	-	1	2	1	1.2	**5**	**2.5**
Totals	**16**	**45.7**	**12**	**54.5**	**4**	**28.6**	**17**	**34.7**	**31**	**37.8**	**80**	**39.6**

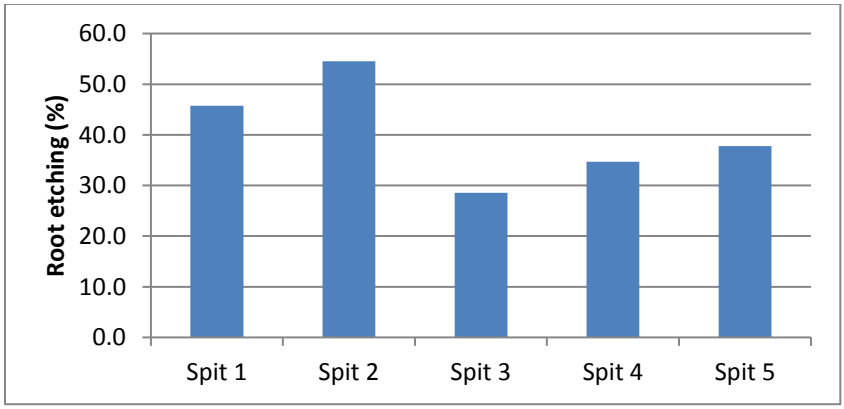


Figure 7.47. Root etching and spit from Profile Two

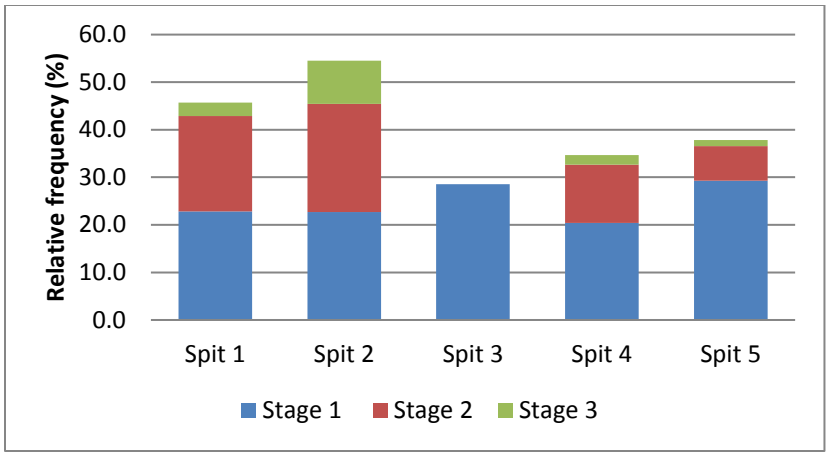


Figure 7.48. Root etching intensity with depth from Profile Two

Table 7.21. Taxonomic abundance of mammal families and spit from Profile Two

	Spit 1		Spit 2		Spit 3		Spit 4		Spit 5		Total	
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Bovid	3	21.4	8	57.1	3	21.4	-	-	-	-	**14**	**27.5**
Carnivore	1	20	2	40	2	40	-	-	-	-	**5**	**9.8**
Rodent	-	-	-	-	-	-	-	-	2	100	**2**	**3.9**
Mammal unid	13	48.1	4	14.8	5	18.5	4	14.8	4	14.8	**30**	**58.8**
Total mammal	**17**	**33.3**	**14**	**27.5**	**10**	**19.6**	**4**	**7.8**	**6**	**11.8**	**51**	

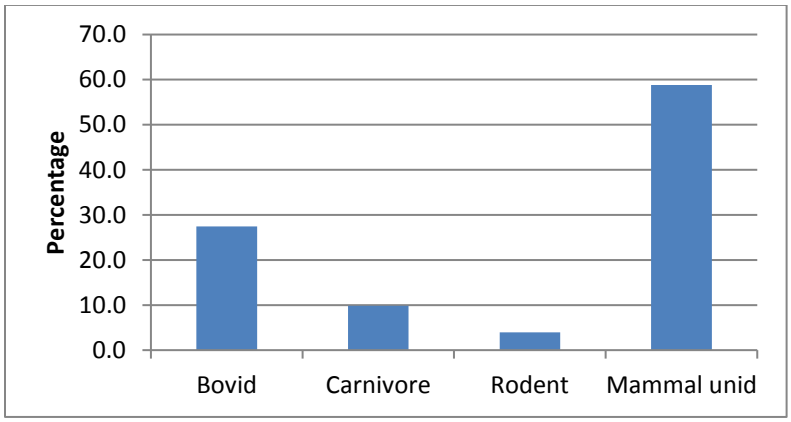


Figure 7.49. Relative frequency of mammalian families from Profile Tw

Table 7.22. Skeletal frequency of mammal remains from Profile Two

	NISP	MNE	MAU	%MAU	MNI
Bovidae					**3**
Horn core	1	1	1	33.3	
Maxilla	1	1	1	33.3	
Premolar	1	1	1	33.3	
Molar	5	4	3	100	
Carnivora					**2**
Premaxilla	1	1	1	33.3	
Maxilla	1	1	1	33.3	
Premolar	1	1	1	33.3	
Incisor	1	1	1	33.3	
Phalange	1	1	1	33.3	
Rodent					**1**
Incisor	2	1	1	33.3	
Unidet					**1**
Premolar	1	1	1	33.3	
Vertebra	1	1	1	33.3	
Caudal vertebra	1	1	1	33.3	
Tarsal/Carpal	1	1	1	33.3	
Sesamoid	1	1	1	33.3	
Phalange	1	1	1	33.3	
Long bone fragment	18	1	1	33.3	

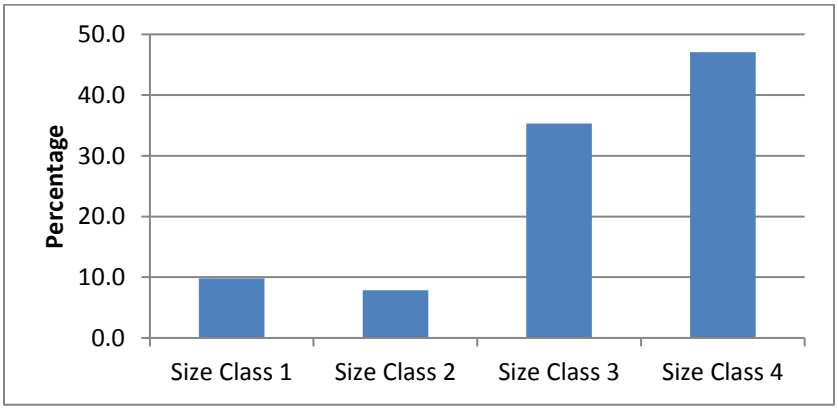


Figure 7.50. Relative frequency of body size class in mammal remains from Profile Two



Figure 7.51. Mammal body size class and spit depth from Profile Two

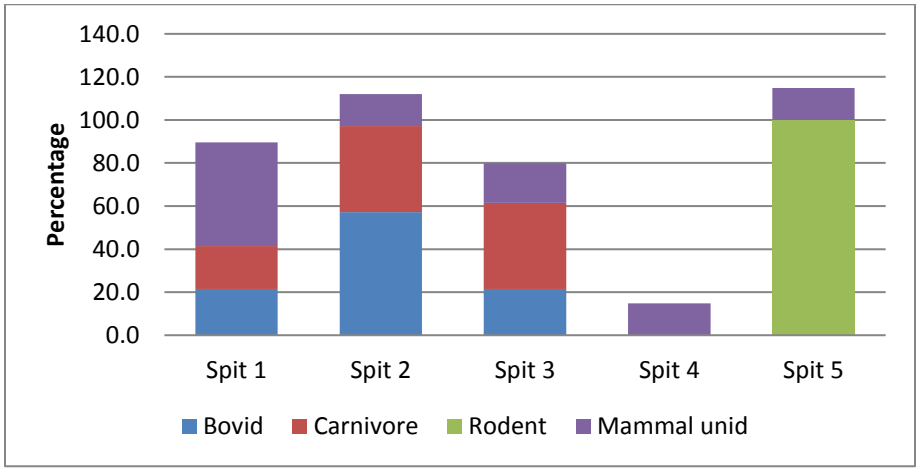


Figure 7.52. Relative frequency of mammalian families and spit from Profile Two

Table 7.23. Mammalian families with body size class from Profile Two

	Size Class 1		Size Class 2		Size Class 3		Size Class 4		Total	
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Bovid	-	-	-	-	2	14.3	12	85.7	**14**	**27.5**
Carnivore	1	20	-	-	4	80	-	-	**5**	**9.8**
Rodent	2	100	-	-	-	-	-	-	**2**	**3.9**
Mammal unid	2	6.7	4	13.3	12	40	12	40	**30**	**58.8**
Total mammal	**5**	**9.8**	**4**	**7.8**	**18**	**35.3**	**24**	**47.1**	**51**	

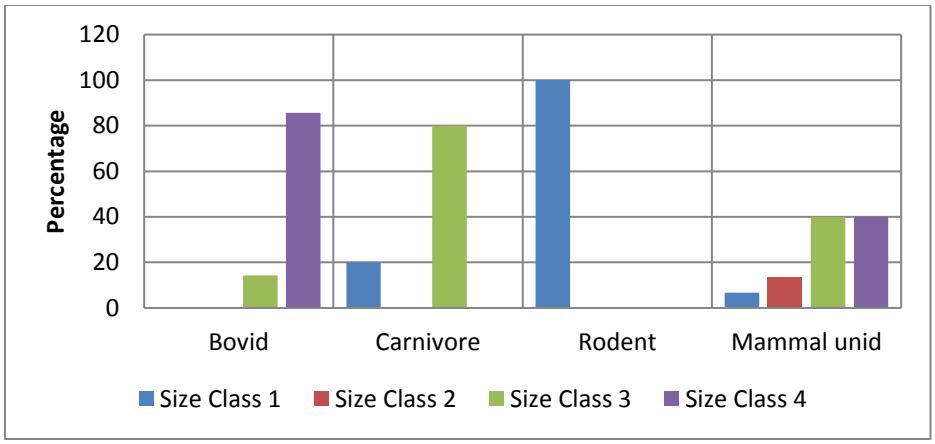


Figure 7.53. Body size class frequency in mammalian families from Profile Two.

Table 7.24. Anatomical composition of Bovidae in Profile Two

	Size class 3		Size class 4		Total	
Element	**N**	**%**	**N**	**%**	**N**	**%**
Horn core	1	7.14	-	-	**1**	**7.1**
Maxilla	-	-	1	100	**1**	**7.1**
Premolar	-	-	1	100	**1**	**7.1**
Molar	-	-	5	100	**5**	**35.7**
Tooth unid	1	16.7	5	83.3	**6**	**42.9**
Total	**2**	**14.3**	**12**	**85.7**	**14**	

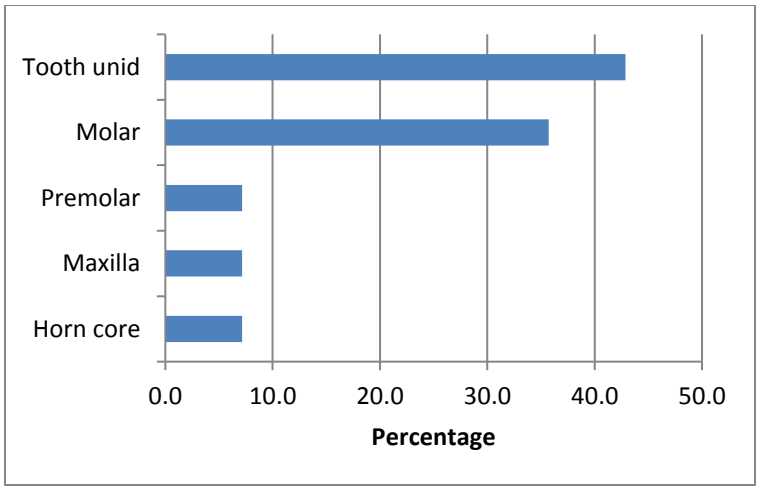


Figure 7.54. Relative frequency of skeletal elements of Bovidae from Profile Two

Table 7.25. Anatomical composition and spit in Bovidae from Profile Two

	Spit 1		Spit 2		Spit 3		Total	
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Horn core	1	100	-	-	-	-	**1**	**7.1**
Maxilla	-	-	1	100	-	-	**1**	**7.1**
Premolar	1	100	-	-	-	-	**1**	**7.1**
Molar	-	-	2	40	3	60	**5**	**35.7**
Tooth unid.	1	16.7	5	83.3	-	-	**6**	**42.9**
Total	**3**	**21.4**	**8**	**57.1**	**3**	**21.4**	**14**	

Table 7.26. Anatomical composition in Carnivora from Profile Two

	Spit 1		Spit 3		Total	
	N	**%**	**N**	**%**	**N**	**%**
Premaxilla	-	-	1	100	**1**	**20**
Maxilla	-	-	1	100	**1**	**20**
Premolar	-	-	1	100	**1**	**20**
Incisor	-	-	1	100	**1**	**20**
Phalange	1	100	-	-	**1**	**20**
Total	**1**	**20**	**4**	**80**	**5**	

Table 7.27. Anatomical composition and spit in Carnivora from Profile Two

	Spit 1		Spit 2		Spit 3		Total	
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Premaxilla	-	-	-	-	1	100	**1**	**20**
Maxilla	-	-	-	-	1	100	**1**	**20**
Premolar	-	-	1	100	-	-	**1**	**20**
Incisor	-	-	1	100	-	-	**1**	**20**
Phalange	1	100	-	-	-	-	**1**	**20**
Total	**1**	**20**	**2**	**40**	**2**	**40**	**5**	

Table 7.28. Anatomical composition in unidentifiable mammals from Profile Two

	Size class 1		Size class 2		Size class 3		Size class 4		Total	
	N	%	N	%	N	%	N	%	N	%
Premolar	-	-	-	-	1	100	-	-	1	3.3
Tooth unid.	-	-	-	-	3	50	3	50	6	20
Vertebra	-	-	-	-	-	-	1	100	1	3.3
Caudal vertebra	1	100	-	-	-	-	-	-	1	3.3
Tarsal/Carpal	-	-	-	-	1	100	-	-	1	3.3
Sesamoid	-	-	1	100	-	-	-	-	1	3.3
Phalange	1	100	-	-	-	-	-	-	1	3.3
Long bone fragment	-	-	4	22.2	6	33.3	8	44.4	18	60
Total	**2**	**6.7**	**5**	**16.7**	**11**	**36.7**	**12**	**40**	**30**	

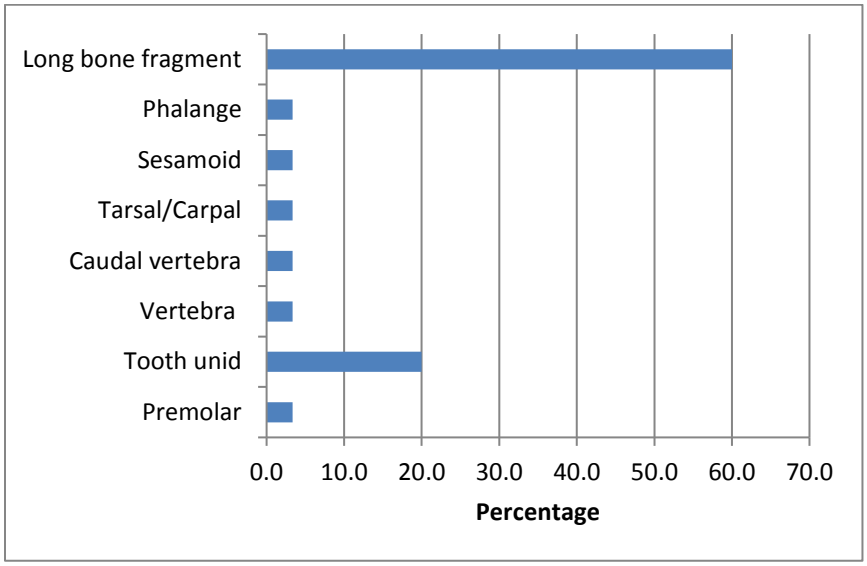


Figure 7.55. Relative frequency of skeletal element in unidentifiable mammal remains from Profile Two

Table 7.29. Anatomical composition and spit in unidentifiable mammals from Profile Two

	Spit 1		Spit 2		Spit 3		Spit 4		Spit 5		Total	
	N	%	N	%	N	%	N	%	N	%	N	%
Premolar	1	100	-	-	-	-	-	-	-	-	1	3.3
Tooth unid.	2	33.3	2	33.3	-	-	-	-	2	33.3	6	20
Vertebra	-	-	1	100	-	-	-	-	-	-	1	3.3
Caudal vertebra	-	-	-	-	1	100	-	-	-	-	1	3.3
Tarsal/Carpal	-	-	1	100	-	-	-	-	-	-	1	3.3
Sesamoid	-	-	-	-	-	-	1	100	-	-	1	3.3
Phalange	-	-	-	-	-	-	1	100	-	-	1	3.3
Long bone fragment	10	55.6	-	-	4	22.2	2	11.1	2	11.1	18	60
Total	**13**	**43.3**	**4**	**13.3**	**5**	**16.7**	**4**	**13.3**	**4**	**13.3**	**30**	

Table 7.30. Descriptive Statistics of maximum length in mammal remains from Profile Two

	Combined	Size Class 1	Size Class 2	Size Class 3	Size Class 4
N	50	5	5	17	24
Minimum	4	10	7	4	20
Maximum	65	15	31	65	44
Mean	25.73	12	24.5	23.94	30.8
Standard Deviation	10.91	1.87	9.67	13.25	6.98

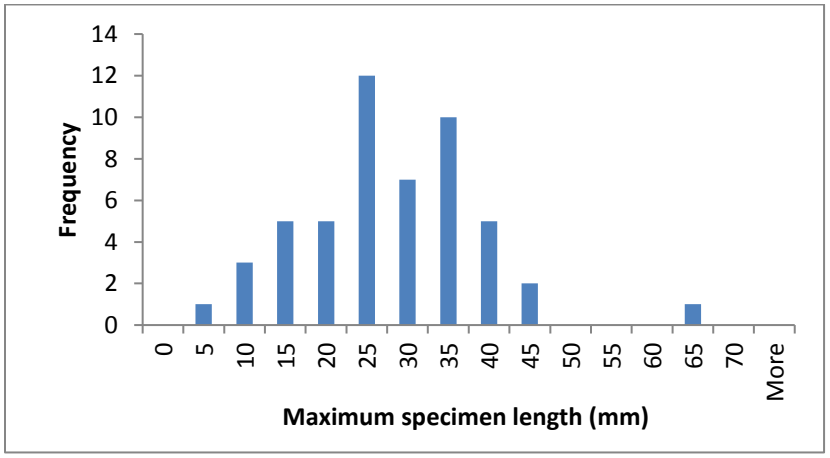


Figure 7.56. Histogram of maximum specimen length in combined mammals from Profile Two

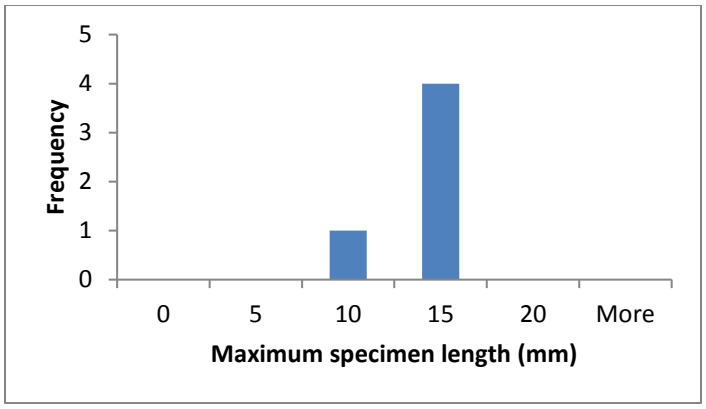


Figure 7.57. Histogram of maximum specimen length in size class one mammals from Profile Two.

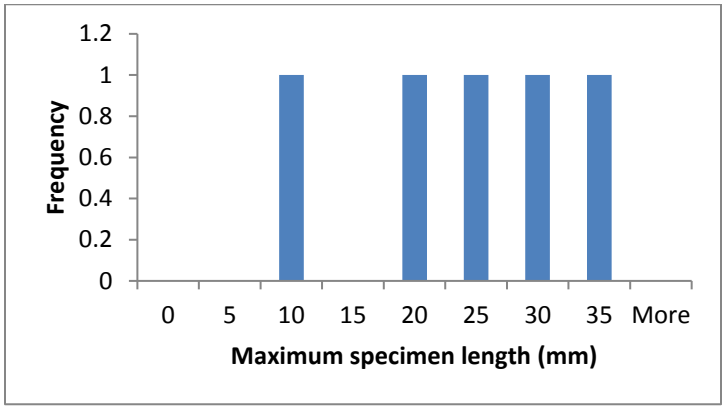


Figure 7.58. Histogram of maximum specimen length in size class two mammals from Profile Two.

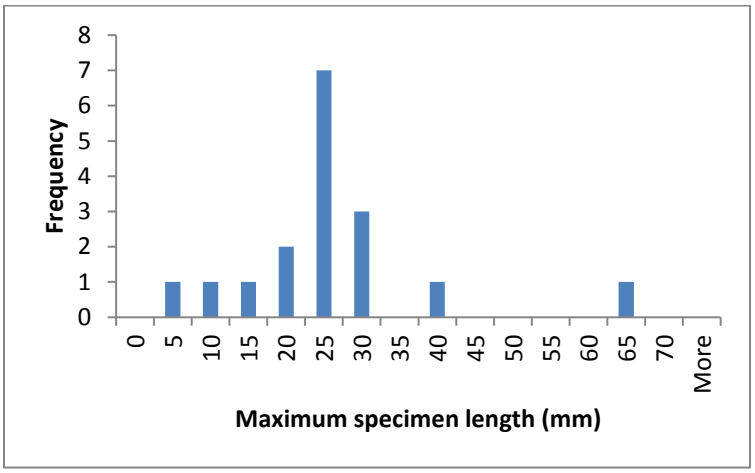


Figure 7.59. Histogram of maximum specimen length in size class three mammals from Profile Two.

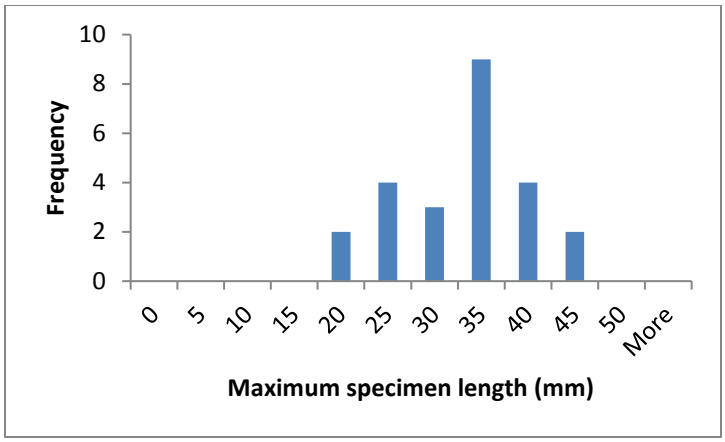


Figure 7.60. Histogram of maximum specimen length in size class four mammals from Profile Two.

Table 7.31. Completeness in mammal remains from Profile Two

	Phalange		Sesamoid		Dentition		Total	
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Size Class 1	2	25	-	-	-	-	**2**	**25**
Size Class 2	-	-	1	12.5	-	-	**1**	**12.5**
Size Class 3	-	-	-	-	2	25	**2**	**25**
Size Class 4	-	-	-	-	3	37.5	**3**	**37.5**
Grand Total	**2**	**25**	**1**	**12.5**	**5**	**62.5**	**8**	**15.7**

Table 7.32. Breakage patterns in mammal remains from Profile Two

	Complete		Fragment		Shaft	
	N	**%**	**N**	**%**	**N**	**%**
Horncore	-	-	-	-	1	100
Phalange	2	100	-	-	-	-
Sesamoid	1	100	-	-	-	-
Long bone fragment	-	-	-	-	15	100

	Complete		Fragment	
Dentition	**N**	**%**	**N**	**%**
Incisor	1	33.3	2	66.6
Premolar	1	33.3	2	66.6
Molar	3	60	2	40
Tooth indet	-	-	12	100

	Maxilla		Fragment	
	N	**%**	**N**	**%**
Maxilla	1	50	1	50
Premaxilla	-	-	1	100

	Vertebra Arch		Vertebra Body	
	N	**%**	**N**	**%**
Vertebra	1	100	-	-
Caudal Vertebra	-	-	1	100

Table 7.33. Fracture outline in mammal remains from Profile Two

	Spiral (Fresh)		Transverse (Dry)		Total	
	N	**%**	**N**	**%**	**N**	**%**
Size Class 2	2	100	-	-	**2**	**25**
Size Class 3	5	83.3	1	16.7	**6**	**16.7**
Size Class 4	8	100	-	-	**8**	**16.7**
Total	**15**	**93.8**	**1**	**6.3**	**16**	**15.7**

Table 7.34. Fracture outline in mammals by spith from Profile Two

	Spiral (Fresh)		Transverse (Dry)		Total	
	N	**%**	**N**	**%**	**N**	**%**
Spit 1	10	90.9	1	9.1	**11**	**32.4**
Spit 3	1	100	-	-	**1**	**5**
Spit 4	2	100	-	-	**2**	**25**
Spit 5	2	100	-	-	**2**	**16.7**
Total	**15**	**93.75**	**1**	**6.25**	**16**	**15.7**

Table 7.35. Fracture angle in mammal remains from Profile Two

	Oblique (Fresh)		Right (Dry)		Mixed		Total	
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Size Class 2	2	66.6	-	-	1	33.3	**3**	**37.5**
Size Class 3	4	50	3	37.5	1	12.5	**8**	**22.2**
Size Class 4	5	45.5	3	27.3	3	27.3	**11**	**22.9**
Total	**11**	**50**	**6**	**27.3**	**5**	**22.7**	**22**	**21.6**

Table 7.36. Fracture angle in mammal remains with spit from Profile Two

	Oblique (Fresh)		Right (Dry)		Mixed		Total	
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Spit 1	7	46.7	5	33.3	3	20	**15**	**44.1**
Spit 3	1	100	-	-	-	-	**1**	**5**
Spit 4	1	50	-	-	1	50	**2**	**25**
Spit 5	2	50	1	25	1	25	**4**	**33.3**
Total	**11**	**50**	**6**	**27.3**	**5**	**22.7**	**22**	**21.6**

Table 7.37. Weathering in Mammals from Profile Two

	Bovid		Carnivore		Rodent		Mammal unid		Total	
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Stage 0	9	64.3	2	40	2	100	24	88.9	**37**	**72.5**
Stage 1	5	35.7	3	60	-	-	6	22.2	**14**	**27.5**
Total	**5**	**35.7**	**3**	**60**	**-**	**-**	**6**	**22.2**	**14**	**27.5**

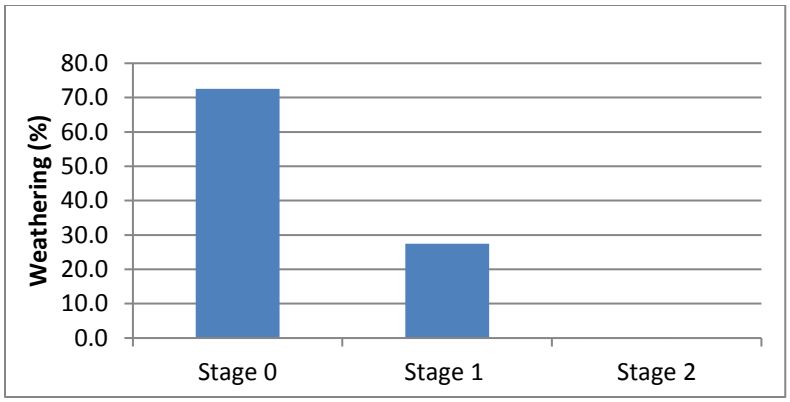


Figure 7.61. Weathering intensity in mammal remains from Profile Two

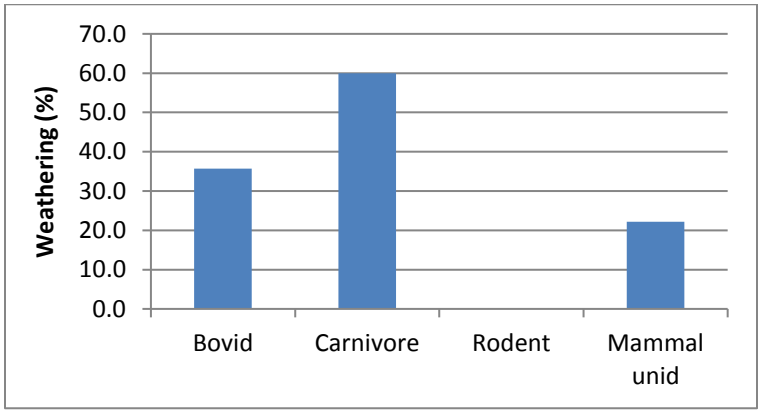


Figure 7.62. Weathering in mammalian families from Profile Two

Table 7.38. Burning in taxonomic groups in Profile Two

	Mammals		Chelonia		Aves		Totals	
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Stage 1	1	2	8	5.4	-	-	**9**	**4.5**
Stage 2	-	-	1	0.7	-	-	**1**	**0.5**
Stage 3	-	-	5	3.4	-	-	**5**	**2.5**
Stage 4	1	2	1	0.7	-	-	**2**	**1**
Totals	**2**	**3.9**	**15**	**10.1**	**-**	**-**	**17**	**8.4**

Table 7.39. Staining in mammal remains from Profile Two

	Bovid		Carnivore		Rodent		Mammal unid		Total	
	N	%	N	%	N	%	N	%	N	%
Stage 0	3	21.4	1	20	1	33.3	5	18.5	**10**	**19.6**
Stage 1	5	35.7	3	60	1	33.3	14	51.9	**23**	**56.1**
Stage 2	5	35.7	-	-	-	-	7	25.9	**12**	**29.3**
Stage 3	1	7.1	1	20	-	-	4	14.8	**6**	**14.6**
Total	**11**	**78.6**	**4**	**80**	**1**	**33.3**	**25**	**92.6**	**41**	**80.4**

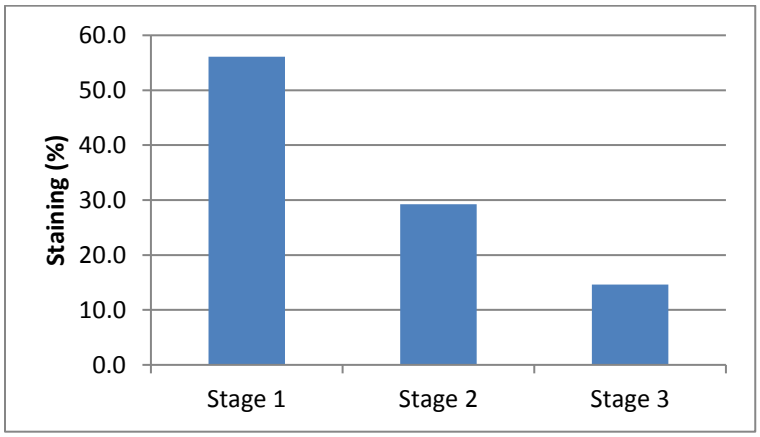


Figure 7.63. Staining intensity in mammalian remains from Profile Two

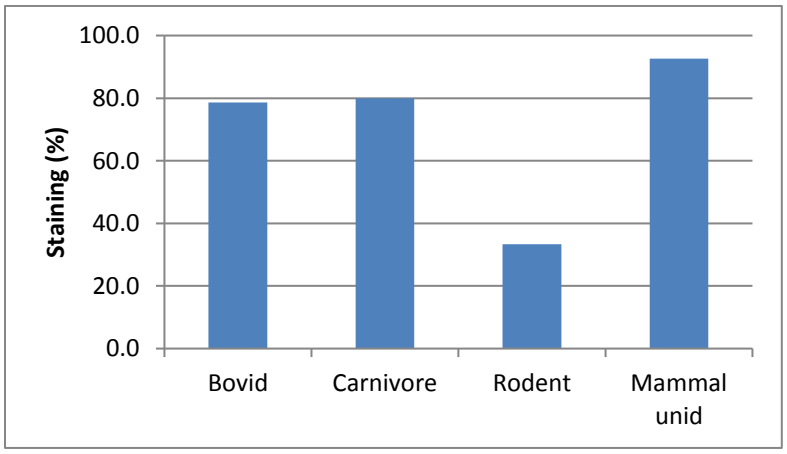


Figure 7.64. Staining in mammalian families from Profile Two

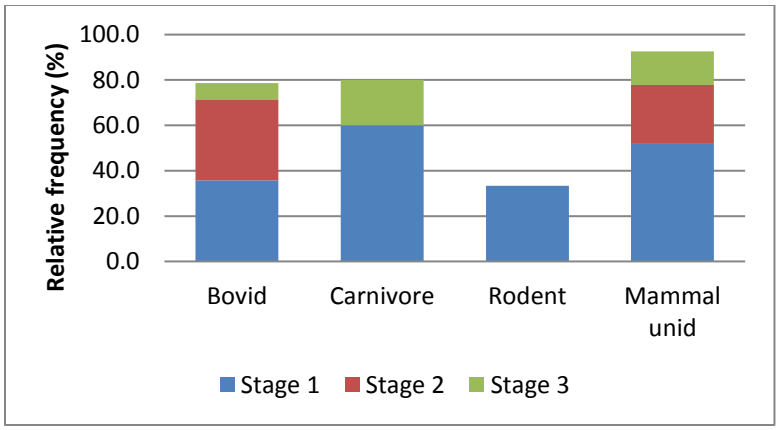


Figure 7.65. Staining intensity in mammal families from Profile Two

Table 7.40. Staining colour in mammal families from Profile Two

	Brown		Purple		Black		Total	
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Bovid	11	100	-	-	-	-	**11**	**78.6**
Carnivore	3	75	1	25	-	-	**4**	**80**
Rodent	1	100	-	-	-	-	**1**	**33.3**
Mammal unid	24	96	-	-	1	4	**25**	**92.6**
Total	**39**	**95.1**	**1**	**2.4**	**1**	**2.4**	**41**	**80.4**

Table 7.41. Abrasion in mammal remains from Profile Two

	Bovid		Carnivore		Rodent		Mammal unid		Total	
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Stage 0	3	21.4	1	20	-	-	3	11.1	**7**	**13.7**
Stage 1	3	21.4	3	60	2	100	14	51.9	**22**	**43.1**
Stage 2	7	50	1	20	-	-	5	18.5	**13**	**25.5**
Stage 3	1	7.1	-	-	-	-	6	22.2	**7**	**13.7**
Stage 4	-	-	-	-	-	-	2	7.4	**2**	**3.9**
Total	**11**	**78.6**	**4**	**80**	**2**	**100**	**27**	**100**	**44**	**86.3**

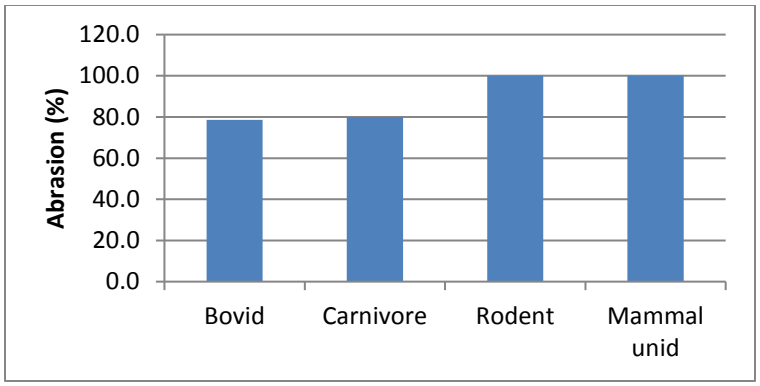


Figure 7.66. Relative frequency of abrasion in mammalian families from Profile Two

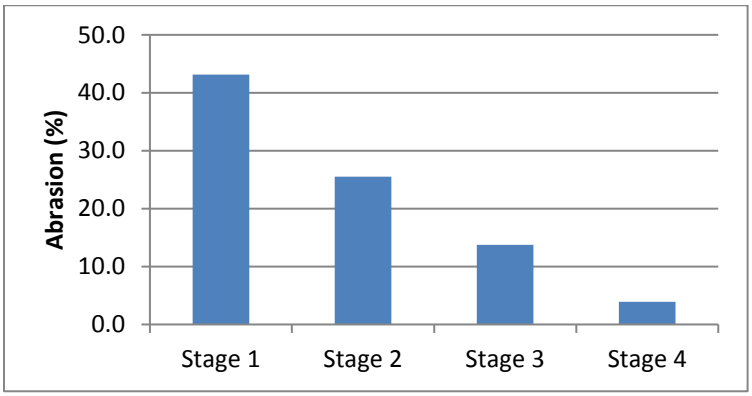


Figure 7.67. Abrasion intensity in mammals from Profile Two

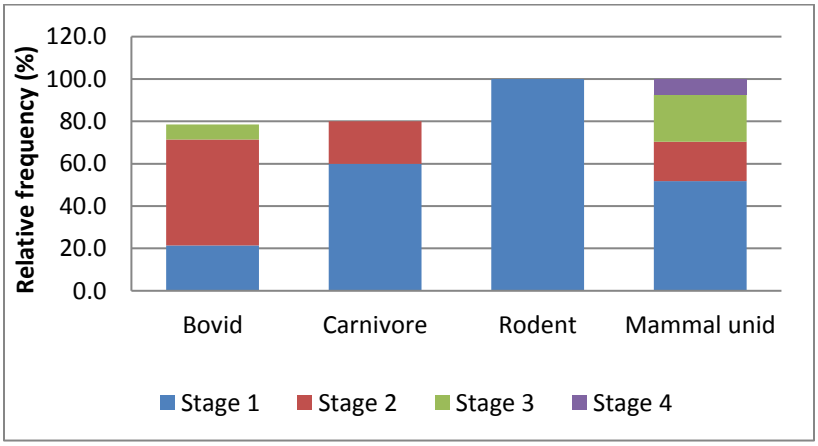


Figure 7.68. Abrasion intensity in mammalian families from Profile Two

Table 7.42. Sheen in mammals from Profile Two

	Bovid		Carnivore		Rodent		Mammal unid		Total	
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Stage 1	2	14.3	-	-	-	-	8	29.6	**10**	**19.6**
Stage 2	3	21.4	2	40	2	100	6	22.2	**13**	**25.5**
Stage 3	2	14.3	-	-	-	-	1	3.7	**3**	**5.9**
Total	**7**	**50**	**2**	**40**	**2**	**100**	**15**	**55.6**	**26**	**51**

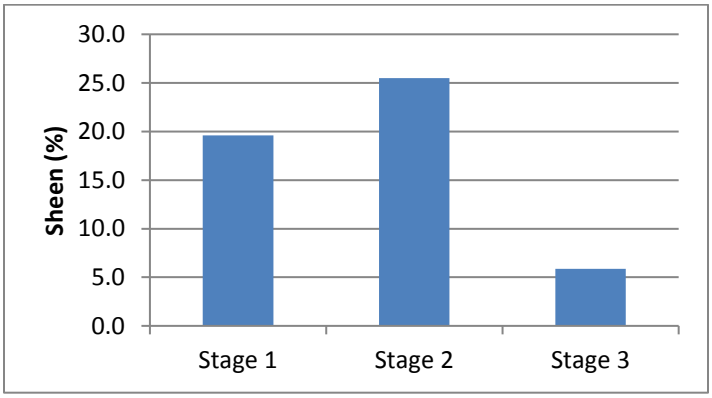


Figure 7.69. Sheen intensity in mammalian families from Profile Two

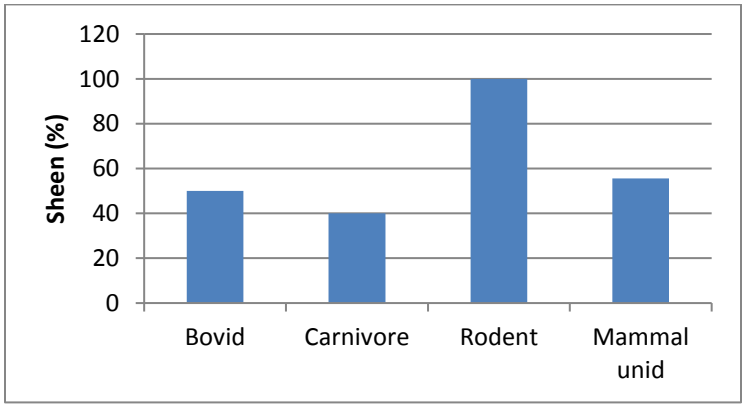


Figure 7.70. Relative frequency of sheen in mammalian families from Profile Two

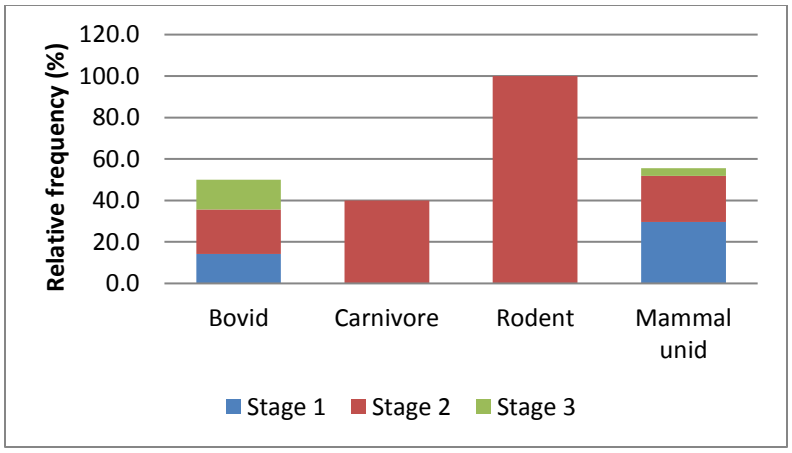


Figure 7.71. Sheen intensity in mammal families from Profile Two

Table 7.43. Trampling in mammal remains from Profile Two

	Bovid		Carnivore		Rodent		Mammal unid		Total	
	N	%	N	%	N	%	N	%	N	%
Stage 0	11	78.6	5	100	-	-	22	81.5	**38**	**74.5**
Stage 1	3	21.4	-	-	2	100	8	29.6	**13**	**25.5**
Total	**3**	**21.4**	**-**	**-**	**2**	**100**	**8**	**29.6**	**13**	**25.5**

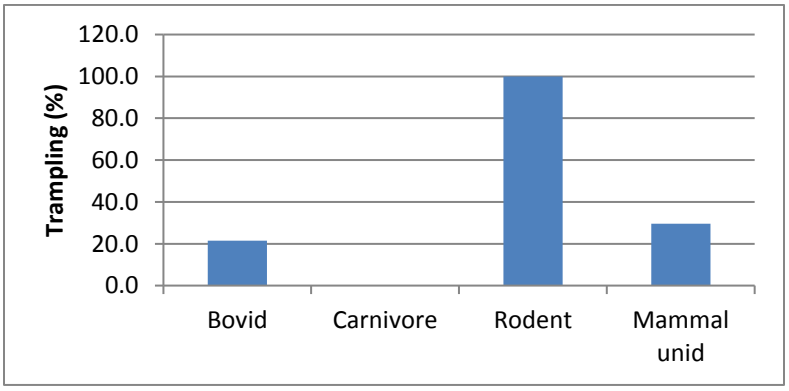


Figure 7.72. Relative frequency of trampling in mammalian families from Profile Two

Table 7.44. Trampling type in mammals and chelonian from Profile Two

	Pit		Notch		Score		Scratch		Total	
	N	%	N	%	N	%	N	%	N	%
Mammal	7	13.7	1	2	8	15.7	-	-	**16**	**26.2**
Chelonia	15	10.1	1	0.7	27	18.2	2	1.4	**45**	**73.8**
Total	**22**	**36.1**	**2**	**3.3**	**35**	**57.4**	**2**	**3.3**	**61**	

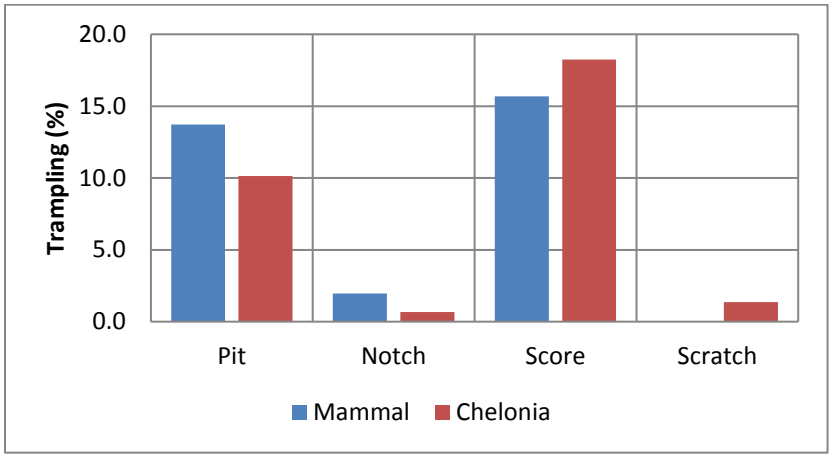


Figure 7.73. Trampling type in mammals and chelonian from Profile Two

Table 7.45. Trampling type in mammalian families from Profile Two

	Pit		Notch		Score		Scratch		Total	
	N	%	N	%	N	%	N	%	N	%
Bovid	-	-	-	-	3	37.5	-	-	**3**	**21.4**
Rodent	2	28.6	-	-	-	-	-	-	**2**	**100**
Mammal unidet	5	71.4	1	100	5	62.5	-	-	**11**	**40.7**
Total	**7**	**43.8**	**1**	**6.3**	**8**	**50**	**-**	**-**	**16**	

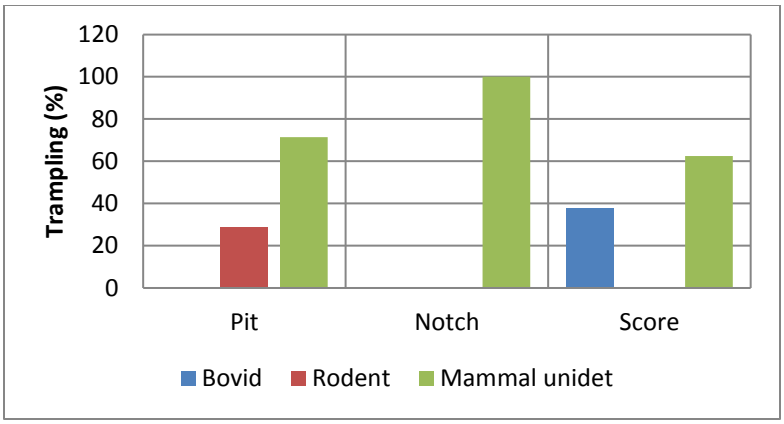


Figure 7.74. Relative frequency of trampling type in mammalian families from Profile Two

Table 7.46. Root etching in mammal remains from Profile Two

	Bovid		Carnivore		Rodent		Mammal unid		Total	
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Stage 0	7	50	2	40	1	50	14	51.9	**24**	**47.1**
Stage 1	4	28.6	2	40	-	-	8	29.6	**14**	**27.5**
Stage 2	2	14.3	-	-	1	50	8	29.6	**11**	**21.6**
Stage 3	1	7.1	1	20	-	-	-	-	**2**	**3.9**
	7	**50**	**3**	**60**	**1**	**50**	**16**	**59.3**	**27**	**52.9**

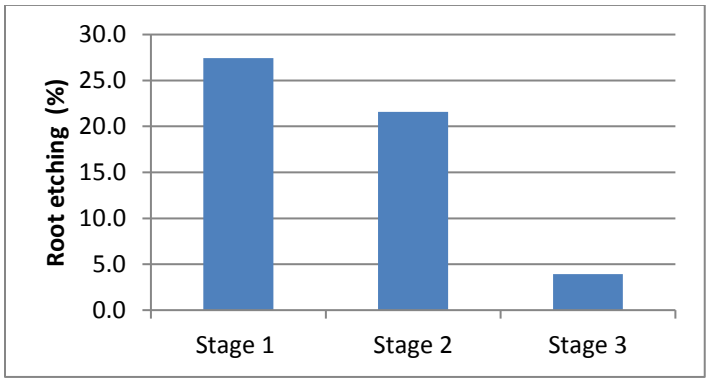


Figure 7.75. Root etching intensity in mammal remains from Profile Two

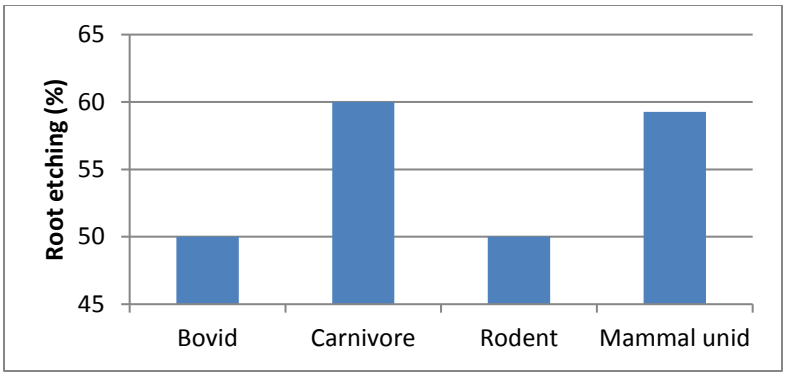


Figure 7.76. Relative frequency of root etching in mammalian families from Profile Two

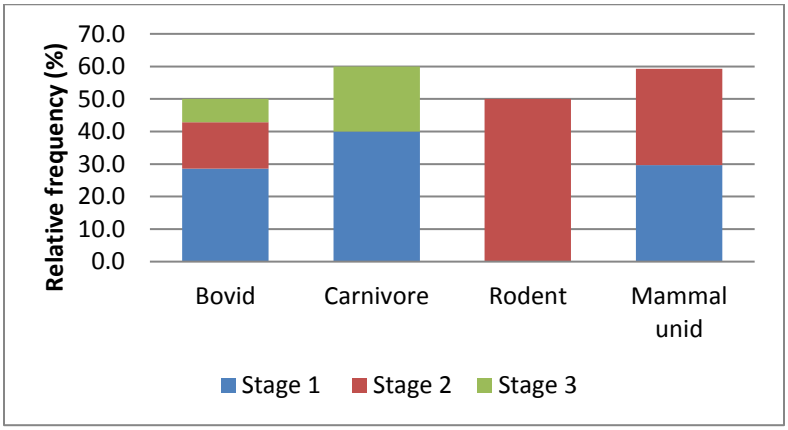


Figure 7.77. Intensity of root etching in mammalian families from Profile Two

Table 7.47. Chelonia body size classes in Profile Two

	Spit 1		Spit 2		Spit 3		Spit 4		Spit 5		Total	
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Size Class 1	6	35.3	1	12.5	1	25	11	25	17	22.7	**36**	**24.3**
Size Class 2	10	58.8	6	75	2	50	29	65.9	51	68	**98**	**66.2**
Size Class 3	-	-	1	12.5	-	-	4	9.1	4	5.3	**9**	**6.1**
Size Class 4	1	5.9	-	-	1	25	-	-	3	4	**5**	**3.4**
Total	**17**	**11.49**	**8**	**5.4**	**4**	**2.7**	**44**	**29.7**	**75**	**50.7**	**148**	**73.3**

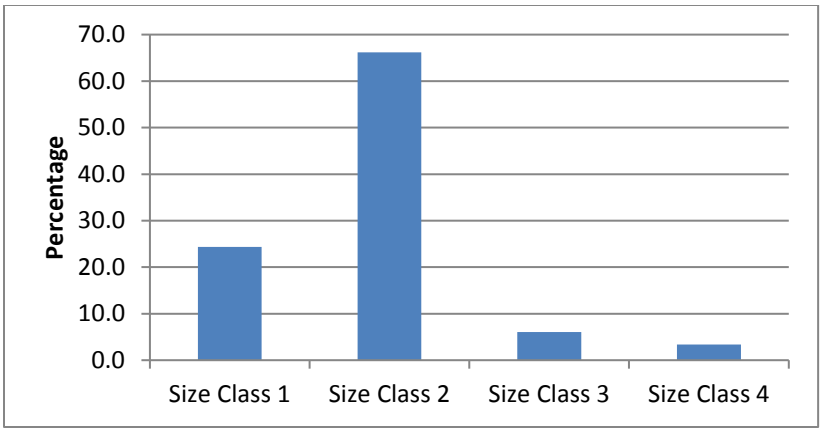


Figure 7.78. Relative frequency of body size classes in chelonia remains from Profile Two

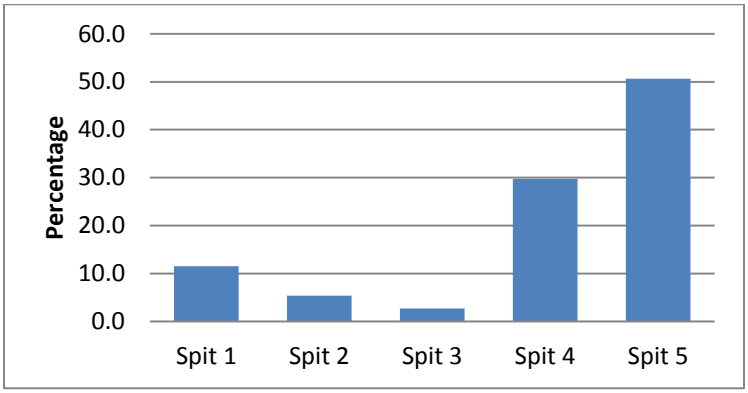


Figure 7.79. Relative frequency of chelonia by spit from Profile Two

Table 7.48. Skeletal frequencies of chelonian from Profile Two

	NISP	MNE	MAU	%MAU	MNI
Scapula	1	1	1	50	2
Humerus	5	4	2	100	2
Radius	1	1	1	50	2
Femur	3	3	2	100	2
Ilium	4	4	2	100	2
Phalange unknown	1	1	1	50	2
Long bone fragment	1	1	1	50	2
Vertebra	2	1	1	50	2
Neural	1	1	1	50	2
Marginal	35	35	2	100	2
Hypoplastron	2	1	1	50	2
Epiplastron	1	1	1	50	2
Plastron indet.	2	2	1	50	2

Table 7.49. Anatomical composition of chelonian remains from Profile Two

	Size class 1		Size class 2		Size class 3		Size class 4		Total	
	N	%	N	%	N	%	N	%	N	%
Scapula	-	-	1	100	-	-	-	-	**1**	**5.6**
Humerus	-	-	4	80	-	-	1	20	**5**	**27.8**
Radius	-	-	1	100	-	-	-	-	**1**	**5.6**
Femur	-	-	3	100	-	-	-	-	**3**	**16.7**
Ilium	-	-	4	100	-	-	-	-	**4**	**22.2**
Phalange unknown	-	-	1	100	-	-	-	-	**1**	**5.6**
Long bone fragment	-	-	-	-	-	-	1	100	**1**	**5.6**
Vertebra	-	-	-	-	1	50	1	50	**2**	**11.1**
Total appendicular/axial material	**-**	**-**	**14**	**77.8**	**1**	**5.6**	**3**	**16.7**	**18**	**12.2**
Neural	-	-	1	100	-	-	-	-	**1**	**0.8**
Marginal	19	54.3	12	34.3	4	11.4	-	-	**35**	**26.9**
Hypoplastron	1	50	1	50	-	-	-	-	**2**	**1.5**
Epiplastron	-	-	-	-	1	100	-	-	**1**	**0.8**
Plastron indet.	2	100	-	-	-	-	-	-	**2**	**1.5**
Indeterminate	14	15.7	70	78.7	3	3.4	2	2.2	**89**	**68.5**
Total Shell material	**36**	**27.7**	**84**	**64.6**	**8**	**6.2**	**2**	**1.5**	**130**	**87.8**
Total Chelonia	**36**	**24.3**	**98**	**66.2**	**9**	**6.1**	**5**	**3.4**	**148**	

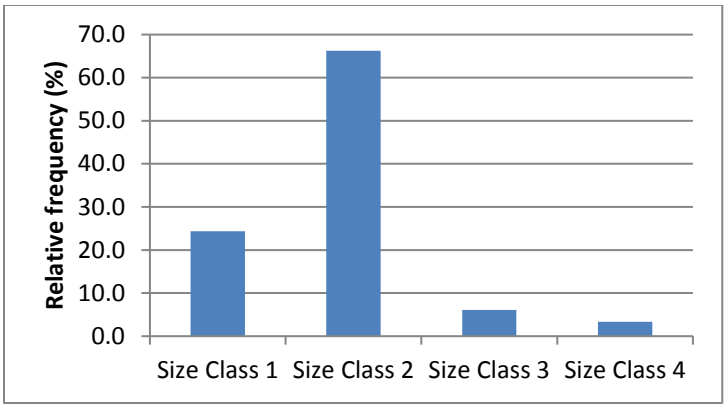


Figure 7.80. Relative frequency of body size classes in chelonia remains from Profile Two

Table 7.50. Anatomical frequency of chelonian remains and spit from Profile Two

	Spit 1		Spit 2		Spit 3		Spit 4		Spit 5		Total	
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Scapula	-	-	-	-	-	-	1	100	-	-	**1**	**5.56**
Humerus	1	20	2	40	1	20	-	-	1	20	**5**	**27.8**
Radius	-	-	-	-	-	-	1	100	-	-	**1**	**5.56**
Femur	-	-	1	33.3	-	-	1	33.3	1	33.3	**3**	**16.7**
Ilium	-	-	-	-	-	-	2	50	2	50	**4**	**22.2**
Phalange unknown	-	-	-	-	-	-	1	100	-	-	**1**	**5.56**
Long bone fragment	-	-	-	-	-	-			1	100	**1**	**5.56**
Vertebra	1	50	-	-	-	-	1	50	-	-	**2**	**11.1**
Total Appendicular/axial	**2**	**11.1**	**3**	**16.7**	**1**	**5.6**	**7**	**38.9**	**5**	**27.8**	**18**	**12.2**
Neural	-	-	-	-	1	100	-	-	-	-	**1**	**0.77**
Marginal	2	5.7	-	-	1	2.9	9	25.7	23	65.7	**35**	**26.9**
Hypoplastron	-	-	-	-	-	-	1	50	1	50	**2**	**1.54**
Epiplastron	-	-	1	100	-	-	-	-	-	-	**1**	**0.77**
Plastron indet.	2	100	-	-	-	-	-	-	-	-	**2**	**1.54**
Indeterminate	11	12.4	4	4.5	1	1.1	27	30.3	46	51.7	**89**	**68.5**
Total Shell material	**15**	**11.5**	**5**	**3.8**	**3**	**2.3**	**37**	**28.5**	**70**	**53.8**	**130**	**87.8**
Total Chelonia	**17**	**11.5**	**8**	**5.4**	**4**	**2.7**	**44**	**29.7**	**75**	**50.7**	**148**	

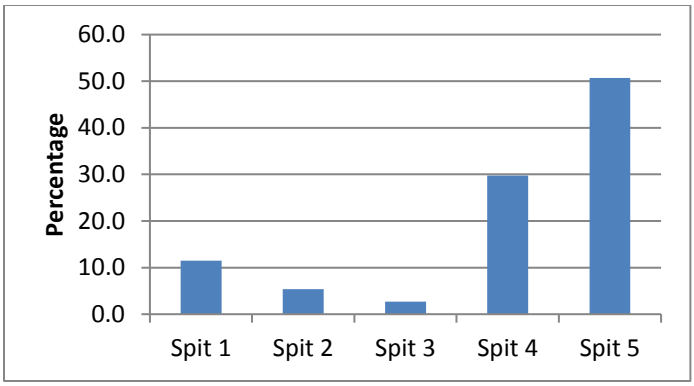


Figure 7.81. Relative frequency of chelonia and spit from Profile Two

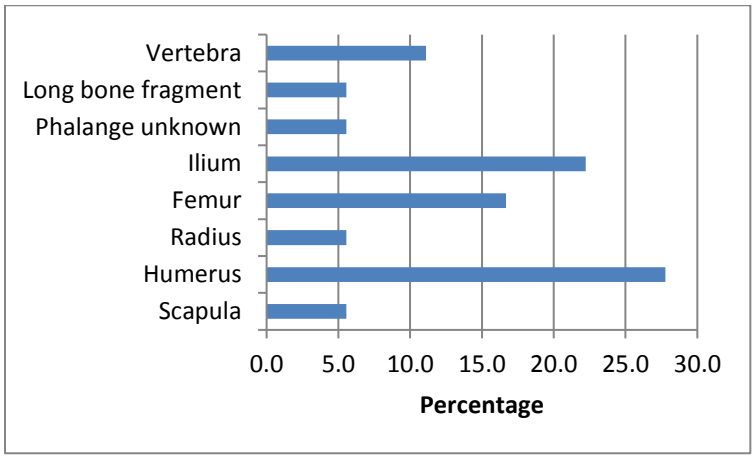


Figure 7.82. Relative frequency of skeletal elements in chelonian from Profile Two

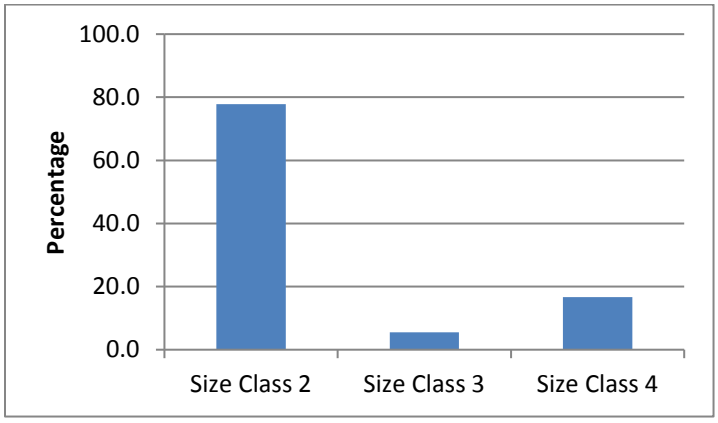


Figure 7.83. Relative frequency chelonia appendicular and axial remains with body size class in Profile Two

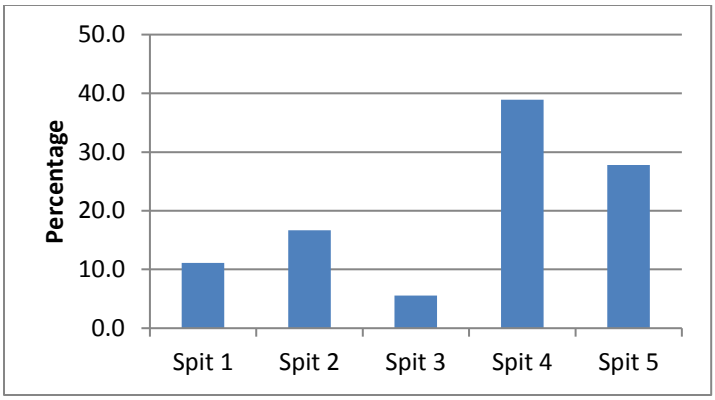


Figure 7.84. Relative frequency of chelonia appendicular and axial remains with spit from Profile Two

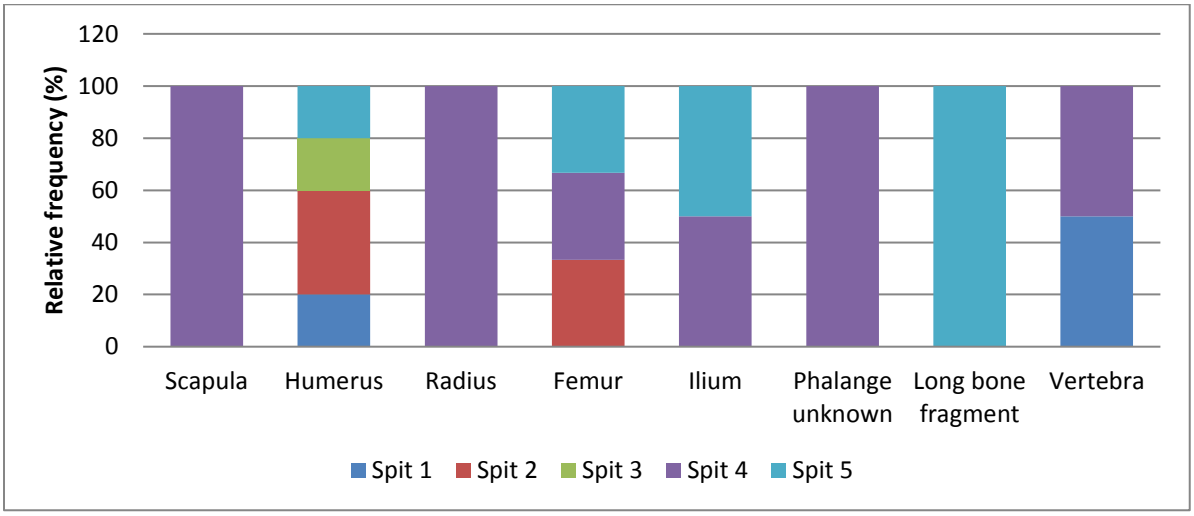


Figure 7.85. Relative frequency of skeletal element representation with spit in chelonian remains from Profile Two

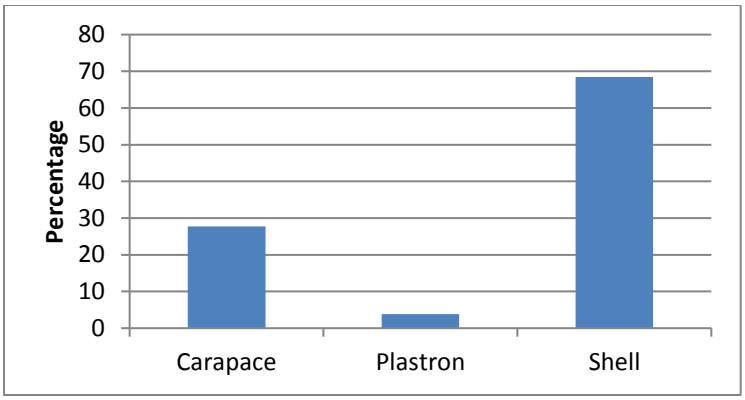


Figure 7.86. Relative frequency of chelonian shell elements from Profile Two

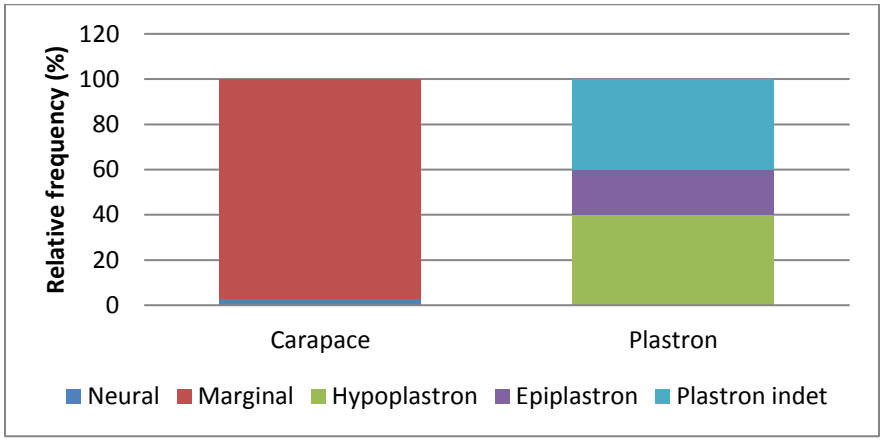


Figure 7.87. Relative frequency of shell elements in carapace and plastron from Profile Two

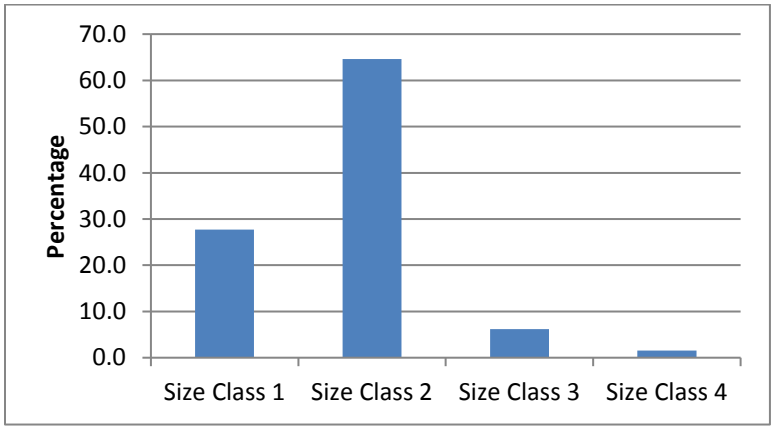


Figure 7.88. Relative frequency of body size class in chelonia shell elements from Profile Two

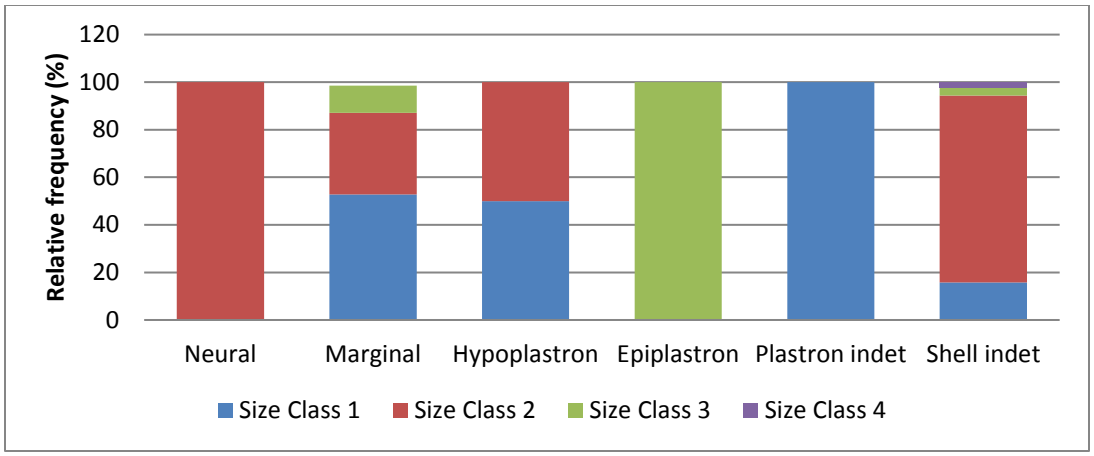


Figure 7.89. Chelonia shell elements with body size class from Profile Two

Table 7.51. Descriptive statistics of maximum length of chelonian remains from Profile Two

	Combined	Size Class 1	Size Class 2	Size Class 3	Size Class 4
N	147	36	98	9	5
Minimum	6	6	7	14	20
Maximum	67	17	28	67	60
Mean	14.58	11.36	13.81	27.44	29.8
Standard Deviation	7.57	3.04	4.15	16.51	19.55

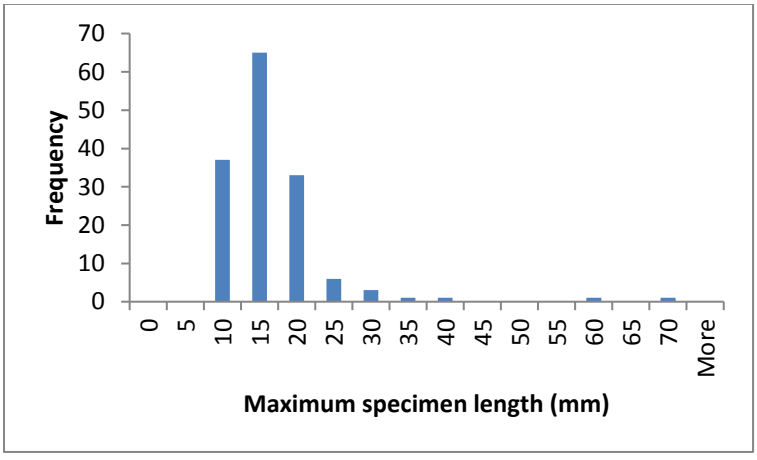


Figure 7.90. Histogram of maximum length of combined chelonia remains from Profile Two

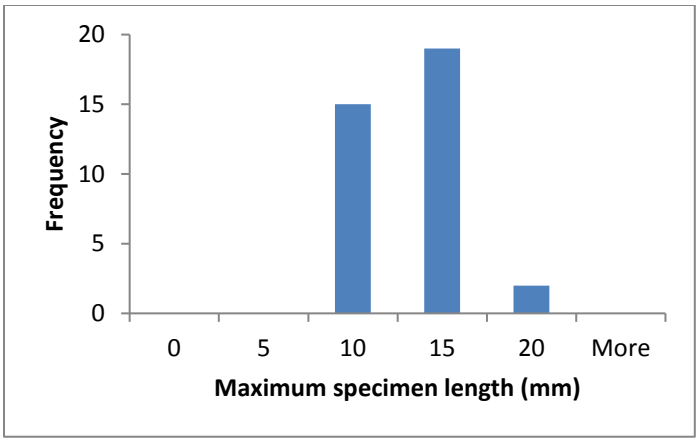


Figure 7.91. Histogram of maximum specimen length in size class one chelonia remains from Profile Two

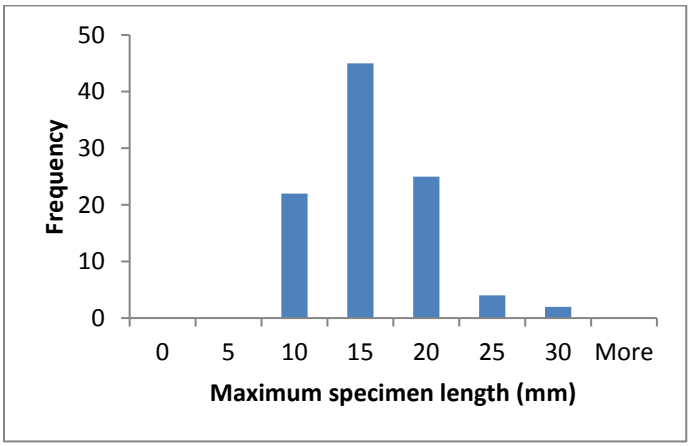


Figure 7.92. Histogram of maximum specimen length in size class two chelonia remains from Profile Two

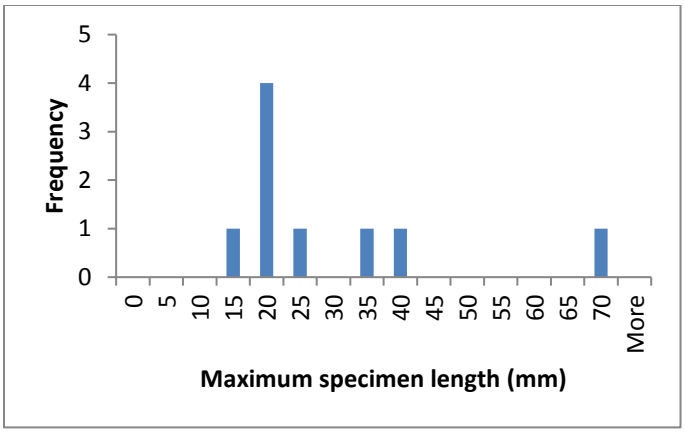


Figure 7.93. Histogram of maximum specimen length in size class three chelonia remains from Profile Two

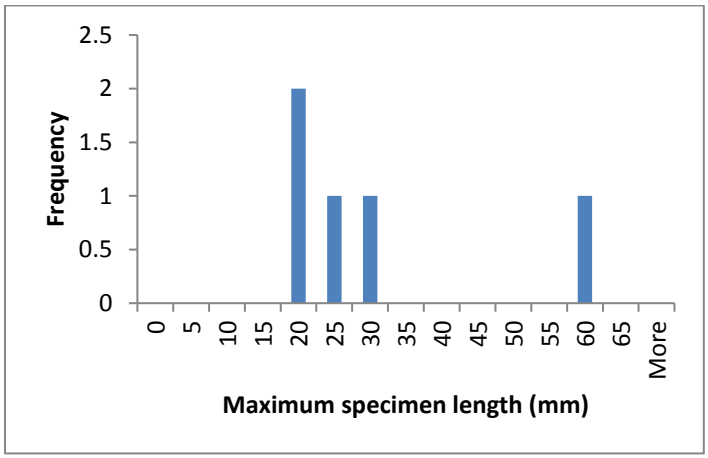


Figure 7.94. Histogram of maximum specimen length in size class four chelonia remains from Profile Two

Table 7.53. Completeness in chelonian remains from Profile Two

	Size Class 2		Size Class 4		Total	
	N	**%**	**N**	**%**	**N**	**%**
Carapace	1	33.3	-	-	**1**	**33.3**
Humerus	-	-	1	33.3	**1**	**33.3**
Phalange	1	33.3	-	-	**1**	**33.3**
Total	**2**	**66.6**	**1**	**33.3**	**3**	**2**

Table 7.54. Breakage classes in chelonia appendicular and axial remains from Profile Two

	Complete		Proximal End		Proximal End (incomplete)		Distal End (incomplete)		Shaft		Proximal Shaft		Distal Shaft	
	N	%	M	%	M	%	M	%	M	%	M	%	M	%
Humerus	1	20	-	-	1	20	-	-	1	20	1	20	1	20
Radius	-	-	1	100	-	-	-	-	-	-	-	-	-	-
Femur	-	-	-	-	-	-	1	33.3	-	-	1	33.3	1	33.3
Long bone frag.	-	-	-	-	-	-	-	-	1	100	-	-	-	-

	Acetabulum		Proximal Shaft		Distal Shaft	
	N	%	N	%	N	%
Ilium	1	25	2	50	1	25

	Complete		Fragment	
	N	%	N	%
Phalange	1	100	-	-

	Distal Blade	
	N	%
Scapula	1	100

	Vertebra Body	
	N	%
Vertebra	2	100

Table 7.55. Fracture outline in chelonia appendicular remains from Profile Two

	Spiral (Fresh)		Transverse (Dry)		Totals	
	N	**%**	**N**	**%**	**N**	**%**
Size Class 2	11	78.6	3	21.4	**14**	**50**
Size Class 4	2	66.6	1	33.3	**3**	**50**
Totals	**13**	**76.5**	**4**	**23.5**	**17**	**47.2**

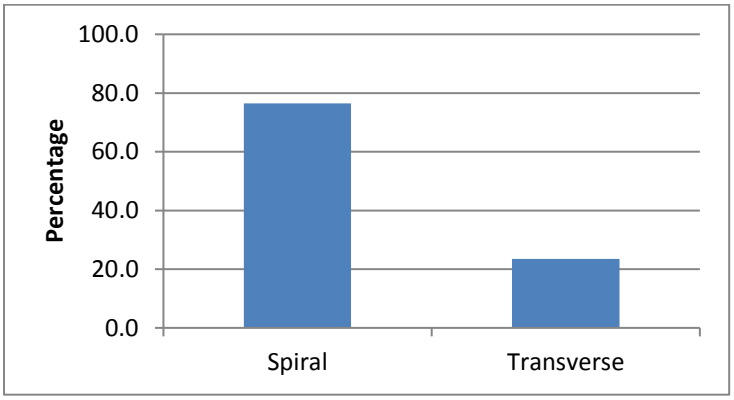


Figure 7.95. Relative frequency of fracture outline type in chelonia appendicular remains from Profile Two

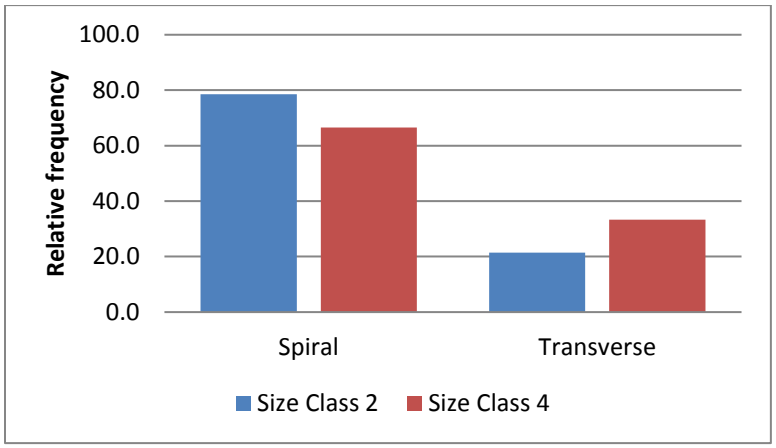


Figure 7.96. Fracture outline type with body size class in chelonian appendicular remains from Profile Two

Table 7.56. Fracture outline in chelonia appendicular elements from Profile Two

	Spiral (Fresh)		Transverse (Dry)		Totals	
	N	**%**	**N**	**%**	**N**	**%**
Scapula	1	100	-	-	**1**	**50**
Humerus	4	100	-	-	**4**	**40**
Radius	1	100	-	-	**1**	**50**
Femur	3	60	2	40	**5**	**83.3**
Ilium	3	75	1	25	**4**	**50**
Long bone fragment	1	33.3	1	66.6	**2**	**100**
Totals	**13**	**76.5**	**4**	**23.5**	**17**	**47.2**

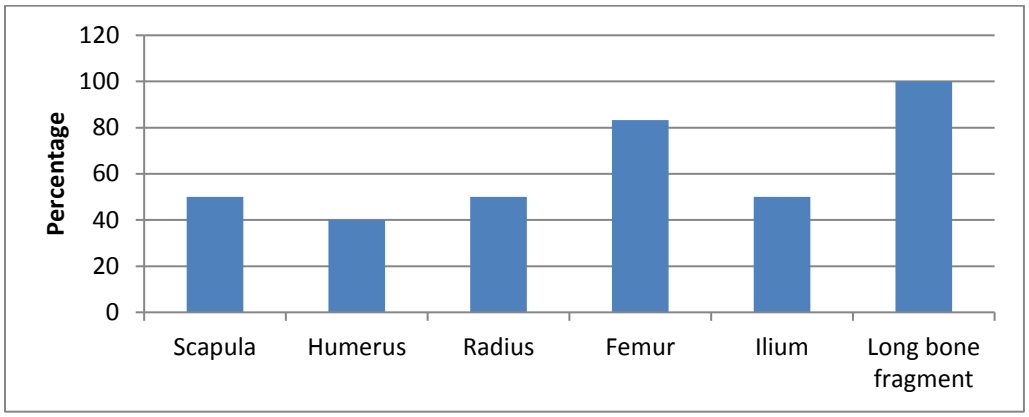


Figure 7.97. Relative frequency of fracture outline in chelonia appendicular elements from Profile Two

Table 7.57. Fracture outline in chelonia shell remains from Profile Two

	Spiral (Fresh)		Transverse (Dry)		Eroded		Total	
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Size Class 1	30	78.9	6	15.8	2	5.3	**38**	**52.8**
Size Class 2	63	62.4	35	34.7	3	3	**101**	**60.1**
Size Class 3	5	55.6	4	44.4	-	-	**9**	**56.3**
Size Class 4	2	100	-	-	-	-	**2**	**50**
Total	**100**	**66.7**	**45**	**30.0**	**5**	**3.3**	**150**	**57.7**

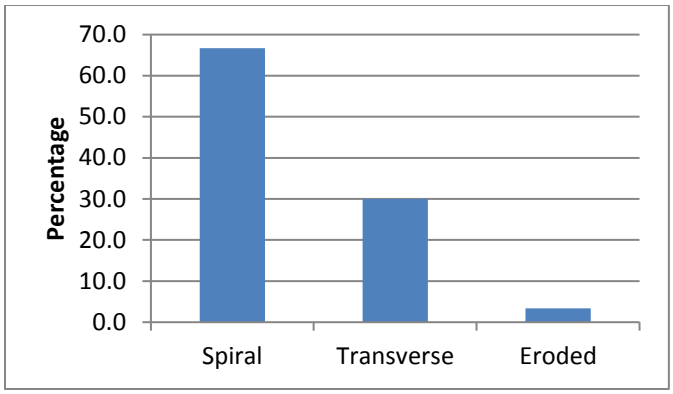


Figure 7.98. Relative frequency of fracture outline type in chelonia shell remains from Profile Two

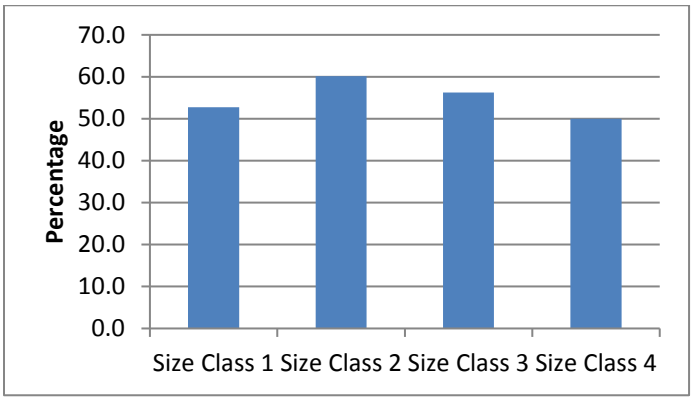


Figure 7.99. Relative frequency of fracture outline with body size in chelonia shell remains from Profile Two

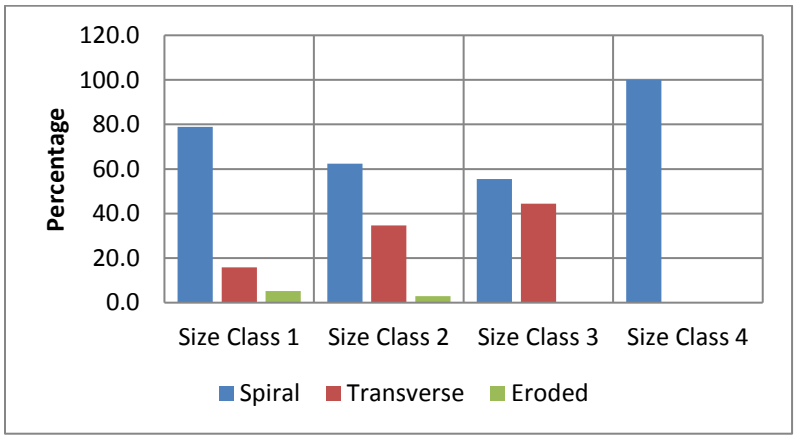


Figure7.100. Fracture outline type with body size class in chelonia shell remains from Profile Two

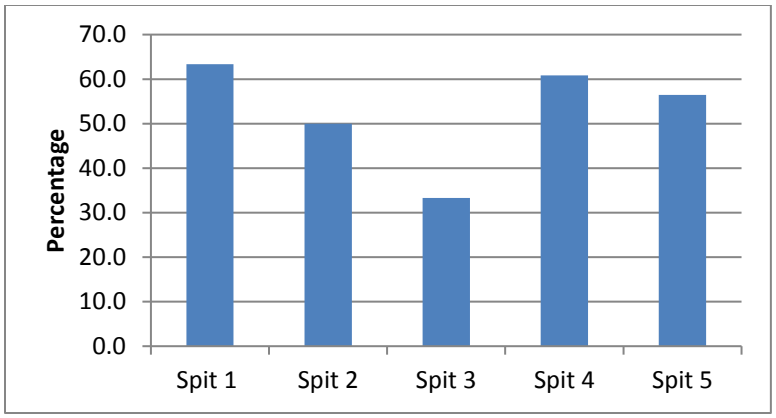


Figure 7.101. Relative frequency of fracture outline by spit in chelonia shell remains with Profile Two

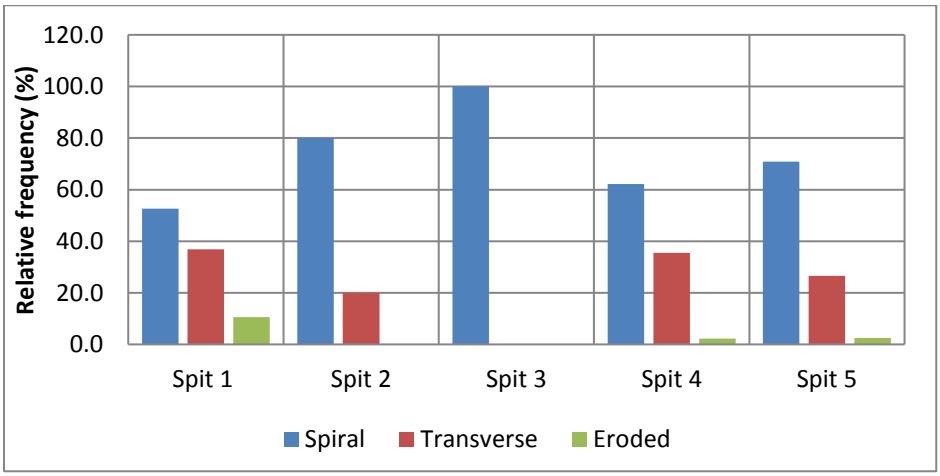


Figure 7.102. Fracture outline type and spit in chelonia shell remains from Profile Two

Table 7.58. Fracture angle in chelonia appendicular remains from Profile Two

	Oblique (Fresh)		Right (Dry)		Mixed		Total	
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Size class 2	8	50	3	18.8	5	31.3	**16**	**9.5**
Size class 4	1	33.3	1	33.3	1	33.3	**3**	**75**
Totals	**9**	**47.4**	**4**	**21.1**	**6**	**31.6**	**19**	**52.8**

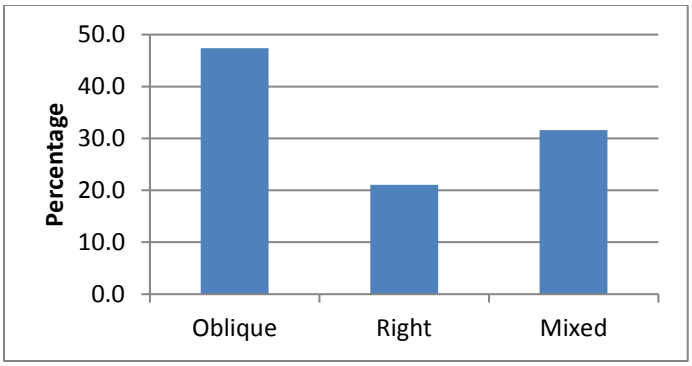


Figure 7.103. Relative frequency of fracture angle type in chelonian appendicular remains from Profile Two

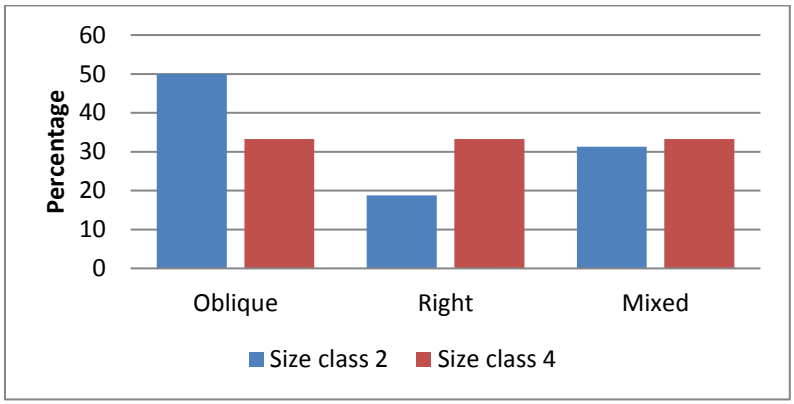


Figure 7.104. Fracture angle type with body size class in chelonian appendicular remains from Profile Two

Table 7.59. Fracture angle in chelonia long bones from Profile Two

	Obliue (Fresh)		Right (Dry)		Mixed		Total	
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Scapula	-	-	-	-	1	100	**1**	**50**
Humerus	4	66.7	-	-	2	33.3	**6**	**60**
Radius	-	-	-	-	1	100	**1**	**50**
Femur	1	25	2	25	2	50	**5**	**83.3**
Ilium	3	75	1	25	-	-	**4**	**50**
Long bone fragment	1	50	1	50	-	-	**2**	**100**
Totals	**9**	**47.4**	**4**	**21.1**	**6**	**31.6**	**19**	**52.8**

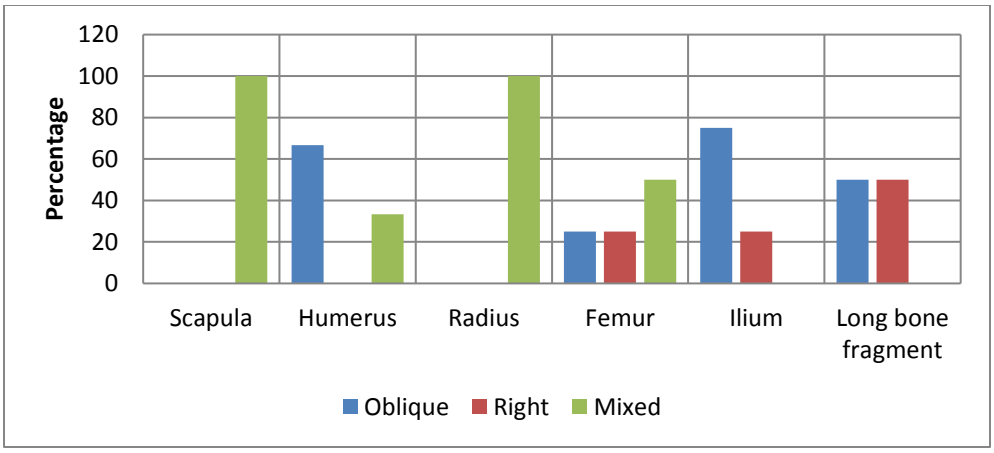


Figure 7.105. Fracture angle type in chelonia long bones from Profile Two

Table 7.60. Fracture angle in chelonia appendicular remains with spit from Profile Two

	Oblique (Fresh)		Right (Dry)		Mixed		Total	
	N	%	N	%	N	%	N	%
Spit 1	1	100	-	-	-	-	**1**	**25**
Spit 2	3	75	1	25	-	-	**4**	**66.7**
Spit 3	-	-	-	-	1	100	**1**	**50**
Spit 4	1	20	1	20	3	60	**5**	**35.7**
Spit 5	4	50	2	25	2	25	**8**	**80**
Totals	**9**	**47.4**	**4**	**21.1**	**6**	**31.6**	**19**	**52.8**

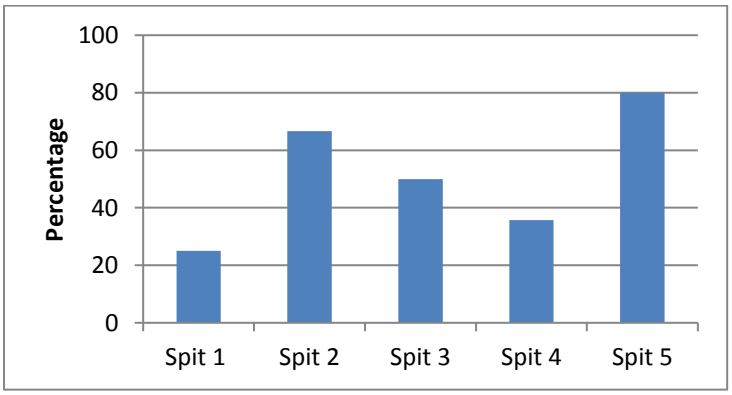


Figure 7.106. Relative frequency of fracture angle in chelonian appendicular remains and spit from Profile Two

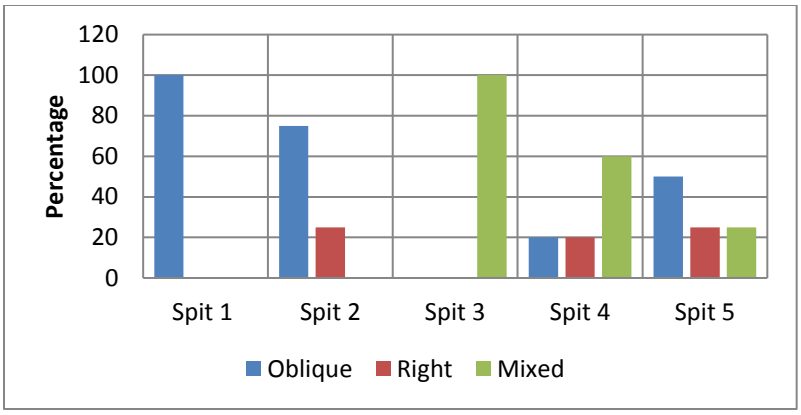


Figure 7.107. Fracture angle type with spit in chelonian appendicular remains from Profile Two

Table 7.61. Fracture angle in chelonia shell remains from Profile Two

	Oblique (Fresh)		Right (Dry)		Mixed		Total	
	N	%	N	%	N	%	N	%
Size Class 1	19	50	12	31.6	7	18.4	**38**	**52.8**
Size Class 2	22	22.7	46	47.4	29	29.9	**97**	**57.7**
Size Class 3	3	37.5	3	37.5	2	25	**8**	**50**
Size Class 4	1	33.3	1	33.3	1	33.3	**3**	**75**
Totals	**45**	**30.8**	**62**	**42.5**	**39**	**26.7**	**146**	**56.2**

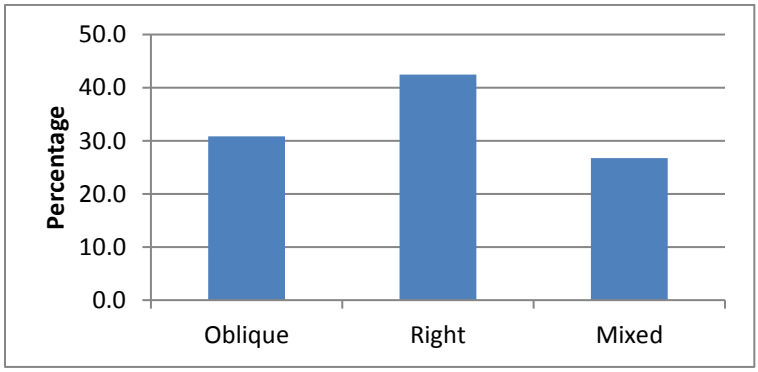


Figure 7.108. Relative frequency of fracture angle in chelonia shell remains from Profile Two

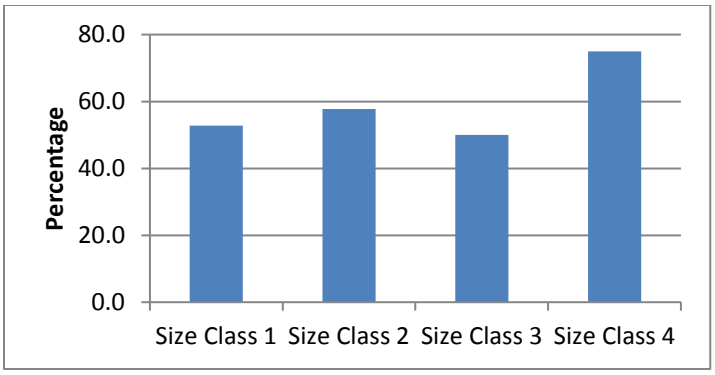


Figure 7.109. Relative frequency of fracture angle with body size class in chelonia shell remains from Profile Two

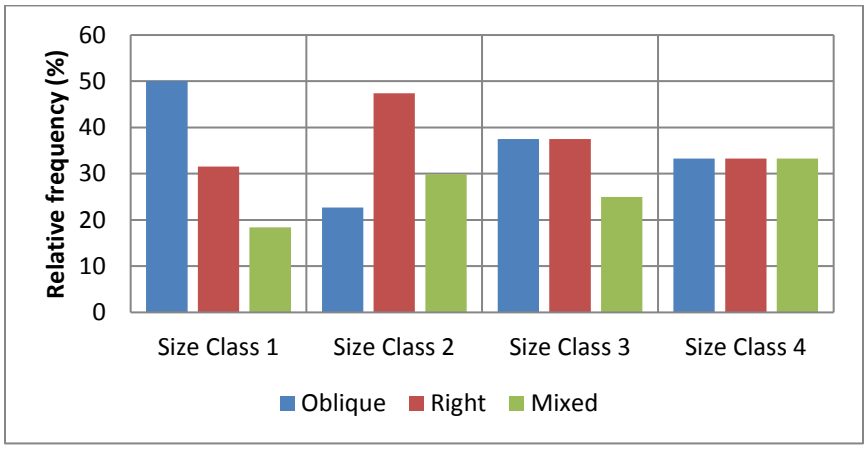


Figure 7.110. Fracture angle type with body size class in chelonia shell remains from Profile Two

Table 7.62. Fracture angle in chelonia shell remains and spit from Profile Two

	Obliue (Fresh)		Right (Dry)		Mixed		Total	
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Spit 1	5	26.3	11	57.9	3	15.8	**19**	**63.3**
Spit 2	1	20	1	20	3	60	**5**	**50**
Spit 3	1	50	1	50	-	-	**2**	**33.3**
Spit 4	18	40	15	33.3	12	26.7	**45**	**60.8**
Spit 5	20	26.7	34	45.3	21	28	**75**	**53.6**
Totals	**45**	**30.8**	**62**	**42.5**	**39**	**26.7**	**146**	**56.2**



Figure 7.111. Fracture angle type and spit in chelonia shell remains from Profile Two

Tabele 7.63. Weathering in chelonia remains from Profile Two

	Skeletals		Carapace		Plastron		Shell		Total	
	N	%	**N**	%	**N**	%	**N**	%	**N**	**%**
Stage 0	13	72.2	31	86.1	3	60	76	85.4	**123**	**83.1**
Stage 1	3	16.7	5	13.9	2	40	9	10.1	**19**	**12.8**
Stage 2	2	11.1	-	-	-	-	4	4.5	**6**	**4.1**
Total	**5**	**27.8**	**5**	**13.9**	**2**	**40**	**13**	**14.6**	**25**	**16.9**

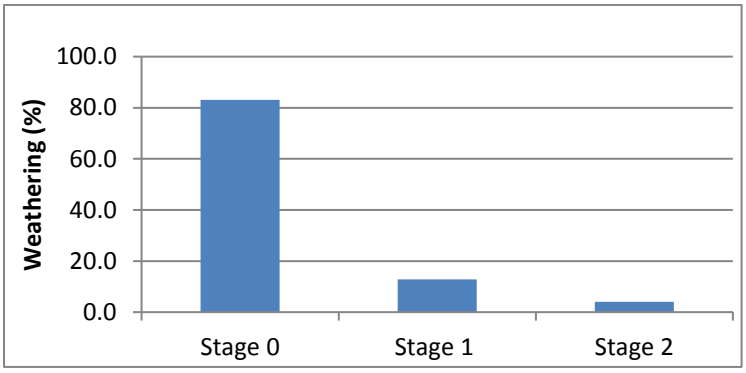


Figure 7.112. Weathering intensity in chelonian remains from Profile Two

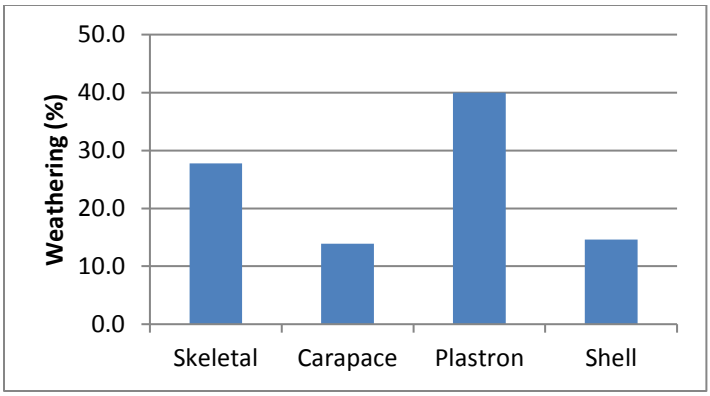


Figure 7.113. Relative frequency of weathering in chelonia elements from Profile Two

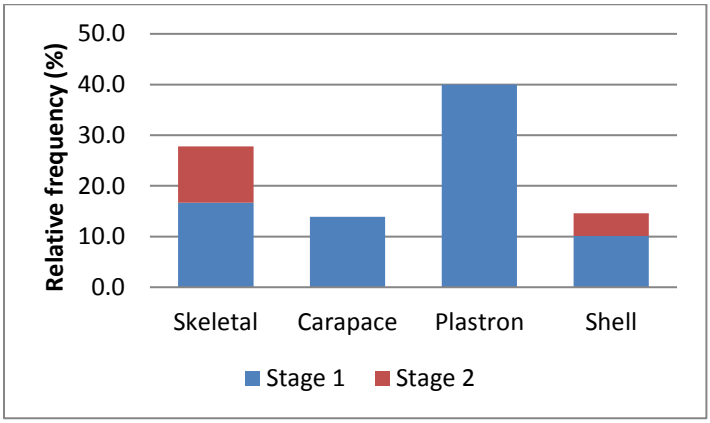


Figure 7.114. Weathering with body size class in chelonia elements from Profile Two

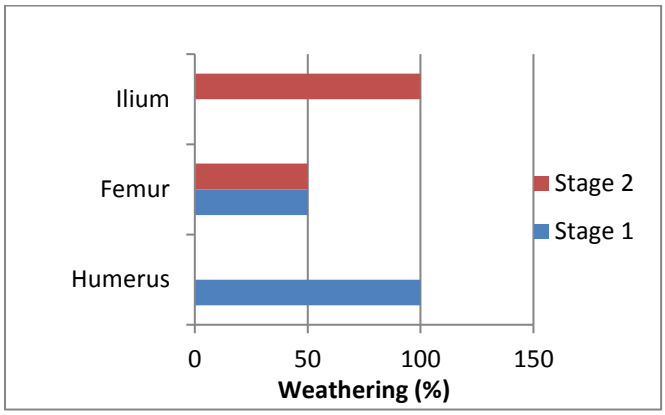


Figure 7.115. Relative frequency of weathering in chelonian appendicular remains from Profile Two

Table 7.64. Weathering in chelonia shell remains with spit depth in Profile Two

	Size Class 1		Size Class 2		Size Class 3		Size Class 4		Total	
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Stage 0	30	83.3	83	98.8	6	75	2	100	**91**	**70**
Stage 1	6	16.7	7	8.3	3	37.5	-	-	**10**	**7.7**
Stage 2	-	-	4	4.8	-	-	-	-	**4**	**3.1**
Total	**6**	**16.7**	**11**	**13.1**	**3**	**37.5**	**-**	**-**	**14**	**10.8**

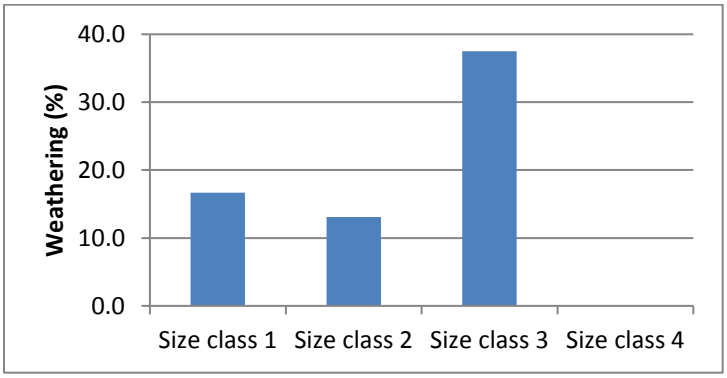


Figure 7.116. Relative frequency of weathering with body size class in chelonian remains from Profile Two

Table 7.65. Burning in chelonia remains from Profile Two

	Skeletals		Carapace		Plastron		Shell		Total	
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Stage 0	16	88.9	30	83.3	4	80	83	93.3	**133**	**89.9**
Stage 1	2	11.1	3	8.3	1	20	2	2.2	**8**	**5.4**
Stage 2	-	-	1	2.8	-	-	-	-	**1**	**0.7**
Stage 3	**-**	-	2	5.6	**-**	-	3	3.4	**5**	**3.4**
Stage 4	-	-	-	-	-	-	1	1.1	**1**	**0.7**
Total	**2**	**11.1**	**6**	**16.7**	**1**	**20**	**6**	**6.7**	**15**	**10.1**

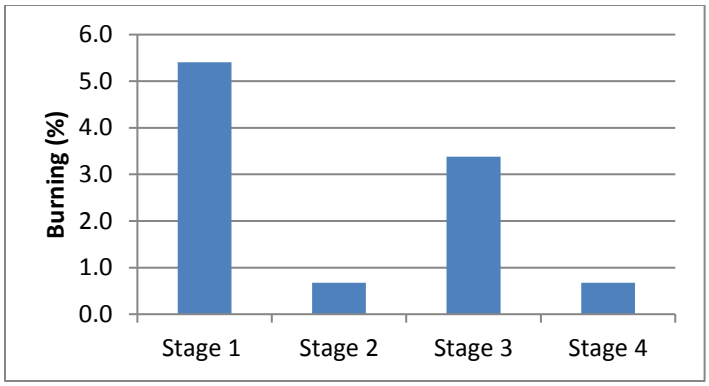


Figure 7.117. Burning intensity in chelonia remains from Profile Two

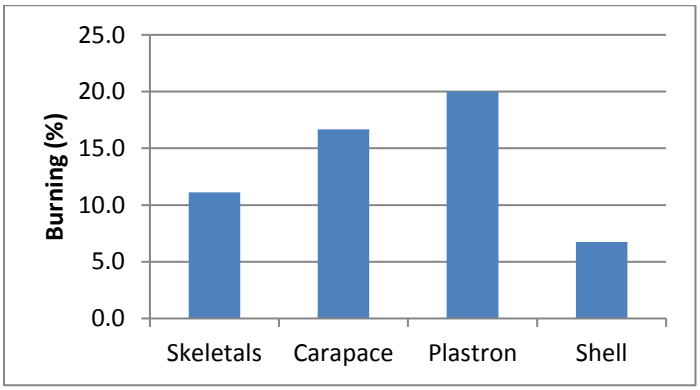


Figure 7.118. Relative frequency of burning in chelonia elements from Profile Two

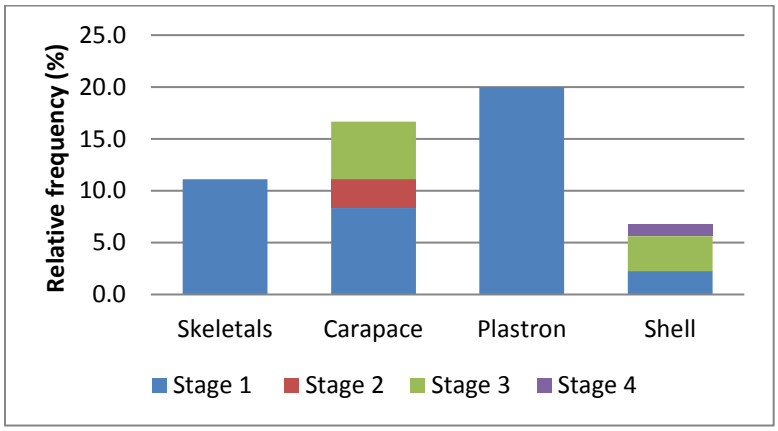


Figure 7.119. Burning intensity in chelonia elements from Profile Two

Table 7.66. Burning intensity with body size in chelonian remains from Profile Two

	Size class 1		Size class 2		Size class 3		Totals	
	N	%	N	%	N	%	N	%
Stage 0	29	80.6	78	92.9	8	100	**115**	**88.5**
Stage 1	4	11.1	2	2.4	-	-	**6**	**4.6**
Stage 2	1	2.8	-	-	-	-	**1**	**0.8**
Stage 3	2	5.6	3	3.6	-	-	**5**	**3.8**
Stage 4	-	-	1	1.2	-	-	**1**	**0.8**
Totals	**7**	**19.4**	**6**	**7.1**	**-**	**-**	**13**	**10**

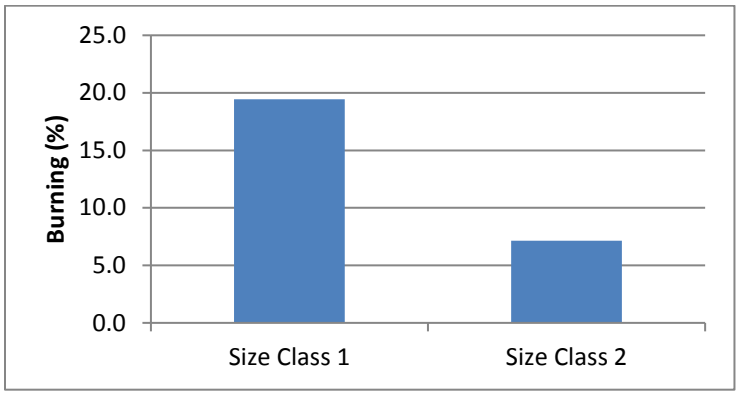


Figure 7.120. Relative frequency of burning with body size class in chelonian remains from Porfile Two

Table 7.67. Burning location on chelonian shell remains from Profile Two

	All Over		Edge		Inner		Totals	
	N	%	N	%	N	%	N	%
Skeletals	2	13.3	-	-	-	-	**2**	**13.3**
Carapace	5	33.3	1	6.7	-	-	**6**	**40**
Plastron	1	6.7	-	-	-	-	**1**	**6.7**
Shell	5	33.3	-	-	1	6.7	**6**	**40**
Totals	**13**	**86.7**	**1**	**6.7**	**1**	**6.7**	**15**	

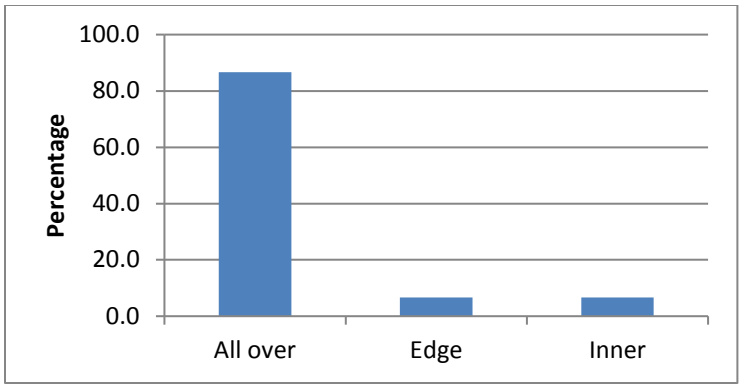


Figure 7.121. Relative frequency of burning location on chelonia shell from Profile Two

Table 7.68. Staining in chelonia elements from Profile Two

	Skeletals		Carapace		Plastron		Shell		Total	
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Stage 0	9	50	18	50	1	20	45	50.6	**73**	**49.3**
Stage 1	5	27.8	11	30.6	3	60	36	40.4	**55**	**37.2**
Stage 2	3	16.7	7	19.4	-	-	8	9	**18**	**12.2**
Stage 3	1	5.6	**-**	-	1	20	**-**	-	**2**	**1.4**
Total	**9**	**50**	**18**	**50**	**4**	**80.0**	**44**	**49.4**	**75**	**50.7**

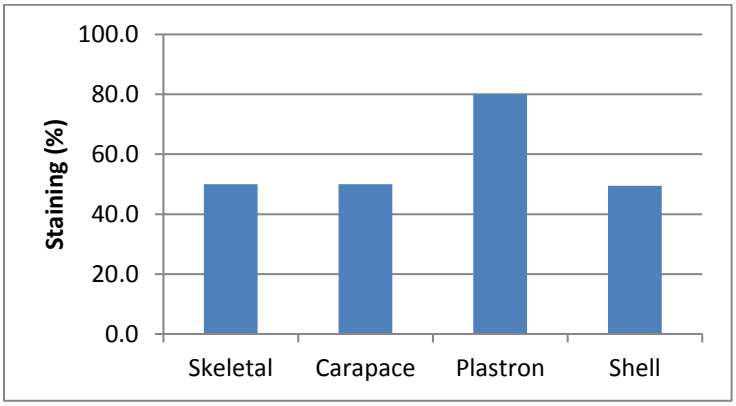


Figure 7.122. Relative frequency of staining in chelonia elements from Profile Two

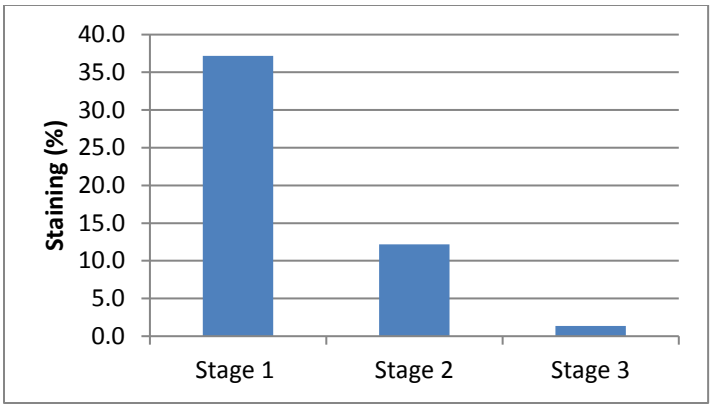


Figure 7.123. Staining intensity in chelonian remains from Profile Two

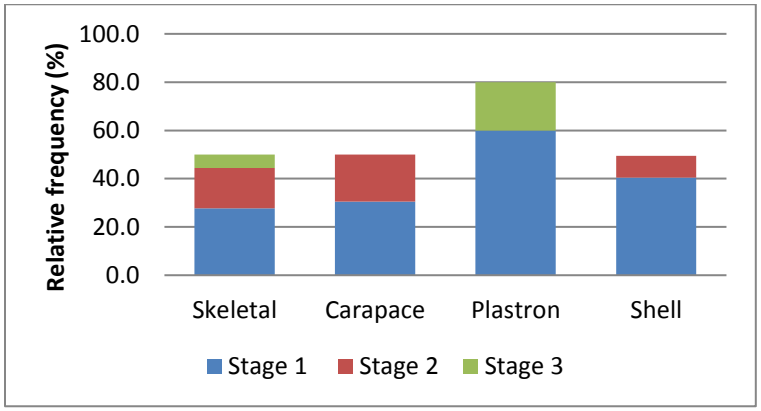


Figure 7.124. Staining intensity in chelonia elements from Profile Two

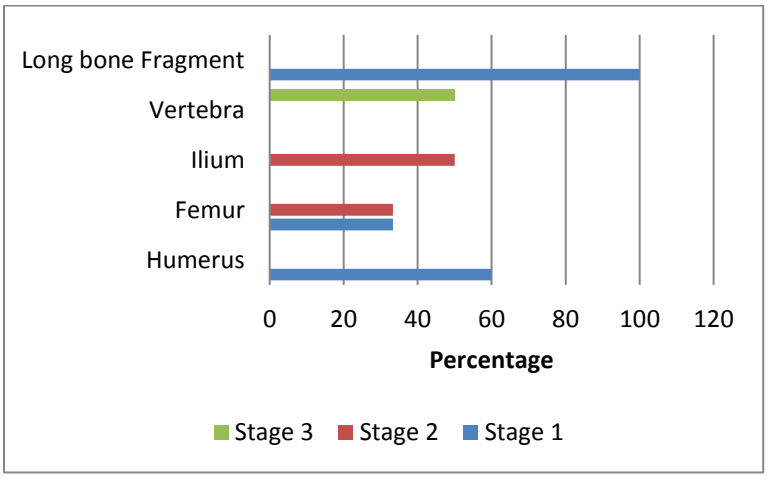


Figure 7.125. Staining intensity in chelonian appendicular and axial remains from Profile Two

Table 7.69. Staining with body size class in chelonia shell remains from Profile Two

	Size Class 1		Size Class 2		Size Class 3		Total	
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Stage 0	18	50	40	47.6	4	50	**62**	**47.7**
Stage 1	10	27.8	37	44	3	37.5	**50**	**38.5**
Stage 2	7	19.4	7	8.3	1	12.5	**15**	**11.5**
Stage 3	1	2.8	-	-	-	-	**1**	**0.8**
Total	**18**	**50**	**44**	**52.4**	**4**	**50**	66	**50.8**

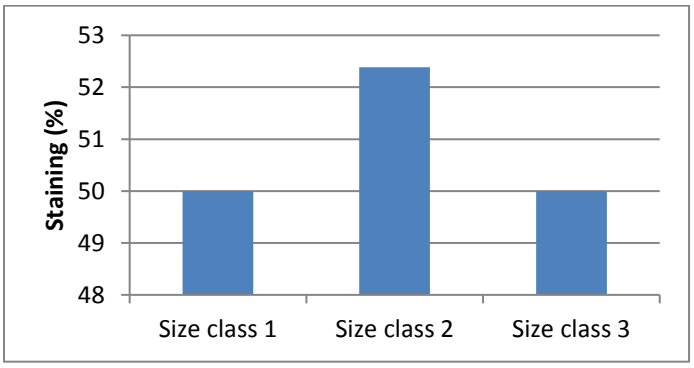


Figure 7.126. Relative frequency of staining in chelonia shell remains from Profile Two

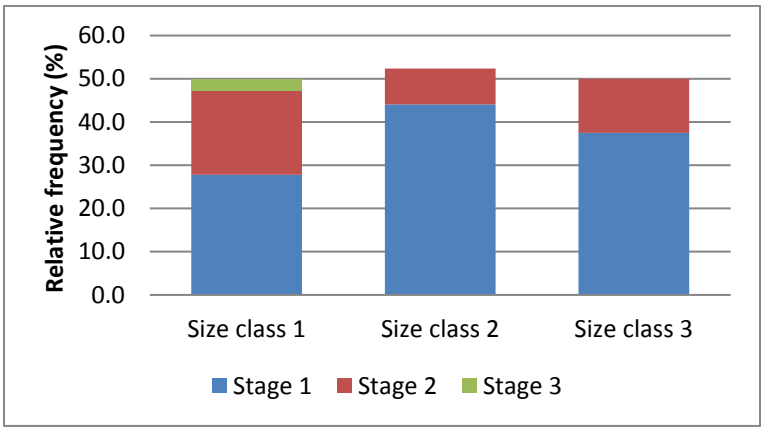


Figure 7.127. Staining intensity with body size class in chelonia shell remains from Profile Two

Table 7.70. Staining type in chelonia shell remains from Profile Two

	Brown		Purple		Black		Orange		Total	
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Size Class 1	9	22	-	-	1	100	8	34.8	**18**	**50**
Size Class 2	30	73.2	1	100	**-**	-	13	56.5	**44**	**52.4**
Size Class 3	2	4.9	-	-	**-**	-	2	8.7	**4**	**50**
Total	**41**	**62.1**	**1**	**1.5**	**1**	**1.5**	**23**	**34.8**	**66**	**50.8**

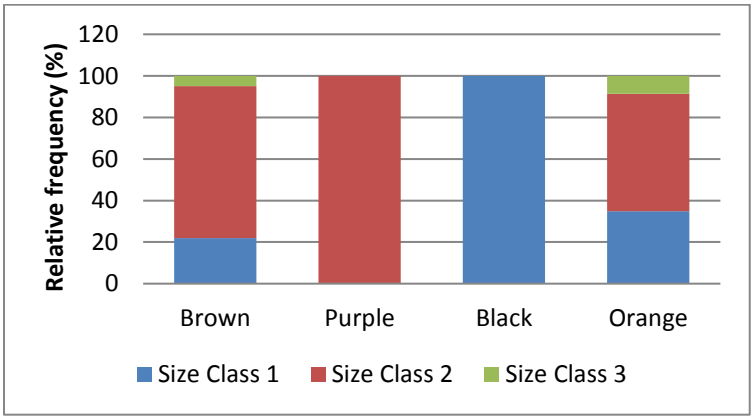


Figure 7.128. Body size class and staining type in chelonia shell remains from Profile Two

Table7.71. Abrasion in chelonia elements from Profile Two

	Skeletals		Carapace		Plastron		Shell		Total	
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Stage 0	1	5.6	1	2.8	2	40	2	2.2	**6**	**4.1**
Stage 1	3	16.7	6	16.7	1	20	13	14.6	**23**	**15.5**
Stage 2	10	55.6	11	30.6	1	20	29	32.6	**51**	**34.5**
Stage 3	**3**	16.7	18	50	1	20	37	41.6	**59**	**39.9**
Stage 4	1	5.6	-	-	-	-	8	88.9	**9**	**6.1**
Total	**17**	**94.4**	**35**	**97.2**	**3**	**60**	**87**	**97.8**	**142**	**95.9**

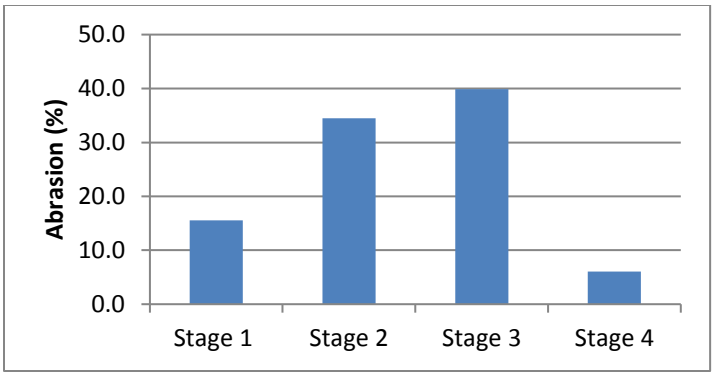


Figure 7.129. Abrasion intensity in chelonian remains from Profile Two

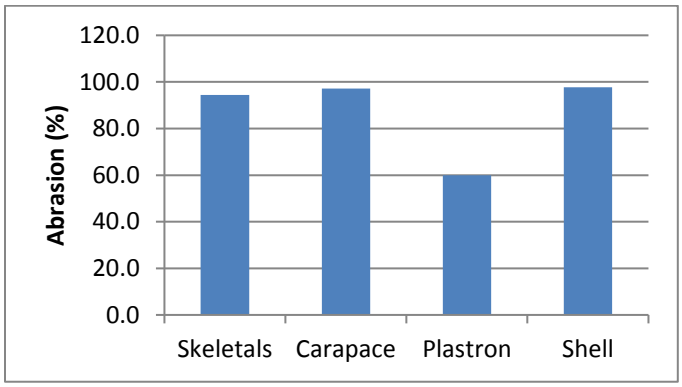


Figure 7.130. Relative frequency of abrasion in chelonia elements from Profile Two

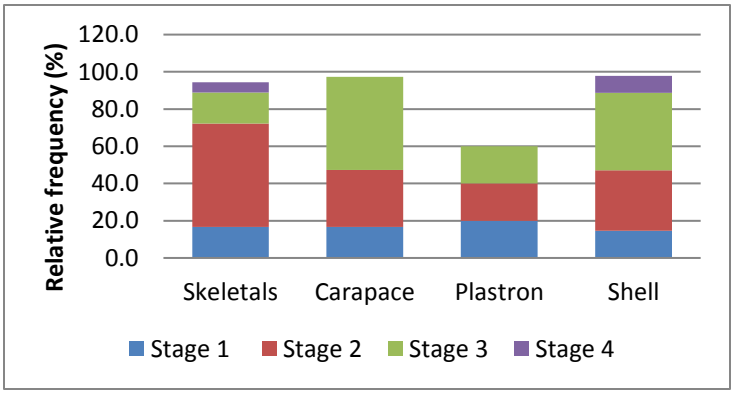


Figure 7.131. Abrasion intensity in chelonian elements from Profile Two

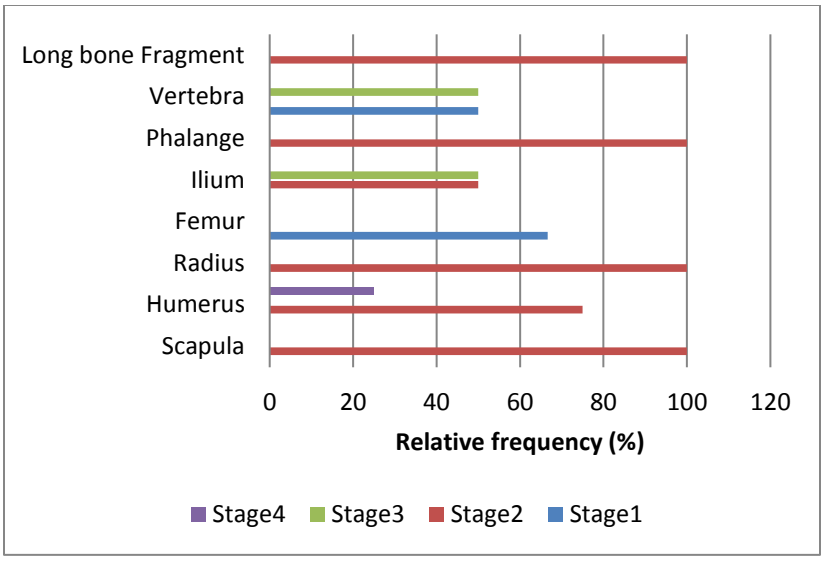


Figure 7.132. Relative frequency of abrasion in chelonia appendicular and axial remains from Profile Two

Table 7.72. Abrasion and body size in chelonia shell remains from Profile Two

	Size Class 1		Size Class 2		Size Class 3		Size Class 4		Total	
	N	%	N	%	N	%	N	%	N	%
Stage 0	3	8.3	2	2.4	-	-	-	-	**5**	**4**
Stage 1	10	27.8	9	10.7	1	12.5	-	-	**20**	**15**
Stage 2	14	38.9	26	31	1	12.5	-	-	**41**	**32**
Stage 3	8	22.2	40	47.6	6	75	2	100	**56**	**43**
Stage 4	1	2.8	7	8.3	-	-	-	-	**8**	**6**
Total	**33**	**91.7**	**82**	**97.6**	**8**	**100**	**2**	**100**	**125**	**96**

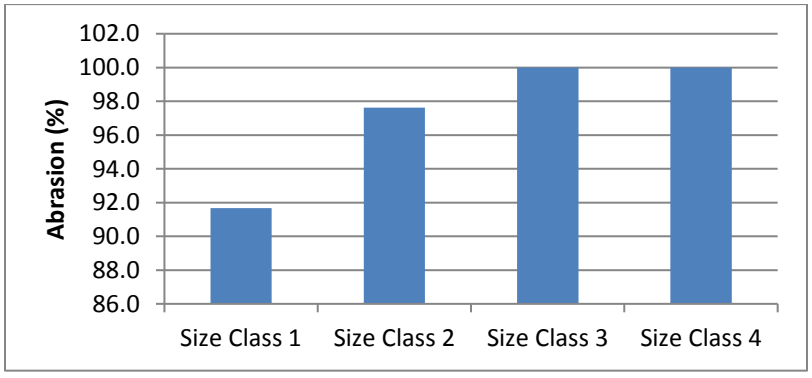


Figure 7.133. Relative frequency of abrasion with body size class in chelonia shell remains from Profile Two

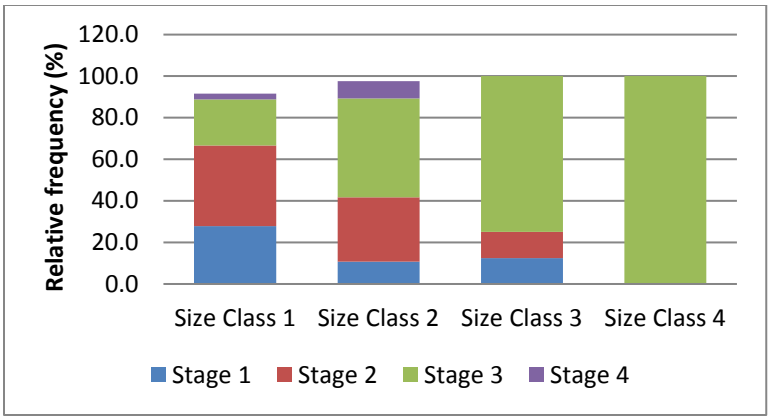


Figure 7.134. Abrasion intensity with body size class in chelonian remains from Profile Two

Table 7.73. Sheen in chelonian remains from Profile Two

	Skeletals		Carapace		Plastron		Shell		Total	
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Stage 0	12	66.7	26	72.2	3	60	65	73	**106**	**71.6**
Stage 1	1	5.6	6	16.7	1	20	18	20.2	**26**	**17.6**
Stage 2	-	-	3	8.3	1	20	5	5.6	**9**	**6.1**
Stage 3	5	27.8	1	2.8	-	-	1	1.1	**7**	**4.7**
Total	**6**	**33.3**	**10**	**27.8**	**2**	**40**	**24**	**27**	**42**	**28.4**

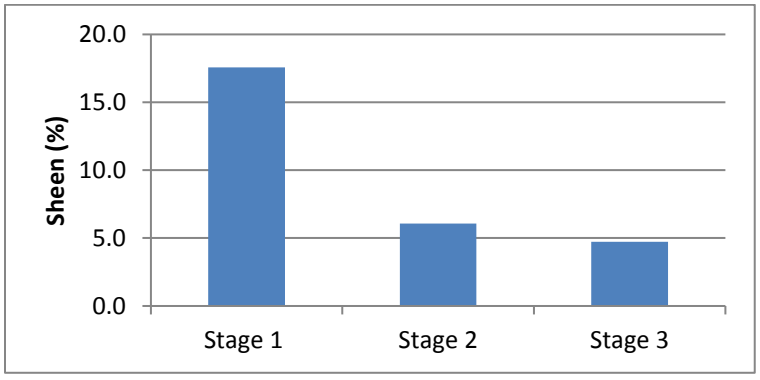


Figure 7.135. Sheen intensity in chelonian remains from Profile Two

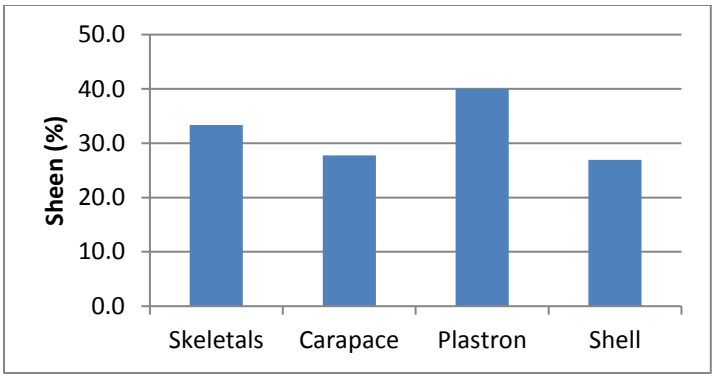


Figure 7.136. Relative frequency of sheen in chelonia elements from Profile Two

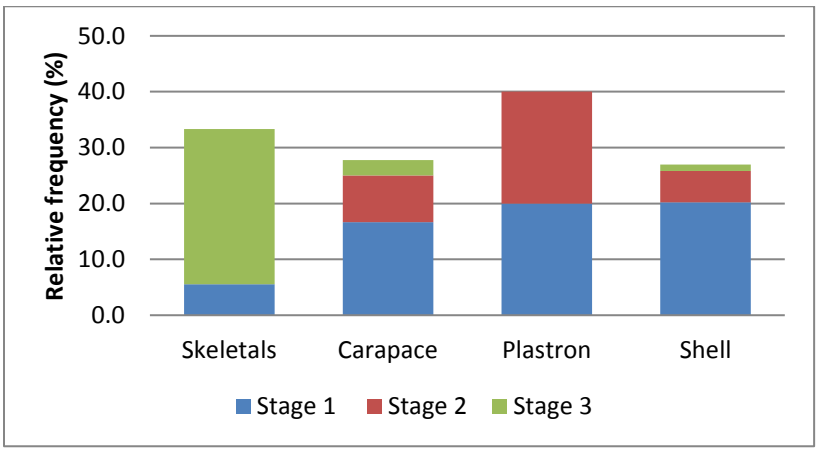


Figure 7.137. Sheen intensity in chelonia elements from Profile Two

Table 7.74. Sheen with body size class in chelonia shell remains from Profile Two

	Size Class 1		Size Class 2		Size Class 3		Size Class 4		Total	
	N	%	N	%	N	%	N	%	N	%
Stage 0	24	66.7	62	73.8	7	87.5	1	50	**94**	**72.3**
Stage 1	9	25	15	17.9	-	-	1	50	**25**	**19.2**
Stage 2	2	5.6	6	7.1	1	12.5	-	-	**9**	**6.9**
Stage 3	1	2.8	1	1.2	-	-	-	-	**2**	**1.5**
Total	**12**	**33.3**	**22**	**26.2**	**1**	**12.5**	**1**	**50**	**36**	**27.7**

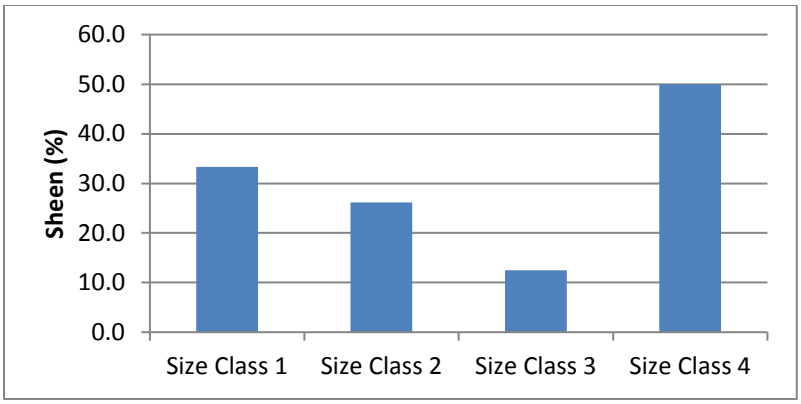


Figure 7.138. Relative frequency of sheen with body size class in chelonia shell remains from Profile Two

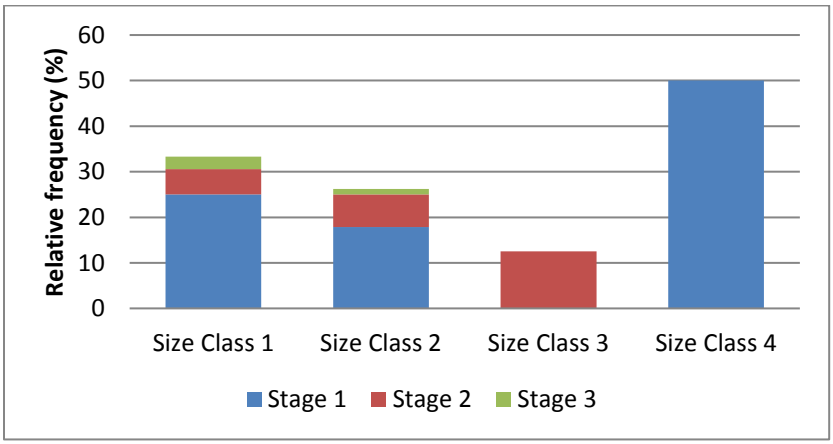


Figure 7.139. Sheen intensity and body size class in chelonia shell remains from Profile Two

Table 7.75. Trampling in chelonia remains in Profile Two

	Skeletals		Carapace		Plastron		Shell		Total	
	N	%	N	%	N	%	N	%	N	%
Stage 0	14	77.8	23	63.9	5	100	67	75.3	**109**	**73.6**
Stage 1	4	22.2	13	36.1	-	-	19	21.3	**36**	**24.3**
Stage 2	-	-	-	-	-	-	3	3.4	**3**	**2**
Total	**4**	**22.2**	**13**	**36.1**	**-**	**-**	**22**	**24.7**	**39**	**26.4**

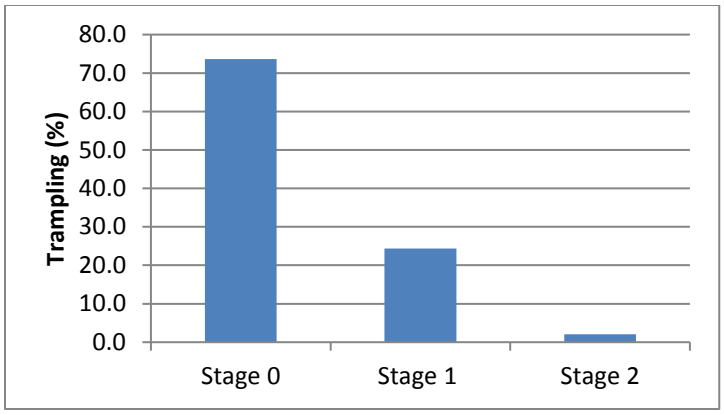


Figure 7.140. Trampling intensity in chelonia remains from Profile Two

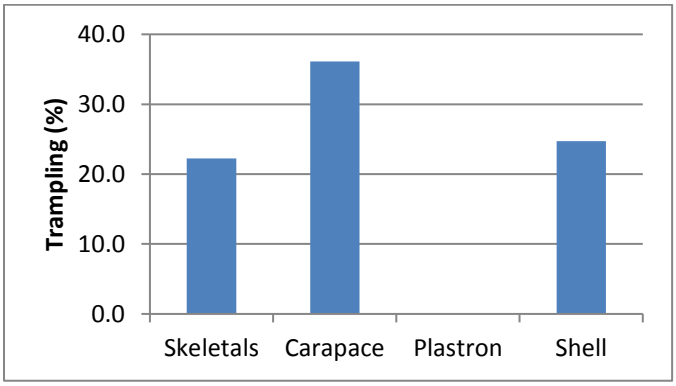


Figure 7.141. Relative frequency of trampling on chelonia elements from Profile Two

Table 7.76. Trampling and body size class in chelonia shell remains from Profile Two

	Size Class 1		Size Class 2		Size Class 3		Size Class 4		Total	
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Stage 0	27	75.0	60	71.4	6	75	1	50	**94**	**72.3**
Stage 1	9	25	21	25	2	25	1	50	**33**	**25.4**
Stage 2	-	-	3	3.6	-	-	-	-	**3**	**2.3**
Total	**9**	**25**	**24**	**28.6**	**2**	**25**	**1**	**50**	**36**	**27.7**

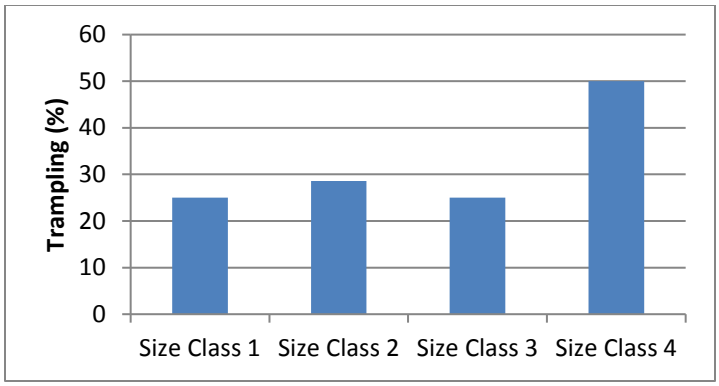


Figure 7.142. Relative frequency of trampling and body size class in chelonian shell remains from Profile Two

Table 7.77. Trampling type in chelonia elements from Profile Two

	Pit		Notch		Score		Scratch		Total	
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Skeletals	3	20	1	100	1	3.7	-	-	**5**	**27.8**
Carapace	5	33.3	-	-	10	37	-	-	**15**	**41.7**
Shell	7	46.7	-	-	16	59.3	2	100	**25**	**28.1**
Total	**15**	**33.3**	**1**	**2.2**	**27**	**60**	**2**	**4.4**	**45**	

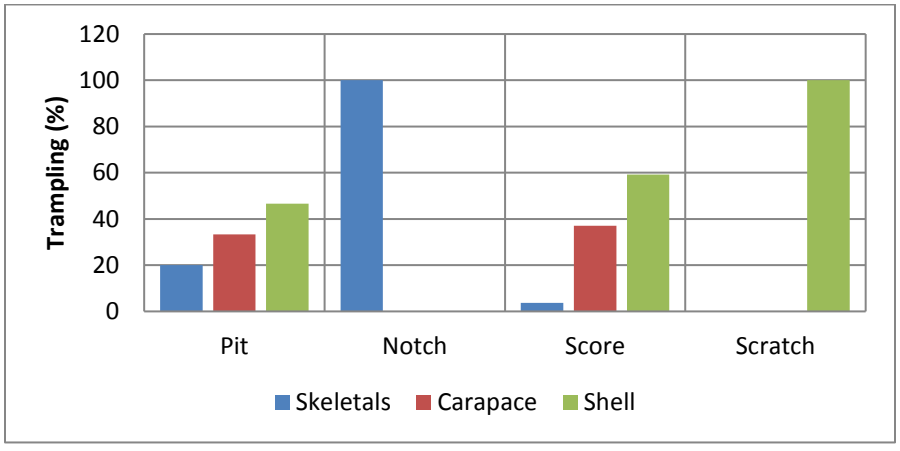


Figure 7.143. Trampling type in chelonia elements from Profile Two

Table 7.78. Root etching in chelonia from Profile Two

	Skeletals		Carapace		Plastron		Shell		Total	
	N	%	N	%	N	%	N	%	N	%
Stage 0	13	72.2	29	80.6	3	60	51	57.3	**96**	**64.9**
Stage 1	1	5.6	7	19.4	1	20	27	30.3	**36**	**24.3**
Stage 2	2	11.1	-	-	1	20	10	11.2	**13**	**8.8**
Stage 3	2	11.1	-	-	-	-	1	1.1	**3**	**2**
Totals	**5**	**27.8**	**7**	**19.4**	**2**	**40**	**38**	**42.7**	**52**	**35.1**

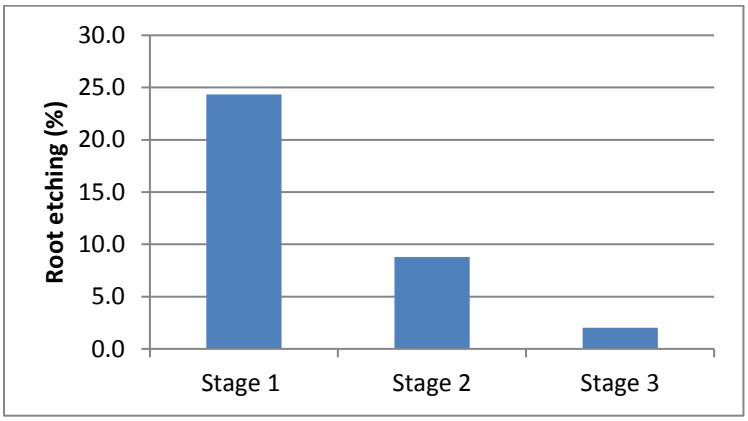


Figure 7.144. Root etching intensity in chelonia remains from Profile Two

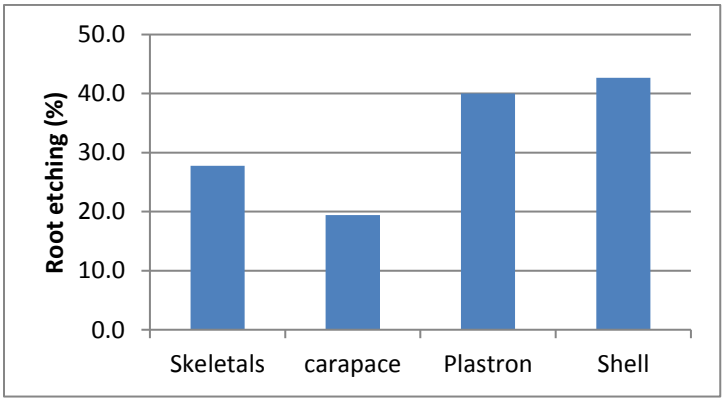


Figure 7.145. Relative frequency of root etching in chelonia elements from Profile Two

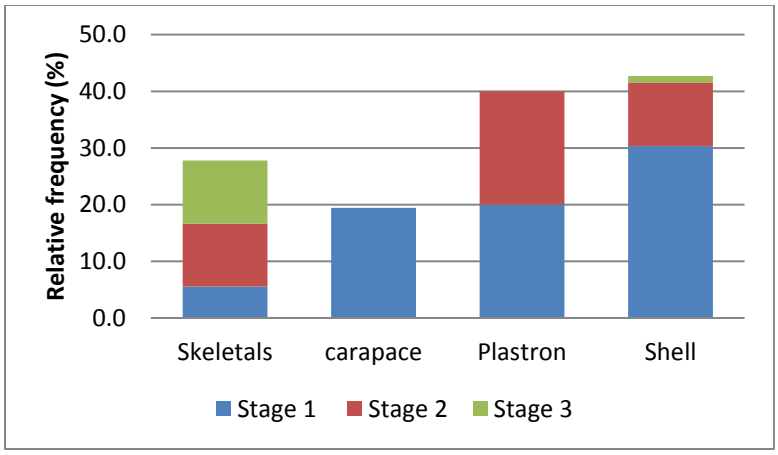


Figure 7.146. Intensity of root etching in chelonia elements from Profile Two

Table 7.79. Root etching in chelonia appendicular remains from Profile Two

	Stage 0		Stage 1		Stage 2		Stage 3	
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Humerus	4	80	-	-	-	-	1	20
Radius	-	-	-	-	1	100	-	-
Femur	2	66.6	-	-	-	-	1	33.3
Ilium	2	50	1	25	1	25	-	-

Table 7.80. Root etching and body size class in chelonia shell remains from Profile Two

	Size Class 1		Size Class 2		Size Class 3		Total	
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Stage 0	24	66.7	52	61.9	5	62.5	**81**	**62.3**
Stage 1	10	27.8	23	27.4	2	25	**35**	**26.9**
Stage 2	2	5.6	9	10.7	-	-	**11**	**8.5**
Stage 3	-	-	-	-	1	12.5	**1**	**0.8**
Total	**12**	**33.3**	**32**	**38.1**	**3**	**37.5**	**47**	**36.2**

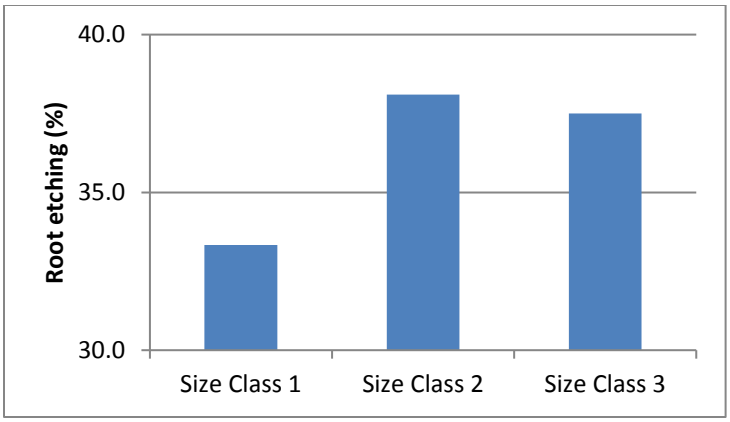


Figure 7.147. Relative frequency of root etching and body size class in chelonia shell remains from Profile Two

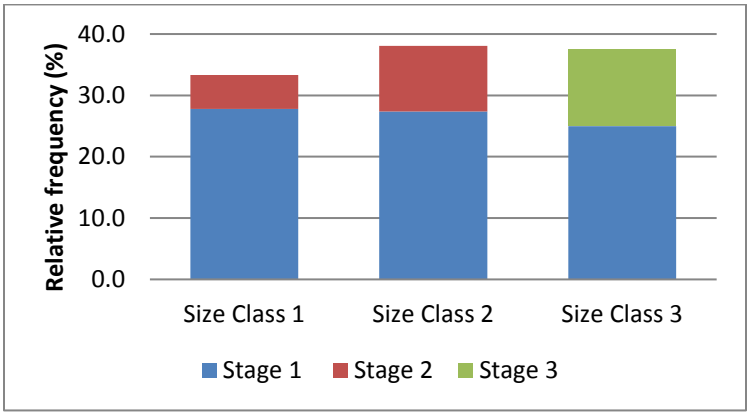


Figure 7.148. Intensity of root etching with body size in chelonia shell remains from Profile Two

Table 7.81. Avian remains from Profile Two

	Spit 1		Spit 4		Spit 5		Total	
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Size Class 2	-	-	-	-	1	33.3	**1**	**33.3**
Size Class 3	1	33.3	-	-	-	-	**1**	**33.3**
Size Class 4	-	-	1	33.3	-	-	**1**	**33.3**
Total	**1**	**33.3**	**1**	**33.3**	**1**	**33.3**	**3**	**1.5**

Table 7.82. Anatomical representation in avian remains and spit from Profile Two

Element	Size class 2	Size class 3	Size class 4
Humerus	-	1	-
Second phalange	-	-	1
Ulna	1	-	-

Table 7.83 Staining type in avian remains from Profile Two

	Brown	Orange
Humerus	1	-
Second Phalange	-	1
Ulna	1	-

Table 7.84. Abrasion in avian remains from Profile Two

	Stage 1	Stage 3
Humerus	1	-
Second Phalange	-	1
Ulna	-	1

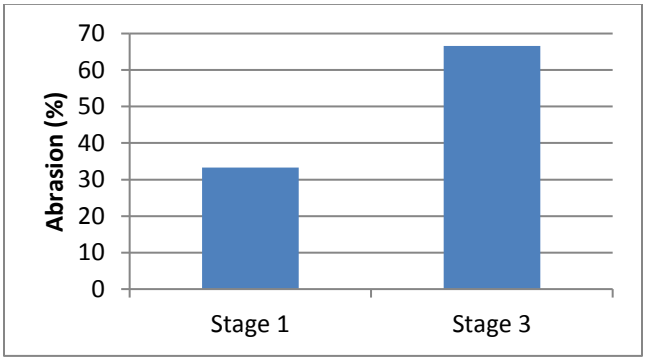


Figure 7.149. Abrasion intensity in avian remains from Profile Two

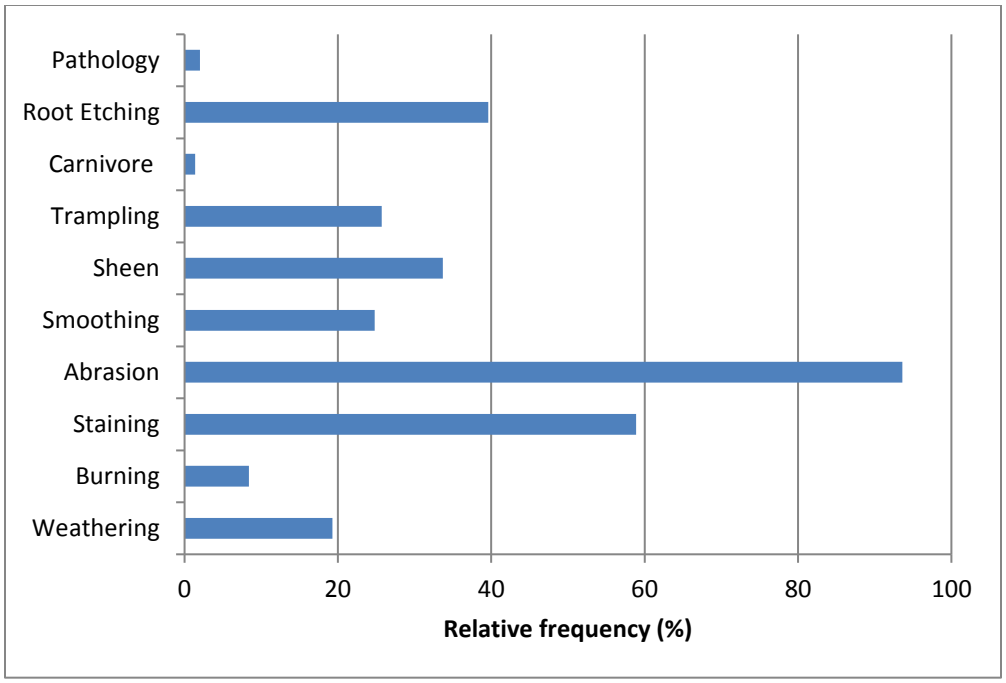


Figure 7.150. Relative frequency of surface modifications in bones from Profile Two

Table 7.85. Relative frequency of surface modifications by taxonomic group in bones from Profile Two

	Mammal	Chelonia	Aves	Total
Weathering	27.5	16.9	-	19.3
Burning	3.9	10.1	-	8.4
Staining	80.4	57	100	58.9
Abrasion	86.3	95.9	100	93.6
Smoothing	3.9	32.4	-	24.8
Sheen	51	28.4	-	33.7
Trampling	25.5	26.4	-	25.7
Carnivore	-	1.4	-	1.4
Root Etching	52.9	35.1	33.3	39.6
Pathology	2	-	-	2

Table 7.86. Relative frequency of surface modifications in bones in the MPPM and LQSM from Profile Two

	MPPM	LQSM
Identifiable specimens (n)	71	131
Identifiable specimens (%)	35.1	64.9
Mammal (%)	57.7	7.6
Chelonia (%)	40.8	90.8
Aves (%)	1.4	1.5
Avg length (mm)	23.2	14.2
Completeness	9.9	2.3
Fracture outline	Spiral	Spiral
Bone Weathering (%)	26.8	15.3
Burning (%)	4.2	10.7
Colour Mottling and Staining (%)	84.5	45
Abrasion (%)	90.1	95.4
Sheen & Polish (%)	25.4	38.2
Trampling (%)	22.5	27.5
Carnivore Modifications(%)	-	2.3
Root Etching (%)	45.1	36.6
Pathology (%)	1.4	-

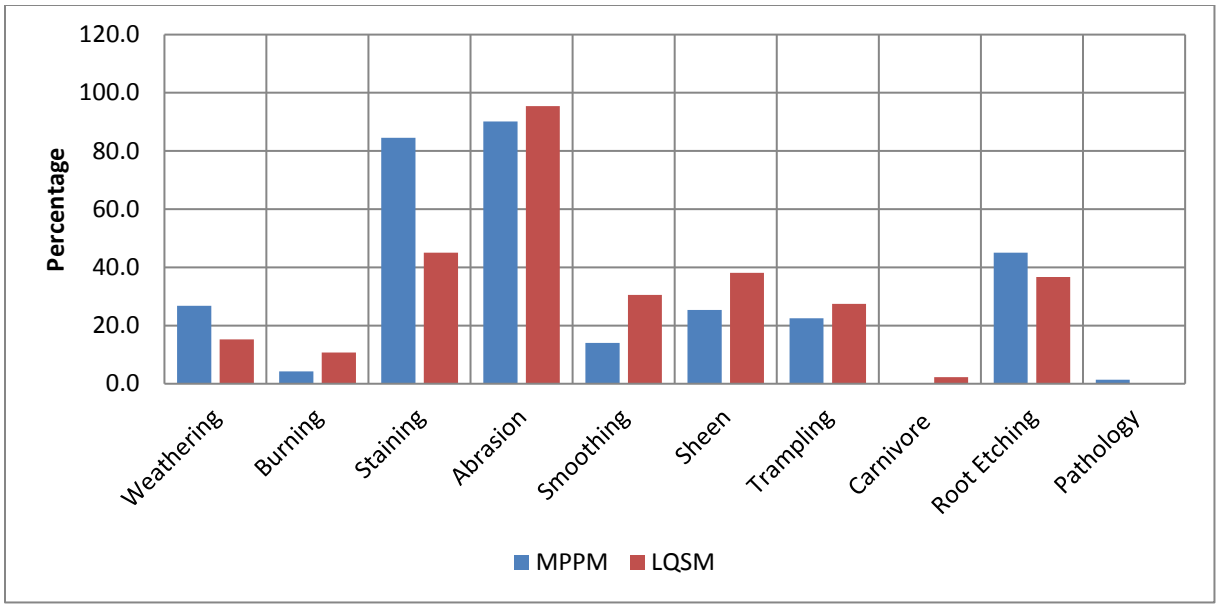


Figure 7.151. Relative frequency of surface modification in bones in the MPPM and LQSM from Profile Two

CHAPTER EIGHT

PROFILE ONE – RESULTS

8.1 SEDIMENTOLOGY

Profile One was located in the southern part of E-Quarry, approximately 200 m south of excavation 1976/2 and the bone bed at the GPS location S32°57'85"; E018°06'637" (Figure 5.1). Much of the quarry floor exposed LQSM and even KGM sediments (Figure 8.1), however there are some residual exposures of MPPM along the edges of the quarry floor (Roberts *et al.* 2011). Profile One was located along a thin band of raised MPPM sediments close to the overburden wall. No previous excavations have been undertaken in this area. Profile One was excavated to a depth of 0.4 m with one corner (0.2 X 0.2 m) taken down a further spit to 0.5 m experimentally. I chose to excavate in this area as it appears to be outside the river channel system represented by excavation 1976/2 and the bone bed. This test pit was expected to sample MPPM and LQSM, transecting right through the contact between these members and giving an insight to their relationship. In addition, initial surveying noted high abundance of small fossil remains outcropping around the edges of the MPPM mound, suggesting highly fossiliferous material could be expected. Sediments from Profile One were sieved through a 3.5 mm mesh and a 1 mm mesh was also used, just the Profile One sediments.

8.1.1 Excavations

Clearing

Due to the highly vegetated nature of the upper parts of the MPPM in this region bones from the first 0.15 m of the deposit were not assessed in the taphonomic analysis, but were considered to be cleanings. The cleanings were sieved and stored.

Spit One (15 cm – 25 cm)

Root traces and insect disturbance were extensive in this spit. Fossils from this level were, none-the less, collected for taphonomic analysis. Sediments were firm and indurated (lightly cemented) and wetting was required for excavation. The texture compared favourably with the MPPM sediments excavated in other test pits during this analysis, however the colour was darker than is typical for the MPPM. Some mottling of different colours and textures (sandy and silty) in this layer was observed, and is likely linked to root or insect disturbance.

Spit Two (25 cm – 35 cm)

It was in the upper (first 50 mm) part of this spit that pale, sandy sediments consistent with the LQSM are first encountered in Profile One (Figure 8.2). The LQSM layers were softer and easier to excavate and appeared to contained fewer large remains and large numbers of small fragmentary bones. The MPPM and LQSM interfingered finely and were thus excavated together as a contact zone.

Spit three (35 cm – 45 cm)

The LQSM increased in spit three with sediments becoming paler and sandier with depth. Infrequent patchy outcropping of the MPPM continued throughout this spit. In the deeper (from surface) levels of the LQSM bones become very fragile and soft to the touch and were surrounded by a halo of discolouration.

Spit Four (45 cm – 50 cm)

A test corner (0.2 X 0.2 m) of the test pit was excavated an additional 50 mm in depth. Due to time constraints it was not possible to finish the entire spit, but it was hoped this corner would provide some indication of the underlying bone density and preservation. At the time of the excavation, it was presumed, from the manner in which fossils were outcropping on the surface, that there was a bone layer in the MPPM which the excavation would transect. We now know that is not the case and it is

hoped that future opportunities to expand this excavation will arise. The sandy LQSM sediments in this half spit had a fluffy texture.

8.1.2 Sedimentological Analysis

MPPM

The MPPM sediments were firm and consolidated with a strong brown colour (10YR 4/3), quite different from the MPPM sediments in Profiles Two and Four. The MPPM in Profile One was grain supported and poorly sorted. Grains were rounded to well rounded with moderate to high sphericity. There was no sedimentary grading. The contact between the MPPM and LQSM was abrupt and wavy with fine interfingering of the sediments.

The results of the grain size analysis of this material was remarkable. Sediments display a very strong skew in favour of the coarse fraction (>2 mm) (Figure 8.3). There is a slight peak in the fine sands range and silts and muds represent less than 1% of the sediment mass (Figure 8.4). During excavations, this material was found to be highly problematic to sieve as, even when wet, it seemed to form a thick and sticky mud which would not pass through the mesh; if left to dry, the sediment would aggregate into well concreted clumps of differing sizes. Observations of these aggregates under magnification suggest they are made up of fine silt or smaller sized grains. During the sedimentary analysis, aggregated clumps of sediment collected in the largest sieve (2 mm) and the agitation action of the mechanical shaker was insufficient to disperse the individual grains; resulting in an apparent over-representation of very large particles in the sedimentary analysis. In the future this material will need to be prepared with a dispersal agent (for example sodium hexametaphophate solution) and then retested using wet sieving and hydrometer settling. The necessary equipment and chemicals for an analysis of this kind was not available at the time of writing. Thus, there is a high proportion of fine material in the Profile One MPPM. In addition, the darker colour of these sediments suggests that there is a higher proportion of organic material. These characters are typical of a mud flat or possibly marshy deposit. Both Hendey (1981) and Dingle *et al.* (1979) observed marshy or mud flat deposits in the Langebaanweg E-Quarry but in the QSM deposits. Hendey (1981) describes the mud-flats as occurring in the south-central part of E-Quarry and given the quarry size in the late 1970's (see Chapter Three) Profile One may be located in that area.

LQSM

Underlying the MPPM was pale sands (10YR 6/2) of the LQSM. This grain supported sediment was poorly sorted. Quartz grains had low sphericity and were rounded to well rounded. The LQSM did not display any sedimentary grading. The sedimentary analysis of the LQSM was more successful than the MPPM. A relatively high (16.5%) proportion of coarse (>2 mm) material was observed (Figure 8.5). Fine material was rare; silt made up only 0.5% of the mass and no finer material (<0.038 mm) was represented (Figure 8.6). Very fine sands dominated the assemblage although fine sands were also common.

8.2 TAXONOMY

A total of 10 246 bone remains were recovered from Profile One (Table 8.1). Of which, 13% (1 332) were identifiable to element and family, and a further 16% (1 647) were microfaunal remains. The remaining 7 267 specimens recovered from Profile One were unidentifiable and are hereafter excluded from analysis. The number of microfauna remains recovered in Profile One was particularly high, outnumbering the number of identifiable macrofaunal bones. This was partially the effects of the use of a smaller mesh size in this test pit; but may also indicate that high numbers of microfauna were resident in the vicinity of Profile One prior to preservation. Future investigation into the microfauna sampled from this analysis will help address these questions. The majority of remains from Profile One were recovered from spit two (51.8%) and spit one (31.9%) (Table 8.1), while spit four produced only 10 specimens (0.8%) (Figure 8.7). It should be noted however, that spit four is a subsample from a localised region of the test pit and would in any event be expected to produce much fewer remains; and some caution should be applied in comparisons between spit four and the other layers. The increase in remains from spit one to spit two is interesting as this is where the LQSM layer starts to appear and an increase in remains in the LQSM was also observed in Profile Two. However, there is a subsequent drop-off in the number of remains into spit three. Expanded excavation in this region will be needed in order to identify whether these changes in specimen density are related to stratigraphic layers.

8.2.1 Taxonomic Composition of Profile One

Chelonia (83.5%) and mammals (10.3%) were the most commonly recovered remains in Profile One (Table 8.2). Aves, amphibians and pisces make up a negligible (<5%) part of the assemblage and reptiles were not recovered in Profile One. Chelonian remains vastly dominate (>70%) all spits (Table 8.3). Mammals occur in all levels and were particularly prevalent (20.1%) in spit three (Figure 8.8). Amphibian remains were represented by a single specimen from spit two. Amphibia are common in the microfauna sample but few species produce bones that might be classed among the size class one range being dealt with in this study. Fish remains were most prevalent in spit four (10%), suggesting a shift towards a more aquatic environment in the LQSM.

8.3 TAPHONOMY

8.3.1 Bone size frequency and Fragmentation Pattern

Maximum length was recorded for all specimens; however, there were three chelonian specimens on which accurate lengths could not be measured and these specimens were not used in analysis of average length. Overall specimen size was small; the smallest bones measured 3 mm in maximum length and the largest specimen was 69 mm (Table 8.4). The mean length of remains from Profile One was 21.4 mm. Birds (16.6 mm) and fish (8.7 mm) were on average smaller than mammal and chelonia remains (21.7 mm, respectively). Figure 8.9 displays a histogram of maximum length of bones from Profile One. The majority of remains from Profile One ranged between 10 – 40 mm with peaks around 25 mm and 15 mm. Specimens larger than 45 mm, or smaller than 10 mm were rare and there were no outliers.

8.3.2 Bone Surface Modifications

Bone Weathering

Weathering was observed in 248 specimens representing 18.6% of the Profile One assemblage (Table 8.5). Weathering in Profile One was light with, the vast majority of remains displaying stage one (15.3%), or stage two (3.2%). Stage three (0.2%) weathering was so rare as to be negligible (Figure 8.10). In Figure 8.11, it is clear that there is little preference for weathering in any particular taxon with 13% to 20% of mammals, tortoises and birds displaying weathering. Weathering was absent in amphibian and pisces

remains. Stage two weathering was observed occasionally in mammal and tortoise remains and stage three was only observed in 2 (0.2%) chelonia specimens (Figure 8.12). Weathering was least abundant in spit one (17.5%) and generally increased with spit depth (Table 8.6). Stage two weathering was only observed in spits one (1.4%), two (4.2%) and three (3.3%) and was particularly rare in spit one (Figure 8.13). Stage two weathering was absent in spit four, but note the small sample size. Stage three was observed in spit two.

Burning

A total of 140 specimens, representing 10.5% of the Profile One assemblage, display burning damage (Table 8.7). Stages one to five burning were observed, however stage one (3.2%), stage two (4.1%) and stage three (2.9%) were most prevalent, stage four and five were rare (Figure 8.14), indicating that burning was mostly light. Chelonia (11.3%) remains were most strongly affected by burning, followed by birds (7.5%) and mammals (6.6%) (Figure 8.15). Burning was not observed in amphibian or fish remains. Observation of burning in aquatic taxa could be an indication of drying out of wet areas and exposure on the surface, but there is no evidence of that here. Stage one burning was exclusively observed in the chelonia assemblage (Figure 8.16). Stage two burning was dominant in mammals and tortoises; however in birds, stage three was dominant. Higher intensity burning (stage four and five) was only observed in chelonia. Burning was observed in spits one (16.7%), two (8.4%) and three (5.3%) but not four (Table 8.8) and the prevalence of burning decreases with spit depth (Figure 8.17).

Staining

Staining was highly prevalent in Profile One with 75.6% (1007) of the assemblage modified (Table 8.9). The majority of staining observed was stage one (52.5%) or stage two (16.9) with very occasional stage three (6.2%) modification (Figure 8.18). Staining was observed in all taxonomic groups including amphibians and fish, and was highly common, occurring at frequencies greater than 80% of the assemblage in all cases (Figure 8.19). The amphibian specimen displayed only stage one staining. Stage one, two and three staining was observed in all other taxonomic groups, although stage one was always dominant (Figure 8.20). In mammals and pisces, stage three was more common than stage two, perhaps indicating a greater susceptibility to staining damage. Staining was observed in all spits at high

frequency, particularly in spit four where all but one specimen displayed staining (Table 8.10). In all spits, stage one was most common, followed by stage two, while stage three was rare (Figure 8.21). Brown, purple and black staining were observed in Profile One (Table 8.11). Brown (93.6%) staining was by far the most common and purple (0.1%) staining was observed in a single specimen (Figure 8.22). Purple staining was only observed in a stage three specimen, black staining was only observed in stage one and stage two specimens. Black and brown staining were observed at all depths, purple staining was limited to spit two (Table 8.24).

Abrasion

A large proportion (77.8%) of remains from Profile One displayed abrasion (Table 8.13). Stage one (41.4%) abrasion was most common, followed by stage two (22.6%) and stage three (12.3%), while stage four (1.4%) was rare (Figure 8.23). Abrasion was observed in mammals (78.8%), chelonia (79%), aves (58.2%), and pisces (66.7%). In mammals and tortoises stage one (36.5%, 41.1%; respectively) abrasion is most common, although all stages up to four were represented (Figure 8.24). Abraded bones were recovered from all spits but appear to have been particularly prevalent in spit four (Table 8.14). Intense (stage three and four) abrasion was observed in spits one, two and three but not four (Figure 8.25); and stage one abrasion was most common in all spits.

Sheen and Polish

A A total of 48% (639) of remains from Profile One display sheen, a shiny or polished surface (Table 8.15). Sheen was recorded in mammals, chelonia, aves and pisces remains. Sheen in the Profile One assemblage was mostly stage one (28.2%) in intensity and stage four (0.4%) was rare (Figure 8.26). Sheen was most prevalent (76.1%) in the avian assemblage (Figure 8.27). Stage one sheen was most common in mammals (21.2%), tortoises (29.7%) and birds (25.4%), but absent in the fish assemblage (Figure 8.28). The avian and pisces assemblages were dominated by stage three sheen, and intense (stage four) sheen was observed occasionally in all taxa. Bones displaying sheen were observed in all spits at roughly consistent densities (between 45% and 50%) (Table 8.16). Stage one sheen was dominant in all spits, except spit four where stage three was more commonly observed (Figure 8.29).

Trampling

Trampling marks were observed on 452 specimens, representing 33.9% of the Profile One assemblage (Table 8.17). Only stage one (27.7%) and two (6.2%) trampling were observed in Profile One remains, with the former more common. Chelonia (36.6%) remains were most strongly affected by trampling, which was observed on mammals (19%) and birds (28.4%) as well (Figure 8.30). In all taxonomic groups stage one trampling was most common, with mammal remains displaying a particularly small percentage of stage two (1.5%) modification (Figure 8.31). Trampling was observed in all spits (Table 8.18), and in general, the prevalence of trampling decreased with spit depth in Profile One (Figure 8.32). Stage two trampling was absent in spit four and stage one trampling was dominant in all spits (Figure 8.33). Trampling marks observed in Profile One include pits, notches, scores, and scratch marks (Table 8.19). Scores (46.6%) and scratching (31.8%) were the most common trampling marks in Profile One and only a single notched (0.2%) bone was observed (Figure 8.34).

Carnivore Modifications

Tooth Marks

Carnivore tooth marks were rare in the Profile One assemblage, occurring on only 56 (4.2%) specimens (Table 8.20). Carnivore tooth marks were observed in mammals (1.5%), chelonia (4.4%), aves (6%) and pisces (6.7%) (Figure 8.35). Only the chelonian assemblage produced a substantial number (49) of tooth marked bones, however the percentage of modified remains is low in all taxonomic groups. Stage two modification, was only observed on chelonia specimens. Bones displaying tooth marks were recovered from spits one, two and three, but not in spit four (Table 8.21). Spit three displayed the highest prevalence (5.7%) of tooth marked bones (Figure 8.36). Stage two tooth marked bones were observed at low frequencies in all layers (Figure 8.37). The types of tooth marks observed in this analysis include pit, punctures, notches, scores and furrows (Table 8.22). Pits (43.4%) and scores (28.9%) were the most commonly observed tooth marks (Figure 8.38).

Digestion

Digestion was extremely rare in the Profile One assemblage, having been observed on only 33 (2.5%) of remains (Table 8.23). Digestion was observed in mammal (5.8%), chelonia (1.7%), aves (7.5%) and pisces (6.7%) specimens (Figure 8.39). The low prevalence of digestion in chelonia remains is of interest; it could indicate some resistance to digestive corrosion in these remains, particularly given the number of tooth marked tortoise bones recovered. Digestion severity, up to a stage three, was observed; but stage one (2%) modification was most commonly encountered (Figure 8.40). Stage one digestion was most common in all taxonomic groups (Figure 8.41). Stage two digestion was observed on mammals, tortoises and birds and has a high frequency (3%) in the latter group. Stage three digestion was only seen in mammals. Digested remains were most frequently (3.8%) recovered from spit three, and there were no digested remains from spit four (Figure 8.42, Table 8.24). Stage three digestion was recovered in spit one, stage two digestion was recovered at all frequencies and spit three displayed the highest frequency (1%) thereof (Figure 8.43). Table 8.25 and Figure 8.44 display the type of digestive corrosion observed in Profile One. Pitting and surface etching often occur together but were recorded separately, thus this total is greater than the number of digested bones. Pitting (52.4%), surface etching (40.5%) and foramen excavation (7.1%) were observed in digested bones from Profile One. Foramen excavation was relatively rare in the assemblage and appears to be linked to higher severity of digestive corrosion (Figure 8.45).

Root etching

A total of 292 (21.9%) specimens from Profile One displayed root etching (Table 8.26). Root etching was observed in mammals, chelonia, and aves and was most prevalent (23.8%) in the tortoise assemblage (Figure 8.46). Most root etching was light (15.2%), stage one in intensity, although specimens displaying stage two (6.3%) and three (0.5%) were also recovered (Figure 8.47). Stage one root etching was most prominent in all taxonomic groups; and severe (stage three) root etching was only observed occasionally in mammals (0.7%) and chelonia (0.4%) (Figure 8.48). Root etching was observed at all depths, but was particularly prominent (37.7%) in spit one (Table 8.27, Figure 8.49). Higher intensity (stage three, stage two) root etching was observed in the upper levels (Figure 8.50).

Other surface modifications

Remains from Profile One did not display, insect modifications, rodent gnawing or pathology.

8.4 MAMMAL TAXONOMY AND TAPHONOMY

8.4.1 Taxonomic composition of mammals

A total of 137 mammal species representing 10.3% of the assemblage were recovered from Profile One. The vast majority (81%) of mammal remains were unidentifiable even to the family level (Table 8.28). Mammals were otherwise represented by Bovidae (6.6%), Carnivora (8%), Leporidae (3.6%) and Rodentia (0.7%) (Figure 8.51). Mammal families will be dealt with in more detail below. The majority of mammals were derived from size class two (29.9%), size class three (25.5%) and size class one (24.8) individuals (Figure 8.52). Megamammals (size class five) were occasionally (3.6%) recovered. Spit two (62) displayed the largest number of mammal remains (Table 8.29), however the relative percentage of mammal specimens within the spit was highest in spit three (20.1%) (Figure 8.53). Spit one (7.5%) had the lowest relative percentage of mammals. Spit four produced a single mammal bone which still represents 10% of remains from this spit. Spit four, despite the small sampling, shows a consistent percentage of mammal remains relative to the other spits.

Bovidae

Bovids were a commonly recovered mammal family in Profile One. None of the bovid material was identifiable below the family level. Size class one, two and four were equally represented (33.3%, respectively) (Table 8.28). Bovids were recovered in spit one (33.3%), spit two (44.4%) and spit three (22.2%) (Figure 8.54). Table 8.309 displays estimates of skeletal frequencies in mammal remains from Profile One. An MNI of 2 bovids is estimated based on premolar remains from different size class individuals.

Carnivora

Three groups of carnivores were identified from Profile One, they include two felid (1.5%) specimens, a hyaenid (0.7%) and a possible Mellivorinae (0.7%). The latter family was represented by material that bore a strong resemblance to the modern honey badger (*Mellivora capensis*), but whose larger size suggests it might have originated from the wolverine (*Plesiogulo monspessulanus*). There were numerous carnivore remains that could not be identified to a lower taxonomic level, and combined

carnivores (carnivore unident.) were the most commonly occurring group in Profile One. The Felidae and Hyaenidae remains were derived from size class three and the Mellivorinae from size class two individuals (Figure 8.55). Unidentifiable carnivores originated from size class one (28.6%), two (57.1%) and three (14.3%). No large carnivores (size class four or five) were recovered from Profile One. Carnivore remains were recovered from spits one, two and three, with spit two producing the greatest number and diversity of carnivores (Figure 8.56). Three families of carnivore were represented in Profile One, all with an MNI of one (Table 8.30). The indeterminate carnivore sample has an estimated MNI of two, however this material may belong to one of the families already discussed. It is in any event not typical to use indeterminate material in estimates of skeletal frequency. Thus, the MNI of carnivora from Profile One is three.

Small mammals

Small mammal material consistent with a rabbit or hare (Leporidae), as well as material from a large rodent was recovered from Profile One. A total of 5 (3.6%) leporid specimens were recovered, all representing size class one animals. The leporid material was recovered from spit two (80%) and spit three (20%). A single (0.7%) size class one rodent was recovered from spit two. The highest estimate for MNI in both leporidae and rodents was one (Table 8.30).

8.4.2 Anatomical composition of mammals

Bovidae

Bovid remains were represented by dentition in the form of molars, premolars and incisors; metapodials and phalanges (Figure 8.57). Dental remains were derived from size class two and four bovids (Table 8.31). Of particular note, was the recovery of a deciduous incisor from a size two bovid. Size class one was represented by a metapodial, proximal phalange and distal phalange. Bovid remains made up a small percentage of spit three (1%), spit one (0.7%) and spit two (0.6%) and were absent from spit four (Table 8.32). Appendicular remains (phalanges) were recovered from spit two. Spit one produced metapodial remains as well as a single molar. The remaining dental remains were recovered from spits two and three.

Carnivora

Table 8.32 displays the skeletal element and size class in the carnivoran families recovered in Profile One. Felidae were represented by a pelvis and rib fragment. A single metacarpal from a hyneanid and a single metapodial from a Mellivorine were also recovered. Indeterminate carnivoran remains were represented by metatarsal and small compact bones (sesamoid, tarsal and phalange). The proximal phalange was the most commonly (36.4%) occurring element in the carnivores from Profile One (Figure 8.58). Size class one was represented by a metatarsal and a single (25%) proximal phalange. The remaining proximal phalanges were observed in size class two animals, along with a tarsal and metapodial. The remaining carnivore material was derived from size class three individuals. The percentage of carnivore material was low in spits one (0.5%) and two (0.7), but carnivores became more prominent in spit three (1.9%).

Small mammals

Leporidae were represented by humeral remains, proximal phalange and distal phalange. Rodentia were represented by a humerus (Figure 8.59). All leporidae and rodent remains were derived from size class one individuals. Rodents, as well as the majority of the leporid material, were derived from spit two (0.7%); while the leporid humerus originated from spit three (Table 8.34).

Unidentifiable mammals

The majority of unidentifiable mammal remains were represented by long bone fragments (58.6%) (Figure 8.60). Other commonly occurring elements in unidentifiable mammals were metapodial, tarsal and vertebra. Many other elements were retrieved in low densities including parts of the axial skeleton (cranial fragments and assorted vertebra), appendicular remains from the forelimb (scapula, humerus, radius) and hind limb (innominate, femur, tibia, metapodial), and small compact bones (tarsal, sesamoid, phalange). Size class one and two display a high diversity of skeletal elements (Table 8.35); but the larger body size class shows much fewer remains of everything except long bone fragments. The only unidentifiable mammal specimen recovered from spit four was a rib fragment (Table 8.36). Spit three (16.7) preserved a higher percentage of unidentifiable mammals than spits one (6.4%) or two (7%). It is not generally considered useful to estimate MNI in indeterminate material and it is done here

only to show the low ratio of MNI to NISP. An MNI of 5 is estimated based on vertebral remains. The large sample of long bone fragments (65) indicated an MNI of only 4, based on different body size classes.

8.4.3 Bone size frequency distribution and fragmentation pattern of mammals

Maximum length

The maximum length of mammal specimens was assessed as a combined sample and by size class. Table 8.37 displays descriptive statistics for maximum length. From the total of 137 mammal specimens, the smallest remain measured 3 mm in maximum length and the largest specimen was 63 mm. Length in general (minimum, maximum and mean) increased with body size class, as would be expected. Mean length for the combined sample was 21.7 mm. A histogram for the combined sample shows most mammal remains clustered around 10 mm – 45 mm, with peak at 15 mm and 25 mm (Figure 8.61). Remains from size class one were distributed between 10 mm and 30 mm, with the majority of specimens clustered at around 10 mm and 15 mm (Figure 8.62). Size class two displayed a broader spread of specimen size between 5 mm and 40 mm, but with an outlier at 55 mm in length (Figure 8.63). Maximum size in size class two peaked around 15 mm and 25 mm. Size class three showed a trend toward larger specimens with the entire graph moved further to the right (10 mm to 50 mm) and peaks around 25 mm and 30 mm (Figure 8.64). Size class four remains continued this trend with specimens varying between 20 mm and 45 mm and with a peak around 35 mm (Figure 8.65). The sample size in size class five was small, only 5 specimens. Their sizes showed some variation between 35 mm and 70 mm (Figure 8.66). Thus, mammal remains were small, never more than 63 mm in length and maximum length displaeds a distinct correlation with body size.

Fusion

Of the 137 mammal specimens recovered from Profile One, fusion could only be discerned on 33 specimens (24.1%) of the assemblage (Table 8.38). Adults predominated (75.8%) over subadults and juveniles (12.1%, respectively). Size classes one and two displayed numerous remains on which fusion could be identified, this number droped with increasing body size. Adult mammals were observed in size class one (64%), two (24%), three (4%) and four (8%) but not size class five (Figure8.67). Subadults were

derived from size classes one (50%), two (25%) and five (25%). Juvenile remains were observed in size class one (75%) and three (25%).

Completeness

Less than 20% of mammal remains were recovered complete (Table 8.39). Complete remains in mammals were limited to small compact autopodial remains like metapodial, phalange and tarsal/carpal; however a small humerus, caudal vertebra and even a premolar were also recovered complete. Complete remains were most commonly observed in small mammals (66.7%) and carnivores (63.6%) but were relatively rare in bovids (11.1%) and unidentifiable mammals (12.6%) (Figure 8.68). The smaller the body size class the greater the number of complete remains (Figure 8.69), and size classes four and five did not produce any complete remains. Complete mammal remains were recovered from spits one (1.9%), two (1.9%) and three (Table 8.40), with the latter layer displaying the highest relative percentage (2.4%) of complete mammal bones.

Breakage Profile

Table 8.41 displayed the breakage classes observed in mammal remains from Profile One. Mammal long bones were represented by complete (13.3%) remains, proximal ends (9.2%), shaft fragments (73.5%) and distal ends (4.1%). Shaft remains strongly dominate the assemblage; however most of this pattern was being skewed by the large number of long bone fragments. Figure 8.70 shows relative frequency of breakage categories if long bone fragments were removed. In this figure, complete (39.4%) long bones were most commonly followed by proximal end (27.3%), shaft (21.2%) and distal end (12.1%). The most common vertebral part recovered was complete or fragmented centrum (40%), although complete (10%), isolated epiphyses (20%), spinous process (10%) and fragmented (20%) vertebra were also recovered. The scapula was represented by a blade fragment. Pelvis remains included an ilium fragment and an ischium fragment, both preserving part of the acetabulum. All rib and cranial remains were fragmented; similarly, the majority (83.3%) of dental remains were fragmented. On the other hand, the majority (85.7%) of small compact bones (tarsal/carpal) were complete.

Fracture Outline

Fracture outlines and angles were only analysed in long bones; within the 137 mammal remains from Profile One there are 103 long bones. Once all unbroken or indeterminate ends were eliminated 155 long bone fractures remained, representing 75.2% of the possible sample (Table 8.42). Only 31.5% of fracture outlines from size class one remains could be classified, compared to 100% of size class three (Figure8.71). Spiral breaks (77.6%) were the most common fracture outline observed in mammal long bones (Figure 8.72). Transverse (14.7%) breaks were occasionally observed along with negligible splintered (4.5%), eroded (1.9%) and irregular (0.6%) breaks. Spiral breaks were the most common fracture outline in all size classes of mammal (Figure 8.73). Splintered breaks were observed in size class two, three and four; eroded breaks were observed in size class three and five and irregular breaks were only observed in size class two. Positive fracture outlines were observed in spit one (73.8%), spit two (71%) and spit three (87.1%) but not in spit four (Table 8.43). Spiral breaks were the most common fracture outline observed at all depths (Figure 8.74). Transverse breaks were more common in spit two (12%) and three (14.5%) than spit one (4.8%) and eroded and irregular breaks were observed in spit two and spit one respectively. Thus, spiral or fresh breaks were common in the mammal assemblage from Profile One and the number of dry breaks appears to increase with spit depth.

Fracture angle

A total of 115 (55.8%) fracture angles were identified on mammal long bones from Profile One (Table 8.44). Oblique (29.4%) and mixed (30.1%) fracture angles were the most common (Figure 8.75). Generally, the number of fractures that could be analysed increased with body size from size class one (31.5%) to size class four (82.4%) (Figure 8.76); although this drops off in size class five (60%). In size class one and two oblique angles are more common than mixed or right angles, however in size class three and four this pattern is reversed. Right (23.8%) angled breaks are dominant in spit one (Table 8.45). However, in lower spits oblique or mixed angles are more common (Figure 8.77).

8.4.4 Surface Modifications of mammals

Weathering

Weathering was observed on 15.3% (21) of mammal remains, including bovids, carnivores and unidentifiable mammal specimens, but was not observed in small mammals (Table 8.46). Bovids were most strongly affected by weathering with 33.3% of the family modified (Figure 8.78). Unidentifiable mammals, on the other hand, were the only remains to display more intense (stage two) weathering.

Burning

A total of 9 (6.6%) mammal remains were modified by burning (Table 8.47). Burning was observed in small mammals (16.7%) and unidentifiable (7.2%) mammal remains. Burning in mammals was limited to stage two and three.

Staining

Staining was observed in 113 mammal specimens from Profile One, representing 82.5% of mammal remains (Table 8.48). Stage one (44.5%) staining was most common in mammal remains, however unlike other taxa and the general assemblage, stage two (18.2%) and three (19.7%) staining occurred with near equal frequency in mammals (Figure 8.79). Staining was most prevalent in carnivore (90.9%) and bovid (88.9%) remains (Figure 8.80). Bovid remains displayed only stage two (22.2%) and predominantly stage three (66.7%) staining (Figure 8.81). Stage one staining was observed in carnivore, small mammals and unidentifiable mammal remains and was most common in the latter group. In carnivores and small mammals, stage two staining was most common. Brown staining was most common (92%) in mammal remains and was observed in all family groups (Table 8.49). Purple and black staining were each observed in a single unidentifiable mammal specimen.

Abrasion

A total of 105 or 76.6% of mammal remains from Profile One display abrasion damage (Table 8.50). Stage one abrasion was most common (34.3%) in mammals, although stage two, three and four were

also observed (Figure 8.82). Unidentifiable mammal (82.9%) remains and bovids (77.8%) were most strongly affected by abrasion, which was also observed in carnivores and small mammals (Figure 8.83). Carnivores and small mammals display only stage one abrasion; bovids display stage one and stage two (Figure 8.84). Unidentifiable mammal remains display all four stages of abrasion, but stage one (32.4%) was the most prevalent.

Sheen and polish

Sheen was observed in 65 mammal remains representing 47.4% of the Profile One mammal assemblage (Table 8.51). Mammal remains most commonly display stage one (21.4%) sheen, although stages two (12.4%) and three (13.1%) are also prominent (Figure 8.85). Carnivores (66.7%) and bovids (72.7%) were most strongly affected by sheen, which was rare in small mammal (16.7%) remains (Figure 8.86). Small mammals display only stage one sheen (Figure 8.87). Carnivores and unidentifiable mammals display stages one to three sheen; while stage two sheen is absent in bovids, which display stage four sheen.

Trampling

Less than 20% (26) of the mammal assemblage from Profile One displayed trampling (Table 8.52). Trampling was observed in bovids (22.2%), small mammals (16.7%) and unidentifiable mammal (20.7%) remains (Figure 8.88). The majority (17.5%) of trampling in mammals was stage one with only two unidentifiable mammals presenting stage two.

Carnivore Modifications

Tooth Marks

Only two mammal specimens, representing 1.5% of mammal remains, displayed carnivore tooth marks. Both specimens were unidentifiable mammal long bone fragments from spit three and spit four, respectively. Carnivore tooth marks in mammals consisted of a furrow and a notch.

Digestion

Digestion was recorded in 8 mammal specimens, representing 5.8% of the assemblage (Table 8.53). Digestion was thus observed in many more mammal remains than were carnivore tooth marks. Taphonomic analyses of small carnivores has observed similar patterns where the number of tooth marked bones is substantially smaller than the digested specimens (Lloveras et al. 2012; Lloveras et al. 2008; Cohen & Kibii 2015). Digestion was observed in carnivores (18.2%), small mammals (50%) and unidentifiable mammals (2.7%), but was absent from bovids (Figure 8.89). Digestion was most prevalent (50%) in small mammals, which was also the only group in which higher severity (stage two and three) digestion was observed.

Root etching

A total of 17 (12.4%) mammal specimens from Profile One displayed root etching (Table 8.54). Root etching was observed in bovid, small mammal and unidentifiable mammal remains and was most common in the latter families (16.7% and 13.5%, respectively) (Figure 8.90). Stage one root etching was most common (8.8%) in mammal remains (Figure 8.91); and stage two and three etching were only observed in unidentifiable mammal remains.

8.5 CHELONIA TAXONOMY AND TAPHONOMY

8.5.1 Taxonomic composition of chelonia

A total of total of 83.5% (1 112) of the bones recovered in Profile One were chelonian remains (Table 8.55). Size class three (39.4%) and size class two (25.5%) were the most commonly recovered specimens; however, a substantial portion of size class four (20%) were also recovered (Figure 8.92). The relative percentage of tortoise remains was high (>70%) in all spits (Table 8.56). Spit one (88.2%) displayed the highest percentage of chelonia remains, thereafter the relative frequency of chelonia to other taxonomic groups decreased with spit depth (Figure 8.93).

8.5.2 Anatomical composition of chelonia

Of the 1 112 tortoise specimens recovered, 247 (22.2%) specimens were derived from the appendicular and axial skeleton and 865 (77.8%) specimens were assorted shell remains.

Appendicular and axial skeleton

Appendicular and axial remains had low abundance in the chelonian assemblage, making up less than a quarter of all tortoise remains. Indeed, no single element represented more than 12% of the tortoise assemblage (Table 8.57). The most commonly occurring appendicular elements were ilium (11.7%), humerus (10.5%) and femur (10.1%) (Figure 8.94). These elements are large, robust and are among the most diagnostic bones of a tortoise skeleton. Most axial remains were relatively rare, with the exception of vertebra. It was not possible in many cases to assign vertebral remains to specific elements (ex. thoracic vertebra) due to both fragmentation and a scarcity of comparative material. Appendicular remains were more commonly recovered than axial. Hindlimb elements (ilium, ischium, pubis, femur, tibia, fibula) were slightly more common than forelimb (scapula, coracoid, humerus, radius, ulna) (NISP 80 vs 89, respectively). Autopodial elements, with the exception of distal phalange, were sparse. These small elements can be easily lost in a fossil assemblage and in the case of these excavations, may have become incorporated into the microfauna assemblage. The majority of tortoise appendicular and axial remains were derived from size class three (53%) and size class two (36%) individuals; size class one (2.4%) appendicular or axial remains were rare (Figure 8.95). Size class one remains were recovered in

the coracoid, femur, tibia, distal phalange and vertebra (Figure 8.96). Size class four was represented by scapula, humerus, radius, ulna, femur, distal phalange, vertebra and long bone fragments. Zygopodial and stylopodial elements were mostly recovered from size class three individuals, while the autopodium was mostly derived from size class two tortoises. Tortoise appendicular and axial remains contributed almost equally to all spits, but were slightly more common in spits two (19.2%) and four (20%) (Table 8.58). Appendicular remains from spit four were limited to ilium and phalange (Figure 8.97). MNI in chelonia, based on humeral remains, was 5 (Table 8.59).

Chelonia shell elements

The majority (77.8%) of chelonia remains recovered from Profile One were shell elements (Table 8.60). Of the 865 shell remains, 326 (37.7%) were derived from the carapace (Figure 8.98), 174 (20.1%) from the plastron and 365 (42.2%) remains could not be assigned to carapace or plastron and were left as simply indeterminate shell (coded carapace/plastron in the tables). Thus, the majority of tortoise shell remains were unidentifiable to element; and carapace remains were more commonly recovered than plastron elements. The majority of the undiagnostic shell (carapace/plastron) material was derived from size class three (40.8%) and size class two (34%) individuals (Table 8.60; Figure 8.99). Undiagnostic shell material was most common in spit one (70.3%) and spit two (65%) (Table 8.61; Figure 8.100).

Carapace

A number of costals and marginals could be identified to exact element (ex. Marginal 7), however many costals, marginals and even the neurals were not diagnostic at a lower level and are simply coded as costal or marginal. Undiagnostic marginals (58.9%) were, by far, the most commonly recovered carapace elements, followed by undiagnostic carapace (19.9%) remains (Table 8.60; Figure 8.101). Of the material that could be attributed to exact element, the nuchal (1.2%) was the most frequent. The majority of carapace remains were derived from size class one (32.2%) and size class three (27.3%) individuals; while size class two (18.1%) remains were relatively rare (Figure 8.102). Carapace remains identifiable to element were derived from larger sized individuals; for example, costal 1, marginals 1-2, marginal 7-9 were derived from size class four tortoises and costals 5-6 were from size class three tortoises (Figure 8.103). The majority of nuchal remains were derived from size class three (75%) and the remainder from

size class four. Size class one and size class two was observed in neural, costal, marginal and carapace. No size class one or two carapace remains were identifiable to exact element. The majority of carapace remains were recovered from spit two (27.6%) (Table 8.61). Spit four carapace remains were limited to a costal and a marginal. Carapace remains derived from spit three include neural, costal, marginal, carapace (Figure 8.104). Identifiable carapace elements were predominantly derived from spit two. An MNI of 4 was calculated for carapace remains in Profile One, based on neural fragments (Table 8.62).

Plastron

A total of 174 plastron remains making up 20.1% of the tortoise assemblage were recovered from Profile One (Table 8.60). All plastron elements were represented; although undiagnostic plastron (60.9%) remains were the most abundant plastron element recovered (Figure 8.105). The xiphiplastron (10.3%) and hypoplastron (10.3%) were the most common plastron remains and the entoplastron (2.9%) the least commonly recovered. There is a clear dominance of size class three (39.1%) and four (51.7%) in the plastron assemblage (Figure 8.106). Size class one elements were observed in the xiphiplastron, hypoplastron and epiplastron (Figure 8.107). Size class two plastron elements included xiphiplastron, hypoplastron, hyoplastron and epiplastron. The majority of plastron remains were recovered from spit one (17.7%) and spit two (12.3%) (Figure 8.108); and no plastron remains were recovered from spit four (Table 8.61). Remains from the xiphiplastron, hypoplastron, hyoplastron, epiplastron and plastron were recovered from spit three, but always in low volumes (Figure 8.109). Based on hypoplastron fragments, an MNI of 8 was estimated for the tortoise plastron remains from Profile One. Shell remains are generally considered inadequate in estimating skeletal frequencies given their high breakage potential and difficulties in identifying isolated and broken remains. Thus, researchers typically rely on estimates derived from the appendicular skeleton, particularly the humerus (Sampson 1998). While I have estimated MNI values in the carapace and plastron assemblages, I consider the MNI based on the appendicular remains of 5 to be the most accurate representation of skeletal frequency.

8.5.3 Bone size frequency distribution and fragmentation pattern of chelonia

Maximum length

The average maximum length of the combined tortoise sample is 21.8 mm. A total of 1109 specimens were analysed for maximum length but three specimens could not be measured and are excluded from this part of the analysis (Table 8.63). The smallest chelonian specimen analysed was 3 mm in length and the largest 69 mm. Average size increases with body size class. Maximum length in the combined tortoise sample clustered around 10 mm to 45 mm with a peak around 25 mm and further smaller peaks around 15 mm and 30 mm (Figure 8.110). Size class one tortoise remains displayed a maximum length between 5 mm and 30 mm with many remains clustering around 15 mm (Figure 8.111). There is no distinct peak in maximum size in size class two remains but most of the sample displayed lengths between 15 mm and 30 mm with a spread between 5 mm and 55 mm (Figure 8.112). Size class three remains were clustered between 10 mm and 45 mm with peaks around 25 mm and a smaller peak around 30 mm (Figure 8.113). Occasional larger specimens (>45 mm) were observed as well as an outlier at 70 mm. Size class four specimens displayed a distinct dropoff in size between 20 mm – 25 mm (Figure 8.134). The bulk of size class four specimens were between 25 mm and 45 mm in length, although occasional longer remains were observed. There is a general increase in specimen size with body size, which is most distinct between size classes two and three. Overall specimen size is small.

Fusion

Fusion could only be classified on tortoise appendicular or axial remains and not on shell elements. The state of fusion was observable in 138 (55.9%) specimens from Profile One (Table 8.64). The majority of the remains on which fusion was coded were derived from size class two (31.8%) and three (59.8%) individuals. Most of the tortoise specimens (for which degree of fusion could be identified) were adults (75.4%), juveniles (22.5%) were occasionally observed and subadults (2.2%) were rare (Figure 8.115). Adult chelonia were observed in all size classes (Figure 8.116). Juveniles were observed in size classes one, two and three. Subadults were only observed in size class three.

Completeness

A total of 45 (18.2%) complete bones were recovered from the chelonian assemblage of Profile One (Table 8.65). No shell remains were recovered complete; completeness was only observed in appendicular or axial remains. The complete elements thus, represent 18.2% of the appendicular and axial skeleton, but only 4% of the total tortoise assemblage. Completeness was mostly limited to small compact bones of the autopodium, along with occasional vertebra, ischium and coracoid elements (Figure 8.117). The element most commonly recovered complete was distal phalange (48.9%). Completeness was most commonly observed in size class two (48.9%) and size class three (37.8%) remains (Figure 8.118). Completeness is low in all spits (Table 8.66). Less than 2% of remains from spit one were complete, there is however, a gradual increase in the number of complete remains in spit two (3.8%) and spit three (4.8%) up to 10% in spit four (Figure 8.119).

Breakage Profile

All shell remains were fragmented. Breakage categories were only recorded for appendicular and axial remains. Only one long bone (metapodial) was recovered complete (Table 8.67). Otherwise breakage in long bones was pretty evenly distributed between proximal (31.6%), distal (33.7%) and shaft (33.7%). Vertebra were represented by complete (8.3%), centrum (79.2%), vertebral arch (8.3%) and transverse process (4.2%). Tortoise vertebra, like mammal vertebra, were most commonly represented by the centrum. Coracoid and scapula remains in tortoises are long robust bones, similar in structure to long bones, and are thus coded here in a similar way. Coracoid remains were represented by fragments (57.1%), anterior parts and complete remains (21.4%, respectively). The majority of scapula remains were proximal parts (63.6%), although shaft (27.3%) and distal (9.1%) remains were also recovered. Delicate mandibular fragments were recovered in tortoises from the premolar row and molar row. The ilium (65.9%) was the most common part of the innominate, followed by the ischium (18.2%) and pubis (15.9%). All cranial remains were fragmented. Most (94.6%) phalange and tarsal/carpal elements were complete.

Fracture Outline

Appendicular skeleton

A total of 193 (44.9%) fracture outlines were classified in chelonia long bones from Profile One (Table 8.68). In this analysis, I have included innominate bones (ishium, ilium, pelvis) in the long bone sample due to their elongate shape and robust structure. Innominate bones were never recovered articulated and it is assumed that they would behave in the system (once separate from the rest of the skeleton) in the same way as any other long bone. Fracture outlines were classified in a smaller percentage of tortoise long bones than in mammal long bones; although like in mammals, size class one displayed the smallest percentage (Figure 8.120). The most common (75.6%) fracture outline observed in the tortoise long bones was spiral breaks. (Figure 8.121). Transverse (18.7%) breaks were infrequent and eroded (3.6%) or splintered (1.6%) breaks unusual. All size classes of tortoise long bones displayed predominantly spiral breaks with many transverse breaks (Figure 8.122). Splinted and irregular breaks were only observed in size class three. Eroded breaks were observed in size class three and four. Spit four produced the fewest fracture outlines (Table 8.69), and was limited to spiral breaks (Figure 8.123). Transverse breaks were observed in spits one, two and three, eroded breaks in spits one and two and splintered breaks in spits two and three. Thus, the majority of tortoise long bones display fresh (spiral) breaks, although a reasonable number of remains have dry breaks. Eroded breaks, resulting from natural abrasion (like running water) appear to be limited to larger size bones.

Chelonia shell

In most analyses, fracture outline and angle are normally only investigated in long bones remains (Thompson 2010). As chelonia shell remains greatly outnumber appendicular remains at Langebaanweg (and in general in the archaeological record) I decided to investigate fracture outline and angle in shell remains. The same methodology was used. Each shell specimen was analysed on two sides, proximal/distal or anterior/posterior. A total of 851 (49.2%) fracture outlines out of a possible 1730 shell fractures were classified (Table8.70). Size class four shell remains displayed the lowest proportion of fracture outlines (Figure 8.124). Shell fractures show the same pattern as long bones, where spiral (62.7%) breaks are most common, followed by transverse (35.4%) with occasional eroded (1.4%) breaks and negligible splintered (0.4%) or irregular (0.1%) breaks (Figure 8.125). In all size classes, spiral breaks are the most common fracture outline; however, in size class three and four there is a drop-off in the

relative proportion of spiral breaks and an increase in the proportion of transverse (Figure 8.126). The majority of eroded breaks were observed in size class four remains. On the other hand, the relative proportion of spiral breaks increased with depth while the proportion of transverse breaks decreased (Table 8.71, Figure 8.127).

Fracture angle

Appendicular skeleton

A total of 210 (48.8%) fracture angles were classified in chelonian long bones from Profile One (Table 8.72). The majority of fracture angles in tortoise long bones were oblique (35.7%) and mixed (34.8%) with occasional right (29.5%) angles (Figure 8.128). Generally, the number of fracture angles increased with body size class. Right angles were not observed in size class one (Figure 8.129). Right angles dominated in size class two while oblique angles were dominant in size class four. Mixed fractures were absent in spit four which was dominated (66.6%) by right angles (Table 8.73, Figure 8.130). In other spits, oblique and mixed fractures were consistent.

Chelonia shell

The tortoise shell assemblage displayed 875 (50.6%) fracture angles (Table 8.74). There was a clear dominance of right (46.7%) angled breaks in chelonia shells and a relative absence of oblique (21.1%) breaks, in direct contrast to tortoise long bones (Figure 8.131). Size class two (58.7%) and three (60.6%) displayed the highest abundance of fracture angles and in all size classes right angled breaks were the most common (Figure 8.132). Similarly, right angles were dominant in all spits (Figure8.133). Spit four lacked oblique fractures (Table 8.75).

8.5.4 Bone Surface Modifications of chelonia

Bone Weathering

Weathering was observed in 218 (19.6%) chelonian remains from Profile One (Table 8.76), the vast bulk of which displayed stage one (16.1%) weathering (Figure 8.134). The plastron was most heavily affected

by weathering with 31% of remains displaying modification (Figure 8.135). Stage three weathering was limited to occasional plastron remains. This element also displayed greater numbers of stage two weathering than other tortoise parts. A total of 17.8% (44) of the appendicular tortoise skeleton was weathered (Table 8.77). Weathering was absent from axial remains and from autopodial elements. Long bone fragments displayed a propensity for weathering with 83.3% of remains modified (Figure 8.136). Tibia, femur and humerus also displayed relatively high (> 30%) levels of weathering. Finally, an investigation between body size class and weathering in tortoise shell remains (Table 8.78) displayed a positive correlation between increasing shell size and both weathering prevalence and intensity (Figure 8.137).

Burning

A total of 11.3% (126) of chelonia remains from Profile One displayed burning (Table 8.79). Burning most commonly occurred in plastron (13.8%) and indeterminate shell (14.5%) remains; the carapace (7.1%) appears to have been least affected by burning (Figure 8.138). Stages one (3.9%), two (4.2%) and three (2.9) burning were most prominent in the tortoise assemblage, as they are in the burning sample in general (Figure 8.139). The carapace, despite showing the smallest proportion of burning; displayed higher intensity burning, stage four (0.3%) and five (0.6%), but was otherwise dominated by stage one (2.8%) and two (3.1%) (Figure 8.140). The appendicular and axial skeleton was dominated by stage three (4.9%) burning, the plastron by stage one (7.5%) and indeterminate shell remains by stage two (7.1%). A total of 26 (10.5%) burnt remains were observed in the appendicular and axial tortoise skeleton (Table 8.80). Radius (37.5%) and to a lesser extent tibia (20%) elements were most strongly affected by burning (Figure 8.141). Burning was greater in size class two and three tortoise shell remains (Table 8.81, Figure 8.142). The relative proportion of stage one burning appears to increase with spit depth, as stage two decreases. However, high intensity (stage four and five) burning was observed (at low proportions) in spits three and four. Burning damage on chelonia shell remains was located on both sides (inner and outer surface) on the majority (78%) of the sample (Table 8.82, Figure 8.143).

Staining

Some 822 tortoise specimens representing 73.9% of the assemblage displayed staining (Table 8.83). Stage one (53.7%) staining was most common in chelonia remains, although occasional stage two (16.1%) and stage three (4.1%) were also observed (Figure 8.144). Staining was observed on appendicular and axial (76.9%) remains, carapace (78.5%), plastron (45.4%), and indeterminate shell (81.4%); although the plastron seems to have been somewhat resistant to staining (Figure 8.145). Stage one staining was dominant in all chelonia skeletal parts (Figure 8.146). Staining was observed in all appendicular and axial tortoise remains recovered (Table 8.84). Although stylopodial and zygopodial remains appear more resistant to staining than the autopodium (Figure 8.147). Staining was observed in all body size classes of chelonia (Table 8.85). Size class four remains display the lowest prevalence (55.9%) of staining, but in all cases stage one was most common (Figure 8.148). Tortoise remains display only black (6.2%) and brown (93.8%) staining, no purple staining was observed (Table 8.86).

Abrasion

Almost 80% (879) of tortoise remains from Profile One displayed abrasion (Table 8.87). Abrasion was observed in the appendicular and axial skeleton (79.4%), carapace (77.6%), plastron (64.9%), and indeterminate shell remains (86.8%). The majority of abrasion was stage one (41.1%), with stage two (24.9%) and three (12.8) also frequent, stage four (0.3%) was very rare (Figure 8.149). Stages one to three abrasion were observed in all tortoise parts and stage one was always the most common abrasion (Figure 8.150). Stage four abrasion was absent from plastron remains. Abrasion was observed in all sizes of shell and there was little difference in the prevalence of abrasion by body size classes (Table 8.88). In all body size classes, stage one abrasion was most common; and stage four abrasion was observed in size class one and four (Figure 8.151).

Sheen

Sheen was observed on 517 chelonia remains from Profile One, representing 46.5% of all tortoise specimens (Table 8.89). The majority of staining in chelonia remains was stage one (29.7%) in intensity and more severe modification became progressively rarer (Figure 8.152). The prevalence of sheen was similar in appendicular and axial (56.7%) remains, carapace (40.8%), plastron (46.6%) and indeterminate

shell (44.7%) remains (Figure 8.153). Stage one sheen was most common in all tortoise parts (Figure 8.154); however, it is only in the appendicular and axial skeletal remains that stage two and three sheen were recovered in substantial numbers. There is little difference in the amount of sheen in shell remains at any body size; sheen was observed on 40% – 50% of remains from all size classes (Table 8.90). Size class one shell remains display higher relative percentages of stage two (13%) and three (6.8%) sheen, otherwise sheen intensity was very similar in all size classes (Figure 8.155).

Trampling

A total of 407 chelonia remains from Profile One, representing 47.1% of the assemblage displayed trampling marks (Table 8.91). The majority of trampling marks in the tortoise assemblage were marked to stage one (38%), although occasional stage two (9%) trampling was also observed. Trampling was most prevalent in indeterminate shell remains (Figure 8.156); and in all chelonian parts, stage one was the most common trampling (Figure 8.157). Trampling was most prevalent in size class three (46.1%) and four (43.1%) chelonia shell remains (Table 8.92, Figure 8.158).

Carnivore Modifications

Tooth Marks

Carnivore tooth marks were observed in 49 (4.4%) chelonian remains from Profile One (Table 8.93). They were observed in appendicular (4.5%) remains, carapace (4.9%), plastron (2.9%) and indeterminate shell (4.7%) parts; although they were least prevalent in the plastron (Figure 8.159). Stage two tooth marked bones were observed at low frequency in the appendicular skeleton (0.4%) and at relatively higher frequency in the carapace (1.2%) and indeterminate shell (1.1%) assemblages; stage two was not represented in the plastron (Figure 8.160). Carnivore tooth marks were observed in humerus, femur, tibia, fibula, ilium and ischium elements (Table8.94) and were most prevalent in fibula and humerus remains (Figure 8.161). Tooth marks were recorded in all body size classes of chelonia shell, however size class one (1.2%) displays distinctly less marking than other sizes (Figure 8.162). In addition, stage two is absent from size class one and occurs at low frequency at larger sizes.

Digestion

Digestion was particularly rare in chelonia, occurring on only 1.7% (19) of remains from Profile One (Table 8.96). It was limited to stage one (1.5%) and stage two (0.2%); with the former more prevalent in the assemblage. Digestion was observed in the appendicular skeleton, carapace, and indeterminate shell assemblage; but was absent from plastron remains (Figure 8.163). Digestion was most prevalent (5.7%) in the appendicular skeleton, which was also the only tortoise skeletal part to display stage two modification. Digestion was absent from axial remains (Table 8.97), and appears to have affected autopodoial elements more severely than stylopodial or zygopodial remains (Figure 8.164). Digestion in chelonia shell remains was limited to size class one (5) specimens.

Root etching

A total of 265 (23.8%) chelonia remains from Profile One display root etching, most of it stage one (16.4%) in intensity (Table 8.98, Figure 8.165). Root etching was most prevalent in indeterminate shell remains and was also observed on carapace, shell and appendicular and axial remains (Figure 8.166). Stage one etching was dominant in all tortoise parts and stage three was only observed in appendicular and axial remains and in indeterminate shell remains (Figure 8.168). Root marking was most prevalent in humerus (34.6%), coracoid (28.6%) and radius (25%) elements (Table 8.99, Figure 8.169). Root etching was particularly common in size class three (32.4%) and two (27.2%) shell remains (Table 8.100) and relatively rare in size class one (14.8%) (Figure 8.169). Size class three and two were also the only chelonia shell remains which displayed stage three root etching (Figure 8.170).

8.6 AVES TAXONOMY AND TAPHONOMY

8.6.1 Taxonomic composition of Aves

A total of 67 (5%) bird specimens were recovered from Profile One. The vast majority (94.6%) of bird remains could not be identified, even to family (Table 8.101). Two specimens, representing 3% of the bird assemblage, were attributed to the family Phasianidae, which includes modern francolin, quail and pheasant. These, size class three specimens, were both recovered from spit one (Table 8.102). Remains from this family have been recovered from Langebaanweg previously, and some taxa like *Francolinus* sp. occur in high abundance (Rich 1980; Manegold *et al.* 2013). A single species of large wading bird, Order Ciconiiforme was observed in Profile One. A number of Ciconiiforme birds have been observed in Langebaanweg (Olson 1985b; Haarhoff 1988; Manegold *et al*. 2013). This size class four species was recovered from spit two. Remains of a likely passerine bird, of which there are many in Langebaanweg, most still lacking detailed descriptions and identifications (Manegold *et al*. 2013) were also recovered from Profile One. The passerine was a size class one bird and was recovered from spit two. It is likely that more passerine material may have been incorporated into the microfaunal sample. Future analysis of the bird remains from Profile One by an expert will be needed in order to resolve more of the unidentifiable material. The majority of birds from Profile One were represented by body size class three (44.8%) and size class two (37.3%) specimens (Figure 8.171). Spit two produced the most abundant (37 specimens) and diverse bird remains, however the contribution of birds to spits one (4%), two (5.4%) and three (5.7%) was small but consistent (Figur e8.172). Birds made up 10% of spit four but are only represented by a single specimen.

8.6.2 Anatomical composition of Aves

The most commonly recovered elements of the bird skeleton in Profile One were coracoid (16.4%), tarsometatarsus (10.4%) and tibiotarsus (14.9%) (Table 8.103). Autopodial and axial remains were rare in the bird assemblage (Figure 8.173). Size class one and four remains were relatively rare. Size class one elements included scapula, coracoid, second wing phalange, tibiotarsal and vertebra (Figure 8.174). In size class four, a single element each of humerus, radius, ulna, tarsometatarsus and tarsal/carpal were observed. All other elements were derived from size class two and three individuals. Most bird remains were recovered from spit two (55.2%) and a large number were recovered from spit one (25.4%) (Table 8.104). A second wing phalange was the only bird specimen recovered from spit four (Figure 8.175).

Skeletal frequency estimates are given in Table 8.105, an MNI of five is given in the bird assemblage based on coracoid remains.

8.6.3 Bone Size Frequency Distribution and Fragmentation Pattern of aves

Maximum length

Mean maximum length of bird remains from Profile One was 16.6 mm (Table 8.106), much lower than mean length in mammals or chelonia from Profile One. The smallest bird specimen measured 7 mm in maximum length and the largest 32 mm. In the combined bird sample, specimens fall between 10 mm and 40 mm in length with the majority of specimens falling within the range 15 mm – 25 mm (Figure 8.176). Size class one birds display a maximum length between 10 mm and 20 mm, with a leaning towards larger size, but note the small sample size (Figure 8.177). Bird remains from size class two display a spread between 10 mm – 40 mm with a peak around 15 mm and a trailing off in size from there (Figure 8.178). Size class three remains show the same spread but with more specimens between 15 mm and 30 mm (Figure 8.179). In size class four, specimens display lengths between 15 mm and 35 mm with a peak around 25 mm, but the small sample size must be noted (Figure 8.180). Size in aves was more consistent between size classes than observed in mammals or tortoises but some size classes had very poor sample sizes.

Fusion

Fusion could be observed on a total of 46 (68.7%) avian specimens from Profile One; mostly from size class two and three individuals (41.3%, respectively) (Table 8.107). No subadult specimens were observed and only 1 (2.2%) juvenile was recorded. Adult birds were observed in all size classes, while the juvenile was derived from a size class three individual (Figure 8.181).

Completeness

Completeness was very low (10.4%) in avian remains from Profile One (Table 8.108). Complete avian remains include vertebra (14.3%), second wing phalange (14.3%), cervical vertebra (28.6%) and coracoid

(42.9%), with the latter element most frequently recovered complete (Figure 8.182). Size class two displayed the highest percentage (42.9%) of complete remains and no complete size class four bird specimens were recovered. Complete size class one (28.6%) elements were limited to two coracoids, while size class three (28.6%) complete remains were limited to cervical vertebra. All but one complete bird specimen was recovered from spit one (85.7%) (Table 8.109). Spit two (14.3%) produced a single second wing phalange that was complete. No complete bird remains were recovered from spits three or four.

Breakage Profile

A single avian long bone (second wing phalange) was recovered complete (Table 8.110). The majority of bird long bones were represented by proximal (42.9%) or distal (31.4%) remains. Coracoid remains were predominantly represented by proximal (63.6%) parts, although shafts and complete coracoids were also preserved. Two-thirds of scapula remains were blade. Vertebra were represented by centrum (57.1%) or were complete (42.9%). Finally the sternum, innominate, tarsal, rib and long bone fragments were simply coded as fragmented.

Fracture Outline

Table 8.111 displays the fracture outlines observed in avian remains against body size class. The only fracture outlines observed in bird long bones were spiral (43.1%) and transverse (9.8%) breaks. In size class two, three and four spiral breaks were dominant, while in size class one transverse breaks dominated (Figure 8.183). No particular reason for this is apparent, and it may simply be a factor of the small sample size. When bird fracture outlines were compared with depth, spiral breaks were dominant at all levels, but particularly in spit two (43.2%) and spit three (47.6%) (Figure 8.184). Transverse breaks appear absent in spit four but note that there is only one long bone fracture recorded in birds from this level (Table 8.112), a greater sampling would be required from spit four, before any interpretation can be made of this data.

Fracture angle

A total of 57 fracture angles (55.9%) were analysed in avian remains from Profile One (Table 8.113). The majority of fracture angles in the avian sample were oblique (36.8%) and mixed (35.1%) (Figure 8.185). Oblique fractures dominated size class one (25%) and three aves (28.6%) (Figure 8.186). Mixed fractures were dominant in size class two (22.7%) and right fractures were dominant in size class four (25%). Spit one was dominated by oblique (25%) fractures, while mixed (23.1%) fractures were most common in spit two (Figure 8.187). No fracture angles could be identified from spit four (Table 8.114).

8.6.4 Bone Surface Modifications of Aves

Bone Weathering

Weathering was observed on nine avian specimens representing 13.4% of bird remains (Table 9.116). All weathering in birds was limited to stage one.

Burning

Burning was observed on only five (7.5%) avian appendicular specimens from Profile One (Table 8.116). Stage two (40%) and stage three (60%) burning were observed on bird remains, with the latter occurring more frequently. The humerus was the most strongly affected of bird elements (Figure 8.188).

Staining

A total of 58 bird specimens representing 86.6% of the assemblage displayed staining modification (Table 8.117). The majority of staining in birds was stage one (47.8%), although large proportions of stage two (28.4%) and three (10.4%) were also observed (Figure 8.189). Staining was most commonly observed in size class two (92%) birds and least commonly in size class four (80%) (Figure 8.190). Stage one staining was observed in all size class birds, but was dominant in sizes one to three birds (Figure 8.191). Stage two staining was dominant in size class four, and stage three was observed only in size classes two and three. Black staining was observed on only two specimens.

Abrasion

A total of 39 avian specimens from Profile One representing 58.2% of the assemblage displayed abrasion (Table 8.118). Abrasion was most prevalent in size class four (80%) birds and was least common in size class two (52%) (Figure 8.192). Stage four abrasion was absent from bird remains. The vast majority of bird remains displayed stage one (53.7%) abrasion and stage two and three were negligible (3%, 1.5%; respectively) (Figure 8.193). Stage three abrasion was only observed in size class one birds and stage two abrasion was observed on size class two and four (Figure 8.194).

Sheen

A large proportion of bird remains (76.1%) display sheen (Table 8.119). The most common sheen in bird remains was stage three (34.3%) and stage one (25.4%), while stage four was rare (1.5%) (Figure 8.195). Size class three birds display particularly high prevalence (90.3%) of sheen (Figure 8.196). Size class one birds display only stage one and two sheen (33.3%, respectively), while size class four birds display exclusively stage three sheen (Figure 8.197). Size class four birds display all stages of sheen, although stage three was dominant. Size class three birds display mostly stage one sheen along with stage two and three.

Trampling

Trampling was observed on 19 bird specimens from Profile One, representing 28.4% of bird remains (Table 8.120). Trampling was observed in size class two (32%), three (29%) and four (40%) aves and was most prevalent the latter (Figure 8.198). Size class three birds display only stage one trampling, size class four birds only stage two.

Carnivore modifications

Tooth marks

Only four (6%) bird specimens from Profile One display carnivore tooth marks (Table 8.121). Modified bones include coracoid (9%), ulna (20%) and carpometacarpus (100%).

Digestion

A total of five avian specimens from Profile One, representing 7.5% of the assemblage displayed digestive corrosion (Table 8.122). The majority of digestion in bird remains was stage one (4.5%) in intensity, although stage two (3%) remains were also recovered. Size class one birds displayed the highest prevalence (16.7%) of digestion, which was also observed on size class two (8%) and three (6.5%) remains (Figure 8.199). Stage two digestion was observed in size class two and three, but not size class one.

Root marks

Root etching was observed in 10 avian specimens, representing 14.9% of the bird assemblage (Table 8.123). The majority of root etching in birds was stage one (11.9%) in intensity. Size class one birds displayed high levels (33.3%) of root etching (Figure 8.200).

8.7 AMPHIBIAN TAXONOMY AND TAPHONOMY

8.7.1 Taxonomic and anatomical composition of Amphibia

Amphibian remains are typically very small and vast amounts of these species have been recovered from the microfauna samples at Langebaanweg previously (Matthews *et al.* 2015). Some frog species are quite large bodied and can produce bones large enough to be collected with the macrofauna. A single (0.1%) amphibian, consistent with a size class one individual, was recovered from Profile One, spit two. This specimen was a portion of the innominate.

8.7.2 Bone Size Frequency Distribution and Fragmentation Profile of Amphibia

Maximum length in the amphibian innominate was 15 mm. This pelvis specimen was unfused and must be assumed to have originated from a subadult or juvenile specimen. This specimen is incomplete but displays the acetabulum with partial ilium, ischium and pubis.

8.7.3 Surface Modifications of Amphibia

The only surface modification observed in the amphibian specimen was staining. Stage one staining was observed on the amphibian remain (Table 8.9).

8.8 PISCES TAPHONOMY

8.8.1 Taxonomic composition of Pisces

A total of 15 (1.1%) pisces specimens were recovered from Profile One. The fish sample was dominated by size class one (73.3%) individuals; and no fish remains greater than size class three were observed (Table 9.124; Figure 8.201). The majority of fish remains were recovered from spit two (10), however the contribution of fish to each spit was very small (<2%) in all spits except spit four (Table 8.125; Figure 8.202).

8.8.2 Anatomical composition of Pisces

The vast majority of fish remains from Profile One were isolated vertebra (80%), but three (20%) mandibular fragments were also recovered (Table 8.126). The mandibular remains were all recovered from spit two (Table 8.127) and were derived from size class one individuals. Given the lack of additional material other than vertebra and mandibular fragments and MNI of 1 was estimated.

8.8.3 Bone Size Frequency Distribution and Fragmentation Profile of Pisces

Maximum length

I have already shown that there is generally a correlation between maximum specimen length and body size class and have thus analysed length separately by size class in other taxonomic groups. The small sample size in fish remains has made this impossible as there are less than five specimens in size class two and three. Thus only the combined sample of fish is investigated. Mean length in pisces remains was 8.7 mm (Table 8.128). The minimum length measured was 6 mm and the vast majority of specimens display lengths around 10 mm to 15 mm (Figure 8.203). A single large outlier (size class three) of 21 mm was observed.

Fusion

Fusion could not be analysed in pisces specimens.

Completeness and breakage

Completeness was high in the pisces assemblage with 60% (9) of remains, all vertebra, recovered complete (Table 8.129). Two thirds of the complete fish were recovered from size class one. Complete fish remains were observed in all spits, although the highest abundance (6) occurred in spit two (Table 8.130). All incomplete fish remains display a portion of the centrum.

Fracture outline and angle

Fracture outline and angle were not analysed in the fish remains from Profile One as no long bones were recovered.

8.8.4 Surface modifications of Pisces

Weathering, burning, trampling and root etching were absent in pisces remains from Profile One.

Staining

Staining was observed on 13 fish remains, representing 86.7% of the Profile One assemblage (Table 8.131). The majority of staining in pisces remains was stage one (53.3%) and stage three (20%) (Figure 8.204). Staining was observed in 90.9% of size class one fish remains and 100% of size class two fish. All staining in pisces remains was brown.

Abrasion

A total of 10 pisces specimens from Profile One representing 66.7% of the assemblage displayed abrasion (Table 8.132). Stage two abrasion was observed on a single (6.7%) specimen, all other remains displayed stage one modification. The majority of abrasion in fish specimens was observed on size class one remains.

Sheen

Sheen was observed on six remains, representing 40% of the Profile One pisces assemblage (Table 8.133). Stage three (26.7%) sheen was most common in fish remains, while stages two and four were also observed (6.7%), stage one sheen was absent. All fish bones displaying sheen were derived from size class one individuals, except 1 (33.3%) size class two remain.

Carnivore modifications

A single (6.7%) vertebral specimen from size class one displayed a tooth score. A different vertebral specimen displayed light (stage one) digestive pitting.

8.9 DISCUSSION

8.9.1 Sedimentology

Grain texture (grain size, sphericity, etc.) in the LQSM from Profile One compares favourably with the grain texture characteristics of the LQSM of Profile Two. These test pits were the only excavations to sample the LQSM, and both intersected only the uppermost parts of the deposit. The LQSM in both test pits displays a strong skew towards very fine sands (0.063 mm), although there is a higher proportion of coarse grains (>2 mm) in the Profile One sample. The LQSM in Profile One was slightly darker in colour, with poorer sorting and a greater dominance of a single grain size. Quartz grains in Profile One displayed lower sphericity. Quarts grains can have a long life in a system and it is difficult to make inferences regarding depositional environments from quartz grain shape (Boggs 2011). The lower sphericity of Profile One material suggests it has experienced less travel or been active in a lower energy environment, but this might have occurred a long time before deposition. The dominance of a single grain size, might be the result of a moderate current velocity which winnowed out other size particles. The darker colour of the Profile One LQSM could be the result of slightly different mineral composition in these sediments. Minerology was not investigated in this study. The sediments of the LQSM from Profile One compared favourably with previous sedimentary analyses (Roberts 2006d, Roberts *et al*. 2011). The lack of muds and silts was remarkable. The sediments of the LQSM strongly resembled beach sands of marine origins. Certain estuarine environments with strong tidal influences can result in the deposition of large sand bodies with little mud or silt. This is discussed in greater detail in Chapter Nine. The LQSM interfingers finely into the MPPM and no bedding features were observable in the deposit. The contact between the MPPM and the LQSM does not indicate a hiatus as suggested by Hendey (1976) but more likely contemporaneous or near contemporaneous deposition of the deposits.

The MPPM in Profile One appears to be made up of very fine muds and silts with little sandy material, and possibly a high frequency of organic matter. These characteristics could be considered indicative of a mud flat or marshy environment. Peaty, marshy and tidal flat deposits have been recorded at Langebaanweg previously (Hendey 1976, 1980, 1981; Dingle *et al*. 1979), although the locations of these deposits have either been lost or mined out. Further analysis of the fine grains from the Profile One MPPM using dispersal agents and settling columns (not available at time of writing) will elucidate more details of the possible depositional environment.

8.9.2 Taxonomic Comparsion

Taxonomic composition

The Profile One excavations produced numerous fossils, in fact Profile One represents the second largest assemblage (after Profile Four) in this study (Table 8.134). There was a particularly high percentage of identifiable bones in Profile One and numerous microfaunal remains. It must be borne in mind however, that a smaller mesh size was utilised during Profile One excavations, which would account for the large assemblage of small remains. Taxa recovered from Profile One include mammal, chelonia, aves, pisces and even a large amphibian. Chelonia remains were the most commonly recovered material throughout the test pit excavations in this anlysis.

Profile One was doinated by chelonian which made up as much as 80% of the assemblage. Chelonia include small specimens like padlopers, numerous medium-sized remains consistent with the angulate tortoise (*chersina angulata*) and very large individuals similar to the extant leopard tortoise (*Geochelone pardalis*). A relative of the angulate tortoise (*Chersina* sp.) has been recorded occurring in high abundance from Langebaanweg previously (Hendey 1981). In addition, Meyland & Auffenberg (1986), described a medium-sized tortoise *Geochelone stromeri* from Langebaanweg, related to the large mountain tortoise. The subject of the Langebaanweg chelonian requires the attention of an expert, particularly given most of the chelonian remains are found disarticulated and dispersed. The most commonly recovered mammalian family in Profile One was carnivores followed by bovids, a pattern that is also observed in Profile Two. Profile One displayed particularly low frequency, and poor diversity in mammals. This could either reflect a lack of mammals in the immediate environment prior to fossilisation or a general low mammal frequency in the deposit with concentration of this taxonomic group around the river channel area (Profile Two and Four).

There were high numbers of avian remains in Profile One, including passerines, Phasianidae and large wading birds, all of which are common occurrences at Langebaanweg (Manegold *et al.* 2013). It is unclear why birds should be more abundant in Profile One than in the other test pits. A marshy environment (as indicated by the sedimentology) might be expected to preserve high numbers of avian remains. Species composition of the avian remains from Profile One is inconclusive, but this topic requires the attention of an expert. Previous studies of the anuran community at Langebaanweg has identified the presence of large sized frog remains (Matthews *et al.* 2015) and it is likely that many more frogs bones will be recovered once the microfaunal sample has been analysed. The recovery of fish

remains along with some frog bones suggests the presence of a nearby water source, probably freshwater. Also notable in Profile One is the paucity of megamammal bones, which make up a large part of the bone bed deposit.

Fragmentation Profile

Breakage was high in bones from Profile One, but less so than in Profiles Four or Two. The vast majority of chelonia remains were shell fragments, the appendicular skeleton was however, well preserved. Axial and autopodial elements were rarely preserved in the chelonia assemblage. In mammals, on the other hand, autopodial elements (particularly metapodial and proximal phalange) were the best preserved specimens. These patterns are often seen in fossil chelonia (Thompson & Henshilwood 2014) and mammal (Reynard *et al.* 2015) assemblages. In addition, birds display a similar pattern of element preservation as tortoises with a paucity of axial and autopodial remains. The lack of axial remains including cranial parts from tortoises and birds is not unexpected given the fragile nature of these bones. The lack of autopodial remains could suggest loss of these parts from the skeleton early on during decomposition.

The vast majority of the chelonian assemblage was shell remains and elements of the carapace were more common than the plastron. Thompson & Henshilwood (2014) observed similar patterns of chelonia preservation, they also found (as in this study) that the most common carapace elements were marginals and that a large number of shell remains could not be accurately designated to element. Similarly, autopodial and axial elements were poorly preserved in aves. Bones from Profile One were small, with an average length of 21.4 mm and a maximum bone length of 69 mm in one specimen. This average specimen length is consistent with remains recovered in Profile Two and Profile Four. Fracture outlines indicated that the majority of bones were broken while fresh. Fracture angles, weree more ambiguous but appeard to show a slight tendency towards fresh breaks. Complete remains were rare, and limited in mammals and tortoises to the small compact bones of the appendicular skeleton. The high levels of fracturing observed in bones from Profile One (and the other test pits) would suggest the bones have undergone high levels of abrasion or movement or were active in a high energy environment. However, abrasion damage was light (but frequent) and most indications are for a low energy environment. Trampling damage was faily common and this could provide a means for the fracturing observed.The majority of remains, particularly in the mammal and tortoise assemblages, died

as adults, suggesting a more catastrophic than attritional profile (Klein 1982), but sample size in which epiphyseal fusion could be classified was small.

Surface Modification

Staining, abrasion, sheen, and trampling were the most commonly recorded surface modifications from Profile One. Carnivore modifications (tooth marks and digestion) were rare. Staining was substantially more frequent on bone remains in Profile One than in the other test pits. Staining is a post-depositional process, and it is unclear why Profile One should be more severly affected by this modification. Root etching can occur at the surface - soil interface or in buried bones, where roots have been seen to burrow towards bones, presumably attracted to the nutritional content thereof. There is a strong likelihood at Langebaanweg that fossils may display modern root etching due to the long exposure of the fossils near the surface. The Profile One area, in particular, was well vegetated prior to excavations. Root etching was however, found to be greater in remains from Profile Two. It is unclear how to differentiate modern root etching from ancient activity. Fernández-Jalvo and Andrews (2016) suggest that modern root etching may result in colour changes in the root scores, but more experimental work is required on this subject. This analysis does not attempt to distinguish modern and ancient root etching and this discussion simply serves to emphasise that root etching may be over represented. Modifications that indicate prolonged exposure of bones at the surface prior to burial are uncommon in the Profile One assemblage. Weathering and burning occur with low frequency and insect modifications were absent. Burning was rare, occurring on only 10% of bones, however Profile One displayed the highest prevalence of this modification of the test pits analysed. The majority of burnt bones in Profile One were derived from the MPPM layers. If Profile One was deposited in a marsh environment as has been hypothesised, then there would be more organic matter available for burning, which could result in greater prevalence of this modification during dry periods.

There is a high frequency of trampling modification and extensive abrasion, which could indicate extensive activity of the bones prior to final deposition. The fragmentary nature ofthe Profile One bones and their small general size could indicate transport or other destructive processes. The high levels of polishing in Profile One (greater than in Profiles Two or Four) might support this, however Profile One displayed low intensity of abrasion.

8.9.3 Comparison MPPM – LQSM

In this analysis spit one is taken as being MPPM, and spit three and four as representing the LQSM. Spit two is considered separately as a contact zone, as this is where most of the interfingering of the deposits was observed. It must be noted however, that there is still some intermixing of MPPM and LQSM below spit two.

Taxonomic composition

The contact zone produced the greatest number of remains (fully half of the assemblage) from Profile One, the LQSM produced the smallest, suggesting a lower density of specimens (Table 8.135). It is unclear why bone density should be so high in the contact zone and there may be some sort of concentrating mechanism at work in one or the other member along the contact. Chelonia were the dominant taxon in all layers, but their abundance was lowest in the LQSM. This is in direct contrast to Profile Two where the LQSM produced most of the chelonid remains. The LQSM in general appears to display a greater degree of diversity with larger relative percentages of mammals (19.6%), aves (5.9%) and pisces (1.8%) than the MPPM. The majority of carnivore remains as well as small mammal specimens were recovered from the contact zone. The recovery of aquatic animals in the contact zone (amphibian) and the LQSM may indicate the presence of standing water in the area at the time of deposition, with a transition into marsh or tidal flats in the MPPM.

Fracture Profile

Fracturing was great in both the MPPM and LQSM with no significant differences in fracturing patterns between the deposits. Bones in the MPPM were fractionally (2 mm) longer than in the LQSM or contact zone and completeness was slightly less in the MPPM. The MPPM and LQSM show similar proportions of spiral shaped and oblique angled fractures indicating mostly fresh breaks.

Surface Modifications

Many surface modifications vary only slightly in frequency between the MPPM and LQSM in Profile One. Burning, sheen, trampling, and root etching display a distinct disparity between the MPPM and LQSM in Profile One, with these particular modifications occurring slightly more frequently in the former. It could be argued that the high prevalence of these modifications may be linked to high chelonia numbers but note that the relative proportion of chelonia was similar in the MPPM and the contact zone. Burning and trampling were thus more common in the MPPM. High vegetation cover, as might be expected in a marsh, could account for both these modifications, as animals may have been attracted to the marsh in order to find food. The higher degree of root etching would also be expected in a marsh with high botanical productivity. But the action of modern root etching can not be ruled out. The high percentage of sheen in remains from the MPPM would suggest transport, however other indicators like abrasion do not support this. Other taphonomic processes like trampling have been known to produce polishing on bones (see Chapter Five for more details) (Reynard 2014).

8.9.3 Depositional environment interpretation and conclusions

Lithology in the MPPM suggests a low energy environment with high abundance of mud and plant matter consistent with a marshy or similar environment. Surface modifications and taxonomic composition appear to support this hypothesis. Bone fragmentation in Profile One is lower than in the other test pits suggesting a less destructive environment or depositional process , consistent with a marsh. The LQSM sediments strongly resemble the LQSM in the 1976/2 excavation (Profile Two) but bones are much less heavily fragmented and abraded than in the latter area. The appearance of numerous piscine bones in the lower parts of the deposit could be indicative of standing water in the area at the time of deposition. The LQSM interfingers intricately into the MPPM both laterally and vertically and there is little indication here for the sharp erosional contact described by Roberts (2006) and Roberts *et al.* (2011). Thus, Profile One is reconstructed as a marsh environment, within an estuarine system, with occasional period of standing water.

The Profile One excavation has shown the continued potential of Langebaanweg E-Quarry as a source of new information regarding the depositional conditions, environment and fauna of the site. It also shows the importance of investigating areas outside of the bonebed and river channel deposits in order to

sample other potential microenvironments (like tidal flats) and to contextualise how the high density of bones in those beds may relate to the remainder of the Langebaanweg deposit.



Figure 8.1. View of surface in the Profile One area. Note the horticultural tents in the background

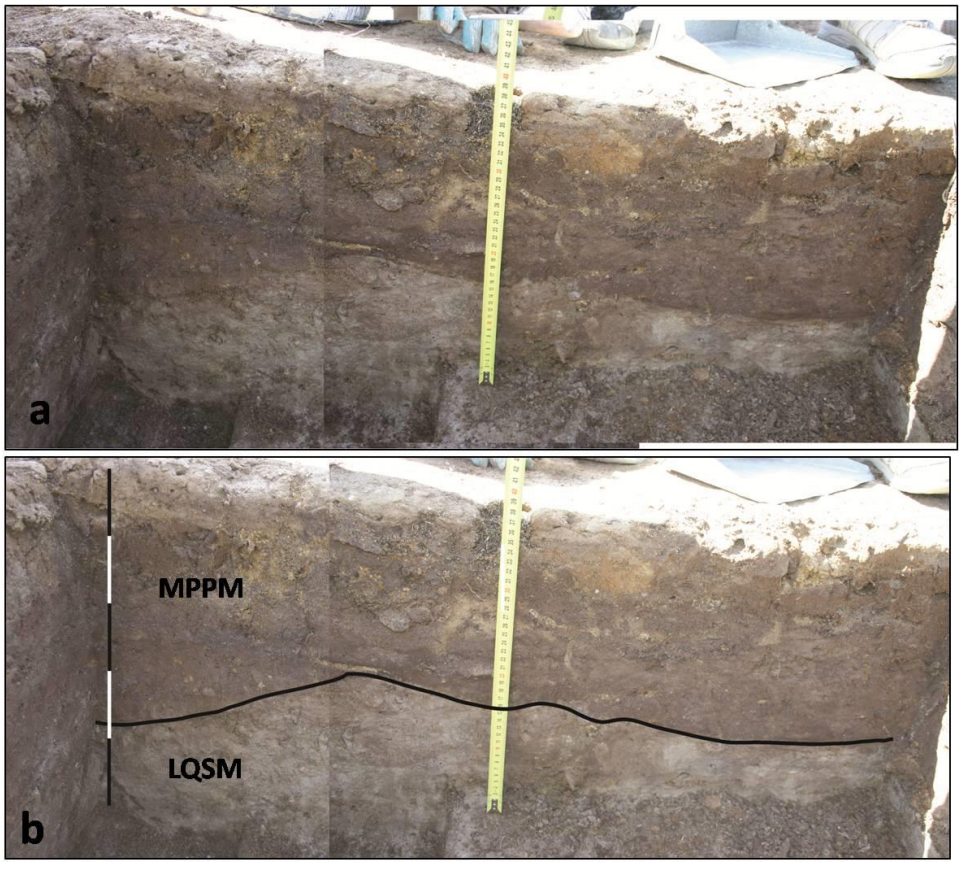


Figure 8.2. Profile wall of Profile One with MPPM and LQSM and their contact marked; a) original, b) annotated image

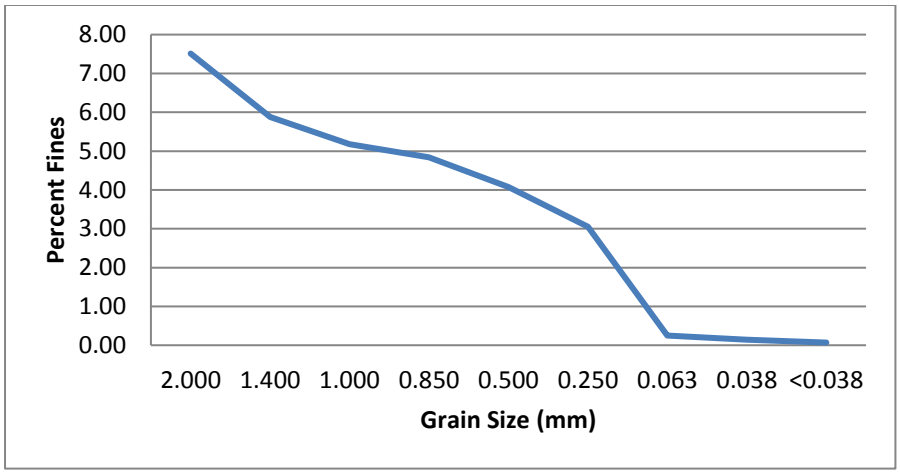


Figure 8.3. Cumulative percentage curve of grain size in the MPPM sample from Profile One

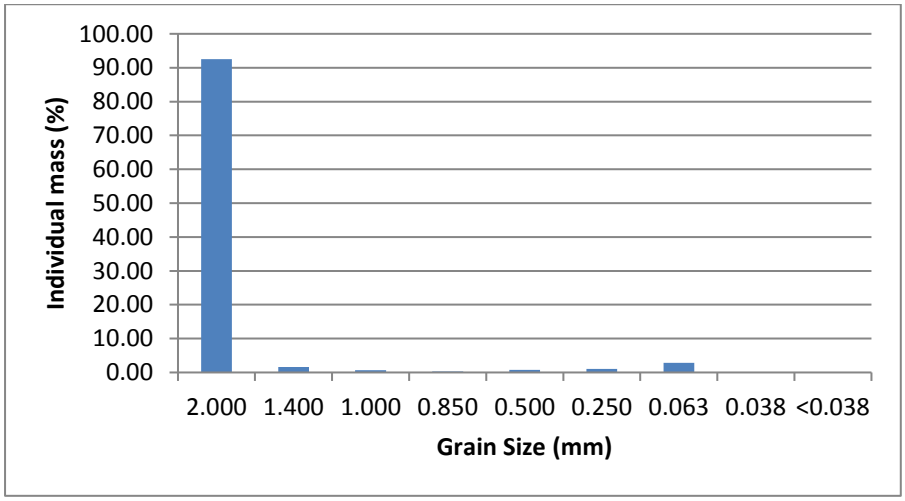


Figure 8.4. Relative frequencies of grain size in the MPPM sample of Profile One

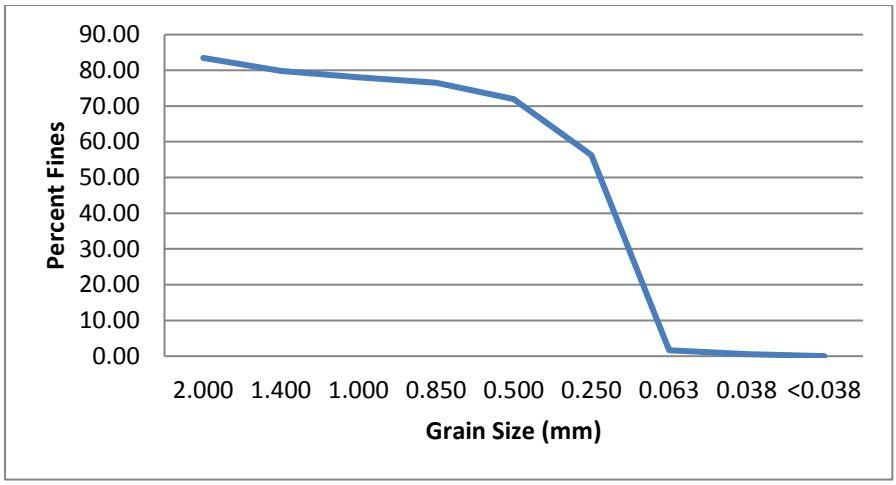


Figure 8.5. Cumulative percentage curve of grain size in the LQSM sample from Profile One

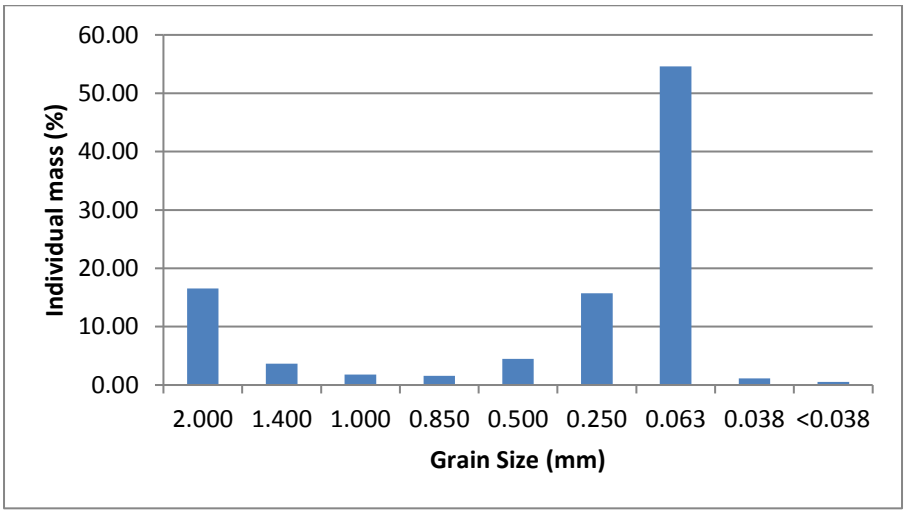


Figure 8.6. Relative frequencies of grain size in the LQSM sample of Profile One

Table8.1. Density of bones by spit from Profile One

	N	%
Spit 1	424	31.9
Spit 2	689	51.8
Spit 3	209	15.7
Spit 4	10	0.8
Total	1332	

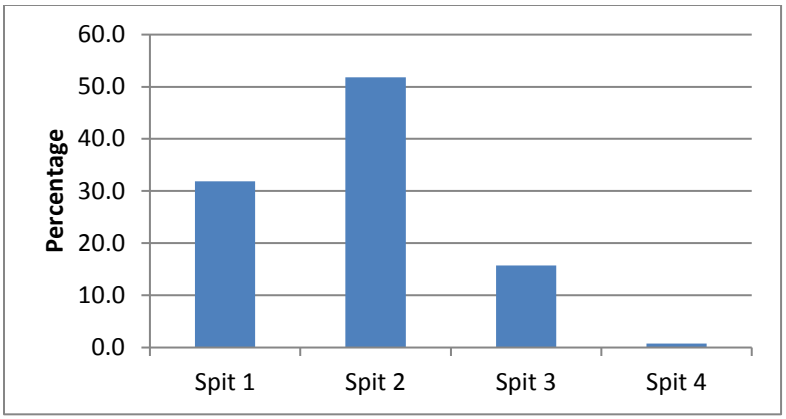


Figure 8.7. Relative frequency of bones by spit from Profile One

Table8.2. Taxonomic composition of Profile One

	N	%
Mammals	137	10.3
Chelonia	1112	83.5
Aves	67	5
Amphibia	1	0.1
Pisces	15	1.1
Total	**1338**	

Table8.3. Taxonomic composition of Profile One by spit

	Mammals		Chelonia		Aves		Amphibia		Pisces		Total	
	N	%	N	%	N	%	N	%	N	%	N	%
Spit 1	32	7.5	374	88.2	17	4	-	-	1	0.2	424	31.9
Spit 2	62	9	579	84.3	37	5.4	1	0.1	10	1.5	689	51.7
Spit 3	42	20.1	152	72.7	12	5.7	-	-	3	1.4	209	15.7
Spit 4	1	10	7	70	1	10	-	-	1	10	10	0.8
Total	**137**		**1112**		**67**		**1**		**15**		**1332**	

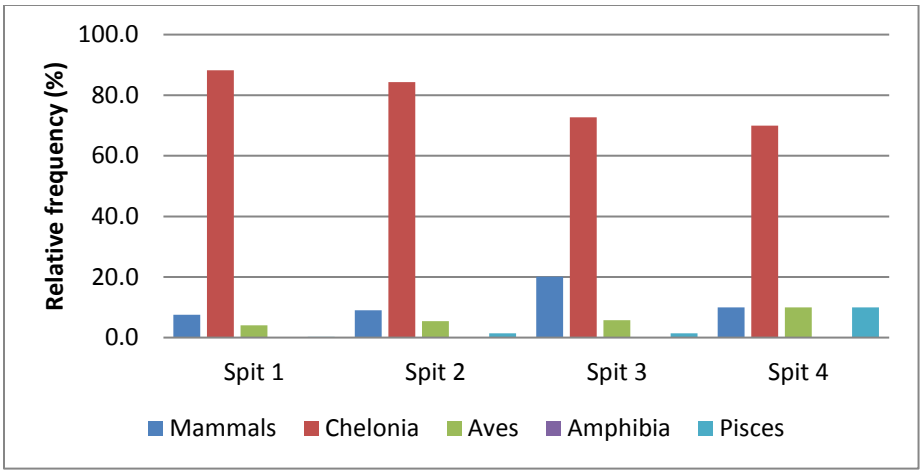


Figure 8.8. Taxonomic composition of Profile One by spit

Table 8.4. Descriptive statistics of maximum length in bones from Profile One

	Combined	Mammal	Chelonia	Aves	Pisces
N	1329	137	1109	67	15
Minimum	3	3	3	7	6
Maximum	69	63	69	32	21
Mean	21.4	21.7	21.8	16.6	8.7
Standard Deviation	8.85	10.76	8.57	6.2	3.9

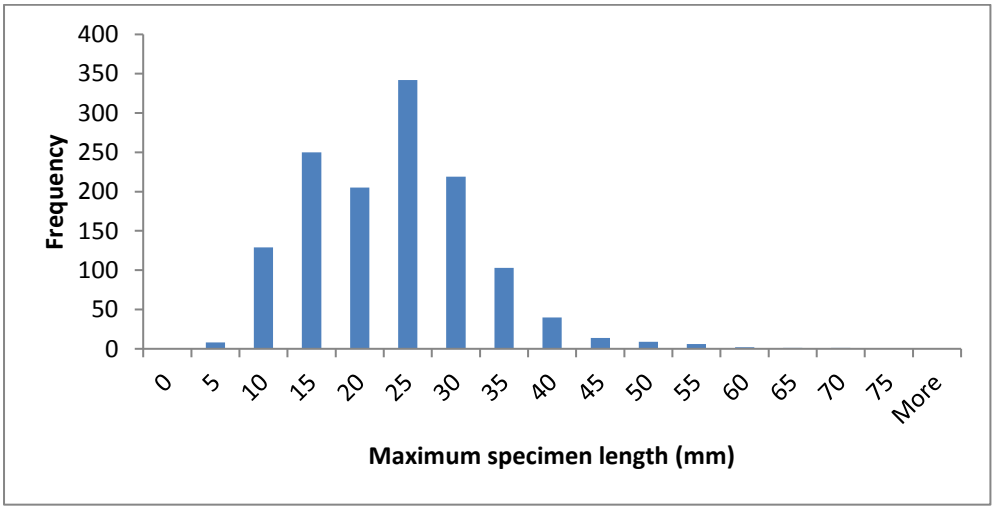


Figure 8.9. Histogram of maximum lengths in bones from Profile One

Table 8.5. Weathering in taxonomic groups from Profile One

	Mammals		Chelonia		Aves		Totals	
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Stage 1	16	11.7	179	16.1	9	13.4	**204**	**15.3**
Stage 2	5	3.6	37	3.3	-	-	**42**	**3.2**
Stage 3	-	-	2	0.2	-	-	**2**	**0.2**
Totals	**21**	**15.3**	**218**	**19.6**	**9**	**13.4**	**248**	**18.6**

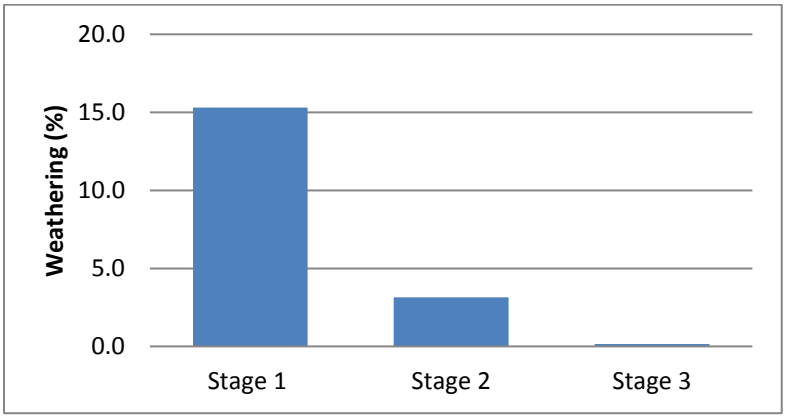


Figure 8.10. Weathering intensity in Profile One

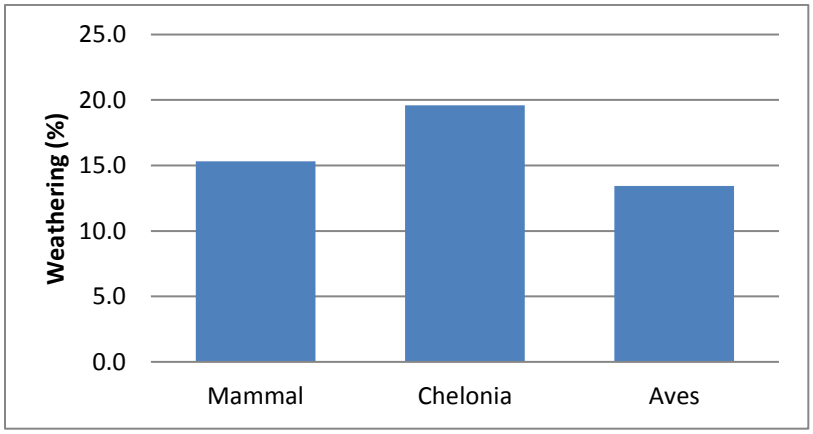


Figure 8.11. Relative frequency of weathered bones by taxonomic group from Profile One

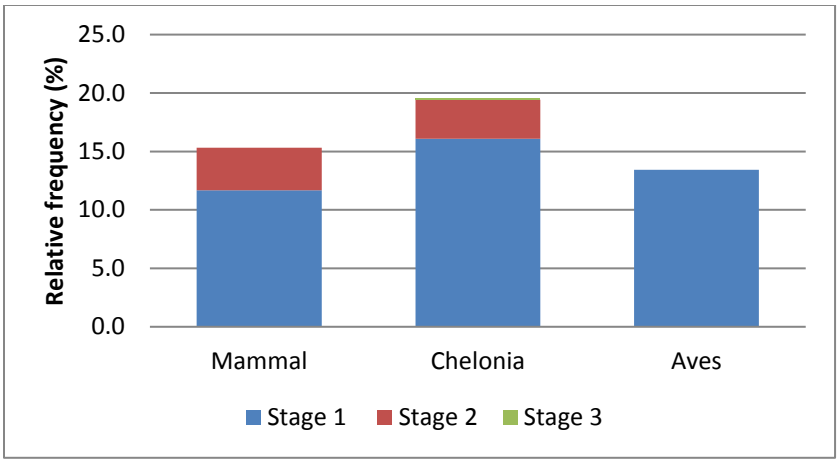


Figure 8.12. Weathering intensity with taxonomic group from Profile One

Table 8.6. Weathering and spit from Profile One

	Spit 1		Spit 2		Spit 3		Spit 4		Totals	
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Stage 1	68	16	102	14.8	32	15.3	2	20	**204**	**15.3**
Stage 2	6	1.4	29	4.2	7	3.3	-	-	**42**	**3.2**
Stage 3	-	-	2	0.3	-	-	-	-	**2**	**0.2**
	74	**17.5**	**131**	**19**	**39**	**18.7**	**2**	**20.0**	**39**	**18.6**

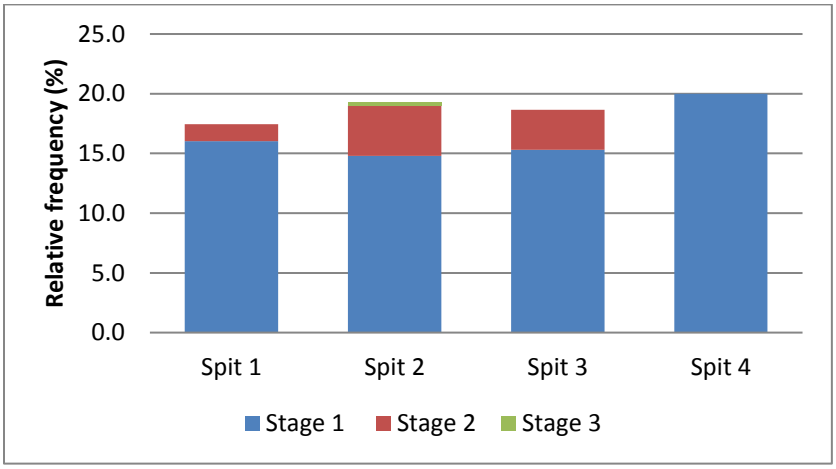


Figure 8.13. Intensity of weathering by spit in Profile One

Table 8.7. Burning by taxonomic group in Profile One

	Mammals		Chelonia		Aves		Totals	
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Stage 1	-	-	43	3.9	-	-	**43**	**3.2**
Stage 2	6	4.4	47	4.2	2	3	**55**	**4.1**
Stage 3	3	2.2	32	2.9	3	4.5	**38**	**2.9**
Stage 4	-	-	1	0.1	-	-	**1**	**0.1**
Stage 5	-	-	3	0.3	-	-	**3**	**0.2**
Totals	**9**	**6.6**	**126**	**11.3**	**5**	**7.5**	**140**	**10.5**

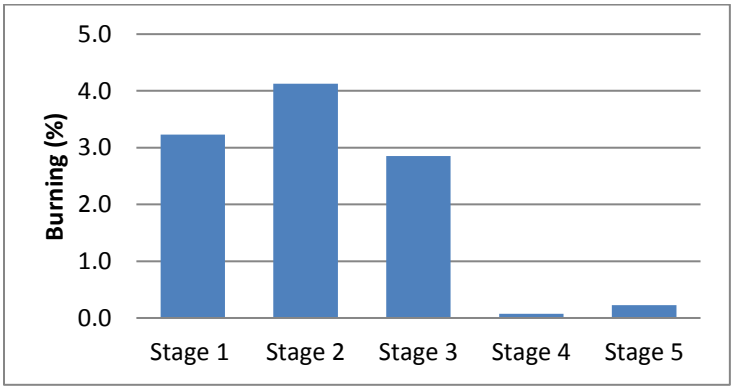


Figure 8.14. Burning intensity in Profile One

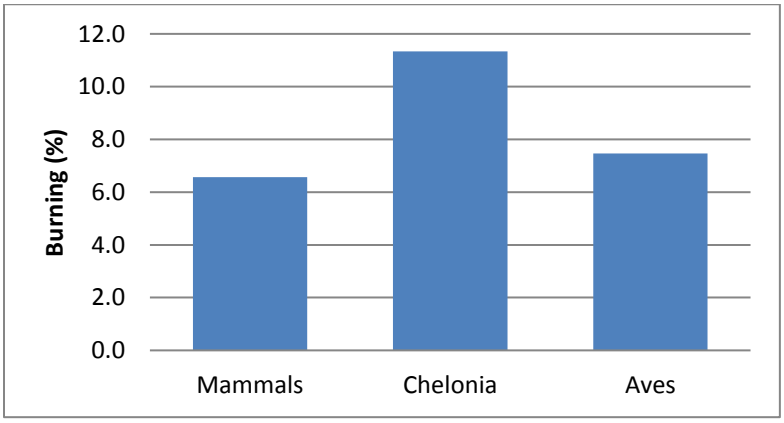


Figure 8.15. Relative frequency of burning by taxonomic group in Profile One

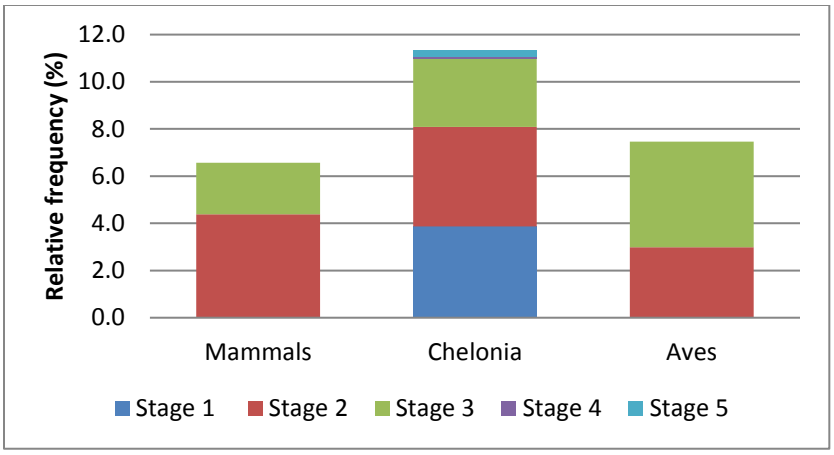


Figure 8.16. Intensity of burning by taxonomic group in Profile One

Table 8.8. Burning intensity with spit in Profile One

	Spit 1		Spit 2		Spit 3		Totals	
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Stage 1	18	4.2	22	3.2	3	1.4	**43**	**3.2**
Stage 2	24	5.7	27	3.9	4	1.9	**55**	**4.1**
Stage 3	29	6.8	7	1.0	2	1	**38**	**2.9**
Stage 4	-	-	-	-	1	0.5	**1**	**0.1**
Stage 5	-	-	2	0.3	1	0.5	**3**	**0.2**
Totals	**71**	16.7	**58**	8.4	**11**	5.3	**140**	**10.5**

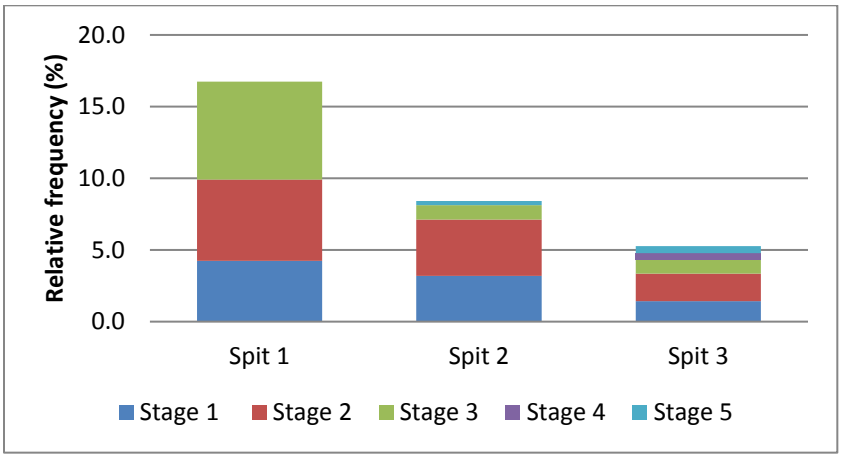


Figure 8.17. Intensity of burning with spit in Profile One

Table 8.9. Staining by taxonomic group in Profile One

	Mammals		Chelonia		Aves		Amphibian		Pisces		Totals	
	N	%	N	%	N	%	N	%	N	%	N	%
Stage 1	61	44.5	597	53.7	32	47.8	1	100	8	53.3	**699**	**52.5**
Stage 2	25	18.2	179	16.1	19	28.4	-	-	2	13.3	**225**	**16.9**
Stage 3	27	19.7	46	4.1	7	10.4	-	-	3	20	**83**	**6.2**
Totals	**113**	**82.5**	**822**	**73.9**	**58**	**86.6**	**1**	**100**	**13**	**86.7**	**1007**	**75.6**

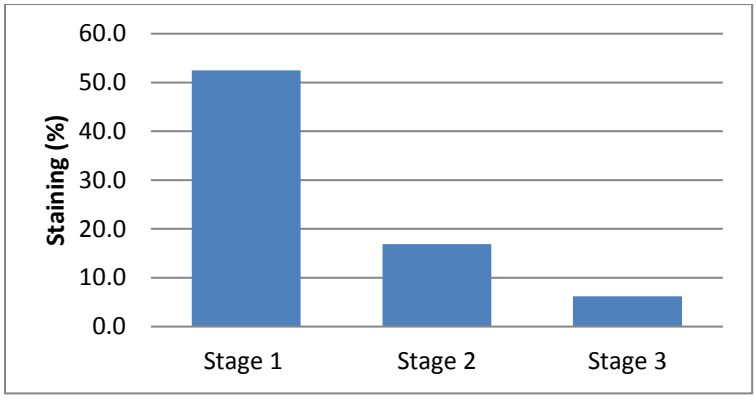


Figure 8.18. Staining intensity in Profile One

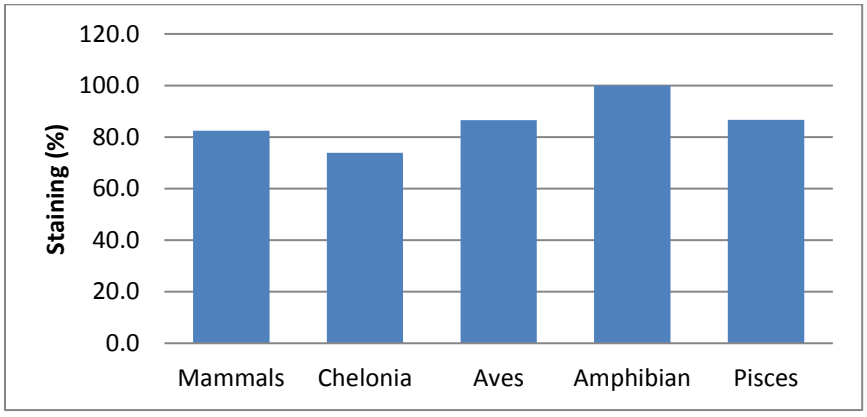


Figure8.19. Relative frequency of staining with taxonomic group from Profile One

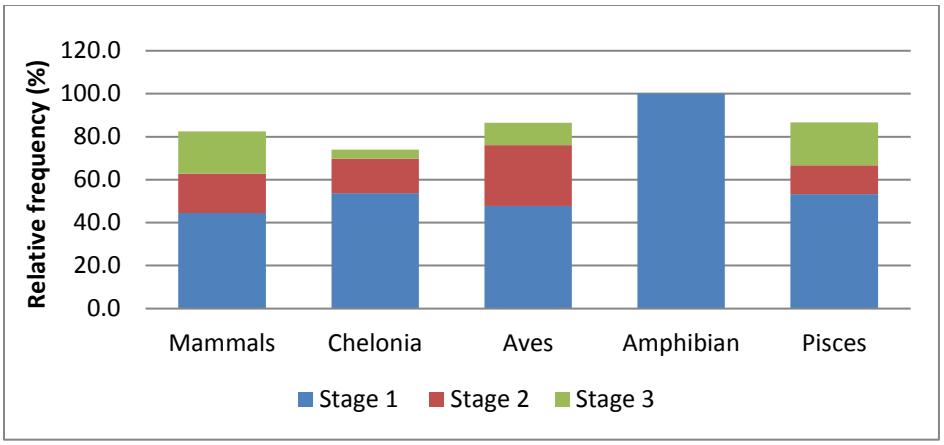


Figure 8.20. Intensity of staining by taxonomic group in Profile One

Table 8.10. Staining intensity and spit in Profile One

	Spit 1		Spit 2		Spit 3		Spit 4		Totals	
	N	%	N	%	N	%	N	%	N	%
Stage 1	235	55.4	349	50.7	109	52.2	6	60	**699**	**52.5**
Stage 2	68	16	133	19.3	22	10.5	2	20	**225**	**16.9**
Stage 3	27	6.4	43	6.2	12	5.7	1	10	**83**	**6.2**
Totals	**330**	**77.8**	**525**	**76.2**	**143**	**68.4**	**9**	**90**	**1007**	**75.6**

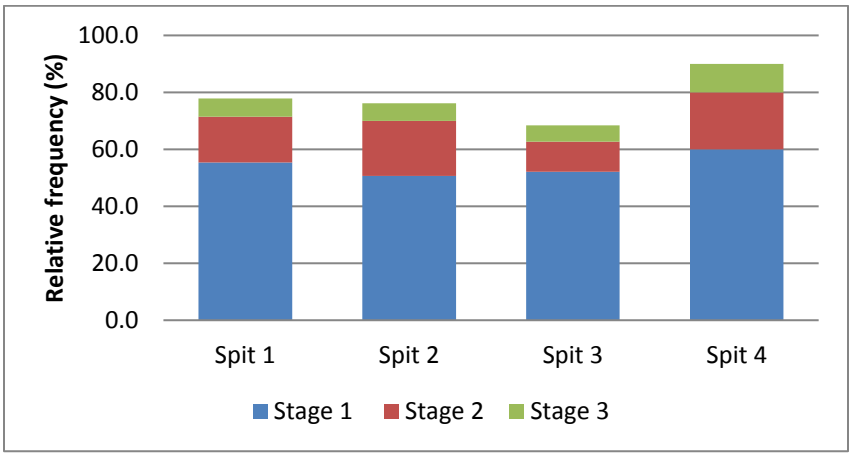


Figure 8.21. Intensity of staining with spit depth in Profile One

Table 8.11. Staining colour from Profile One

	Brown		Purple		Black		Total	
	N	%	N	%	N	%	N	%
Stage 1	651	69	-	-	48	76.2	**699**	**69.4**
Stage 2	210	22.3	-	-	15	23.8	**225**	**22.3**
Stage 3	82	8.7	1	100	-	-	**83**	**8.2**
Totals	**943**	**93.6**	**1**	**0.1**	**63**	**6.3**	**1007**	**100**

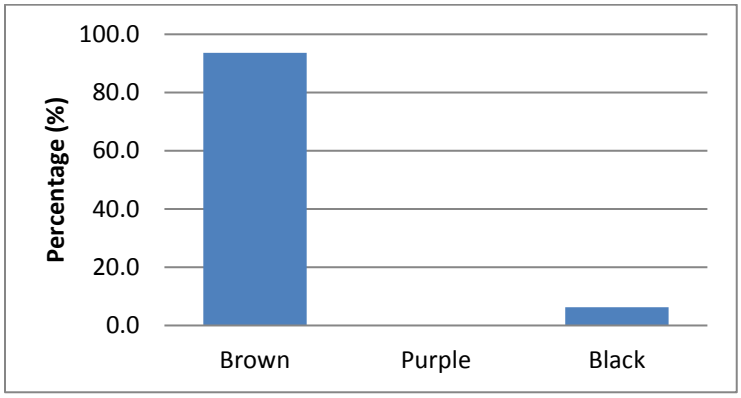


Figure 8.22. Relative frequency of staining colour in Profile One

Table 8.12. Staining colour and spit from Profile One

	Brown		Purple		Black		Total	
	N	%	N	%	N	%	N	%
Spit 1	326	34.6	-	-	4	6.3	**330**	**32.8**
Spit 2	499	52.9	1	100	26	41.3	**526**	**52.2**
Spit 3	113	12	-	-	29	46	**142**	**14.1**
Spit 4	5	0.5	-	-	4	6.3	**9**	**0.9**
Totals	**943**	**93.6**	**1**	**0.1**	**63**	**6.3**	**1007**	

Table 8.13. Abrasion intensity by taxonomic group from Profile One

	Mammals		Chelonia		Aves		Pisces		Totals	
	N	%	N	%	N	%	N	%	N	%
Stage 1	50	36.5	457	41.1	36	53.7	9	60	**552**	**41.4**
Stage 2	22	16.1	277	24.9	2	3	-	-	**301**	**22.6**
Stage 3	20	14.6	142	12.8	1	1.5	1	6.7	**164**	**12.3**
Stage 4	16	11.7	3	0.3	-	-	-	-	**19**	**1.4**
Total	**108**	**78.8**	**879**	**79.0**	**39**	**58.2**	**10**	**66.7**	**1036**	**77.8**

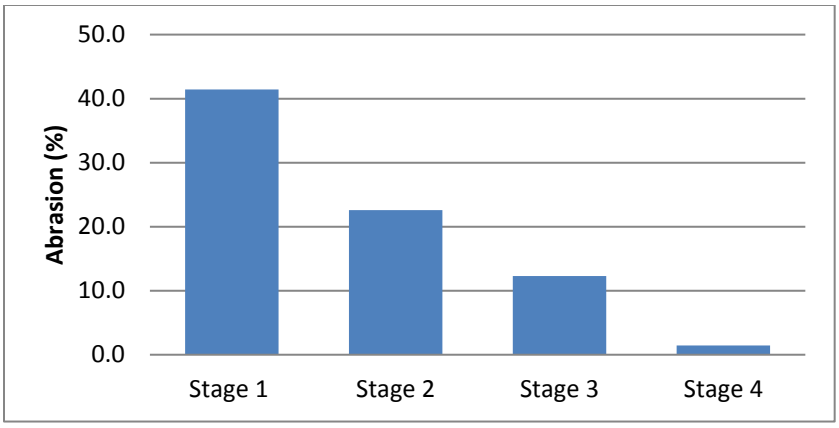


Figure 8.23. Abrasion intensity in Profile One

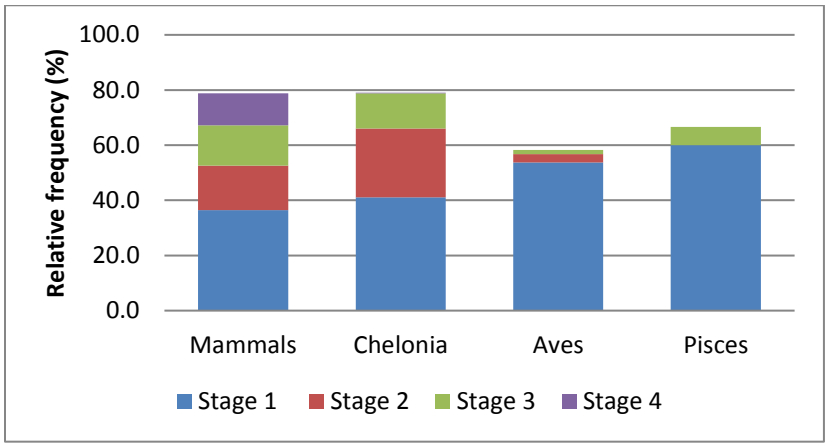


Figure 8.24. Intensity of abrasion by taxonomic group from Profile One

Table 8.14. Abrasion intensity by spit from Profile One

	Spit 1		Spit 2		Spit 3		Spit 4		Totals	
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Stage 1	178	42	283	41.1	85	40.7	6	60	**552**	**41.4**
Stage 2	101	23.8	155	22.5	41	19.6	4	40	**301**	**22.6**
Stage 3	46	10.8	95	13.8	23	11	-	-	**164**	**12.3**
Stage 4	2	0.5	11	1.6	6	2.9	-	-	**19**	**1.4**
Total	**327**	**77.1**	**544**	**79**	**155**	**74.2**	**10**	**100**	**1036**	**77.8**

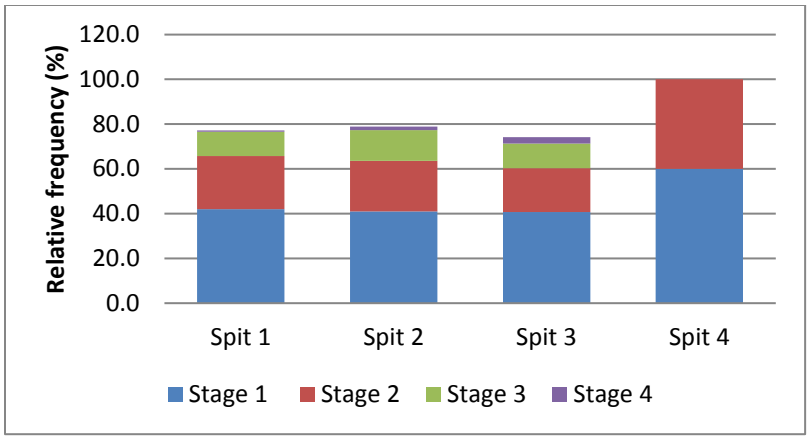


Figure 8.25. Abrasion intensity by spit from Profile One

Table 8.15. Sheen intensity by taxonomic group in Profile One

	Mammals		Chelonia		Aves		Pisces		Totals	
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Stage 1	29	21.2	330	29.7	17	25.4	-	-	**376**	**28.2**
Stage 2	17	12.4	129	11.6	10	14.9	1	6.7	**157**	**11.8**
Stage 3	18	13.1	56	5	23	34.3	4	26.7	**101**	**7.6**
Stage 4	1	0.7	2	0.2	1	1.5	1	6.7	**5**	**0.4**
Total	**65**	**47.4**	**517**	**46.5**	**51**	**76.1**	**6**	**40**	**639**	**48**

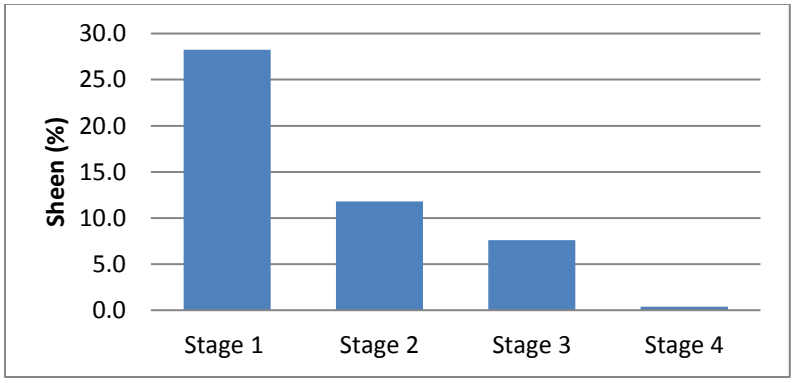


Figure 8.26. Sheen intensity on remains from Profile One

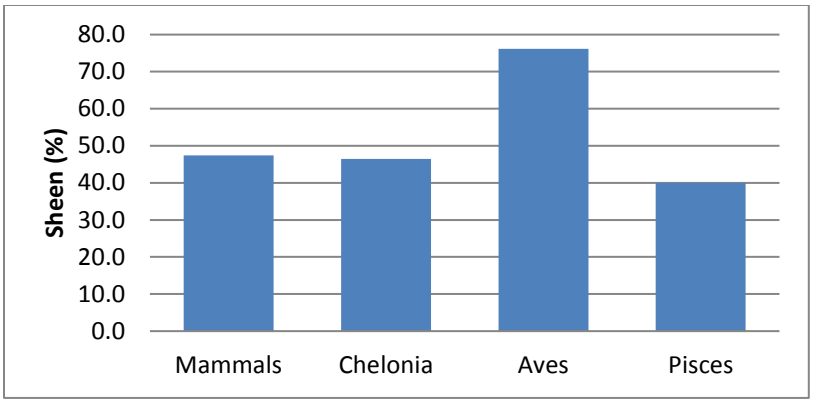


Figure 8.27. Relative frequency of sheen by taxonomic group in Profile One

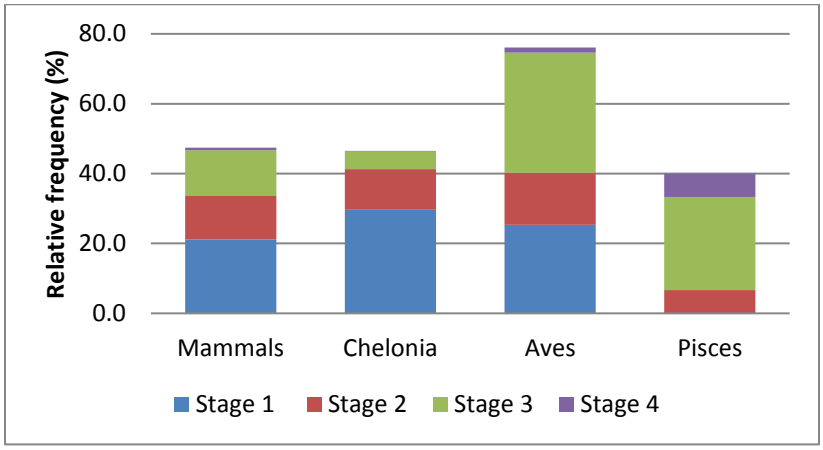


Figure 8.28. Intensity of sheen by taxonomic group in remains from Profile One

Table 8.16. Sheen intensity by spit in Profile One

	Spit 1		Spit 2		Spit 3		Spit 4		Totals	
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Stage 1	140	33	186	27	49	23.4	1	10	**376**	**28.2**
Stage 2	41	9.7	91	13.2	24	11.5	1	10	**157**	**11.8**
Stage 3	35	8.3	41	6	23	11	2	20	**101**	**7.6**
Stage 4	1	0.2	2	0.3	2	1	-	-	**5**	**0.4**
Total	**217**	**51.2**	**320**	**46.4**	**98**	**46.9**	**4**	**40**	**639**	**48**

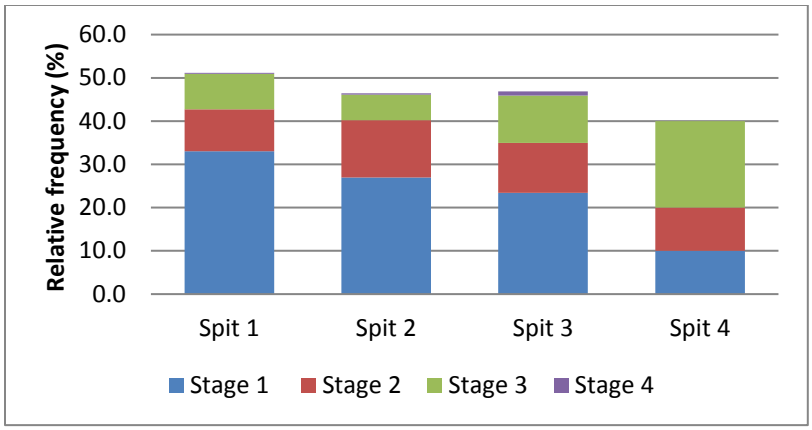


Figure 8.29. Intensity of sheen by spit in Profile One

Table 8.17. Trampling by taxonomic group from Profile One

	Mammals		Chelonia		Aves		Totals	
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Stage 1	24	17.5	329	29.6	16	23.9	**369**	**27.7**
Stage 2	2	1.5	78	7	3	4.5	**83**	**6.2**
Total	**26**	**19**	**407**	**36.6**	**19**	**28.4**	**452**	**33.9**

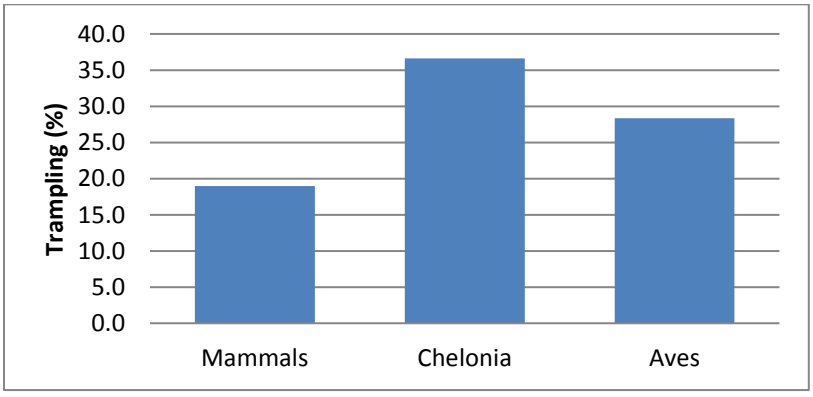


Figure 8.30. Relative frequency of trampling by taxonomic group in Profile One

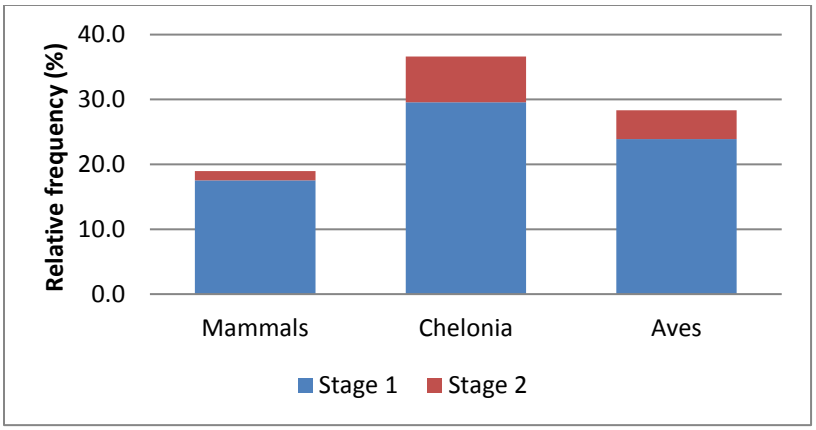


Figure 8.31. Intensity of trampling by taxonomic group from Profile One

Table 8.18. Trampling intensity by spit in remains from Profile One

	Spit 1		Spit 2		Spit 3		Spit 4		Totals	
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Stage 1	149	35.1	166	24.1	52	24.9	2	20	**369**	**27.7**
Stage 2	28	6.6	45	6.5	10	4.8	-	-	**83**	**6.2**
Total	**177**	**41.7**	**211**	**30.6**	**62**	**29.7**	**2**	**20**	**452**	**33.9**

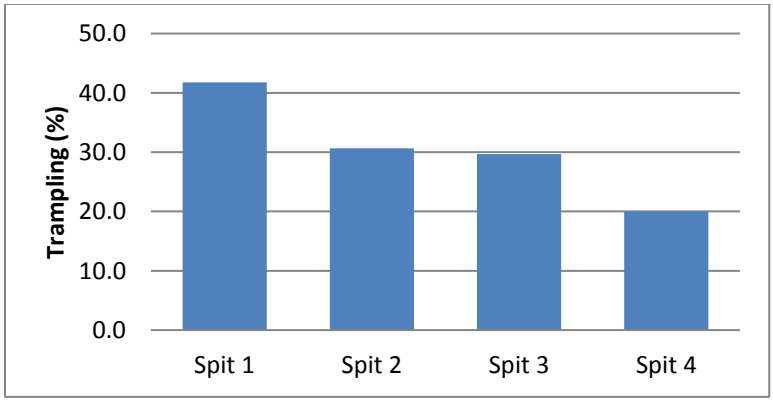


Figure 8.32. Relative frequency of trampling by spit in Profile One

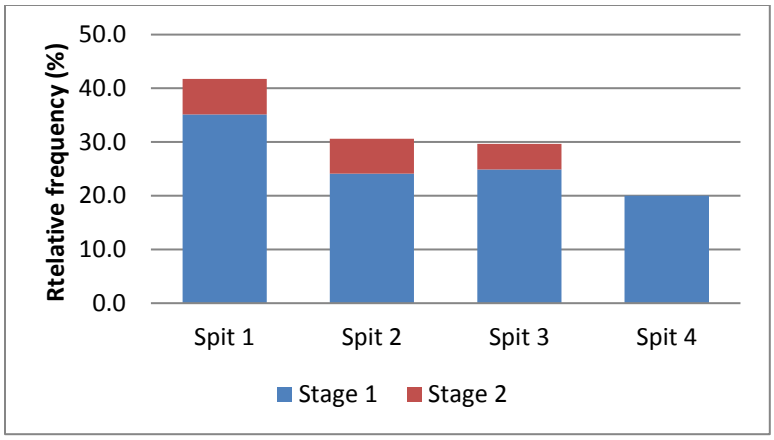


Figure 8.33. Intensity of trampling by spit in Profile One

Table 8.19. Trampling mark type from Profile One

	N	%
Pit	104	21.4
Notch	1	0.2
Score	226	46.6
Scratch	154	31.8
Total	**485**	

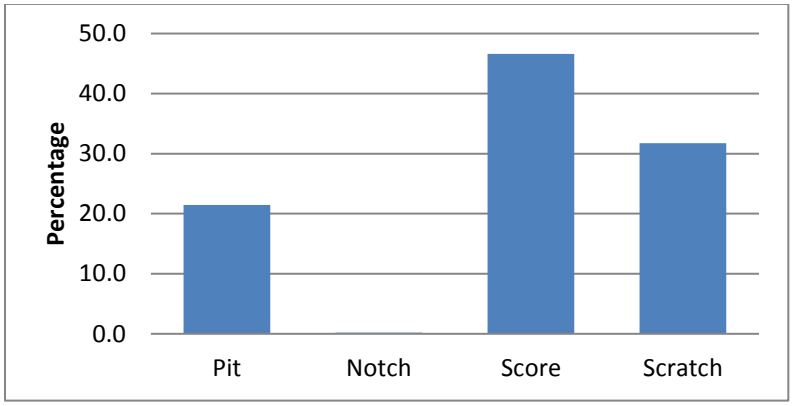


Figure 8.34. Type of trampling mark from Profile One

Table 8.20. Carnvore tooth marks in remains from Profile One

	Mammals		Chelonia		Aves		Pisces		Totals	
	N	%	N	%	N	%	N	%	N	%
Stage 1	2	1.5	40	3.6	4	6	1	6.7	**47**	**3.5**
Stage 2	-	-	9	0.8	-	-	-	-	**9**	**0.7**
Total	**2**	**1.5**	**49**	**4.4**	**4**	**6**	**1**	**6.7**	**56**	**4.2**

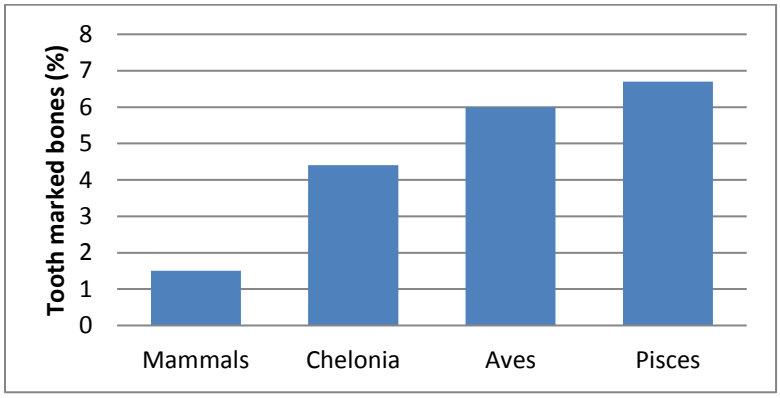


Figure 8.35. Relative frequency of tooth marked bones by taxonomic group form Profile One

Table 8.21. Carnivore tooth marked bone by spit in remains from Profile One

	Spit 1		Spit 2		Spit 3		Totals	
	N	%	N	%	N	%	N	%
Stage 1	15	3.5	22	3.2	10	4.8	**47**	**3.5**
Stage 2	3	0.7	4	0.6	2	1.0	**9**	**0.7**
Total	**18**	**4.2**	**26**	**3.8**	**12**	**5.7**	**56**	

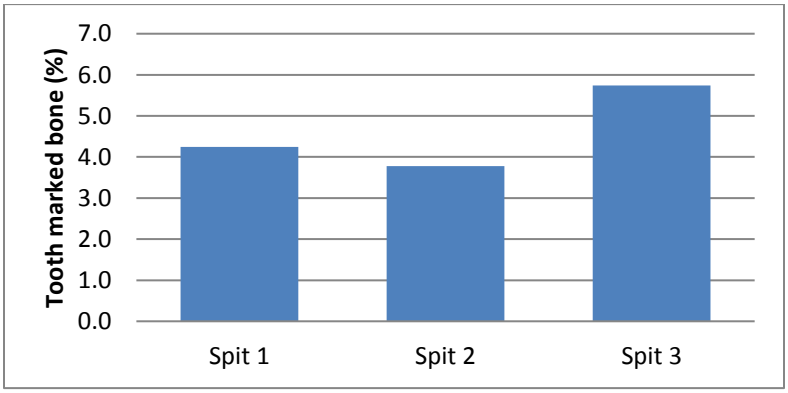


Figure 8.36. Relative frequency of tooth marked bones by spit in Profile One

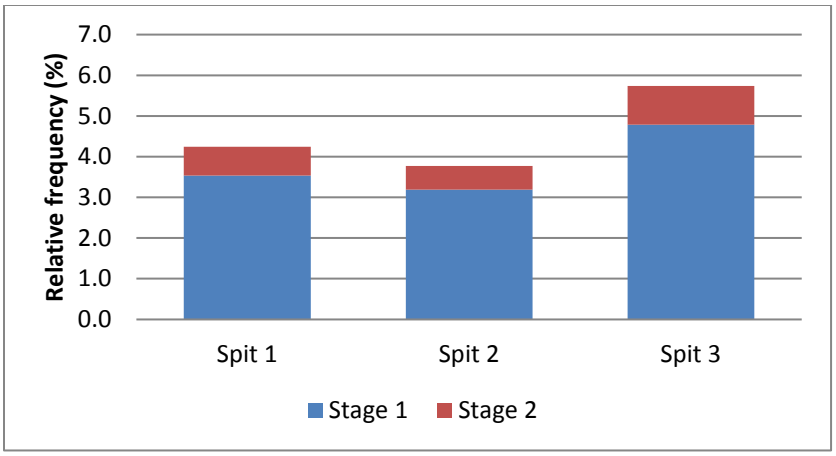


Figure 8.37. Intensity of carnivore marked bones by spit from Profile One

Table 8.22. Type of carnivore tooth marks in Profile One

	N	%
Pit	33	43.4
Puncture	8	10.5
Notch	10	13.2
Score	22	28.9
Furrow	3	3.9
Total	**76**	

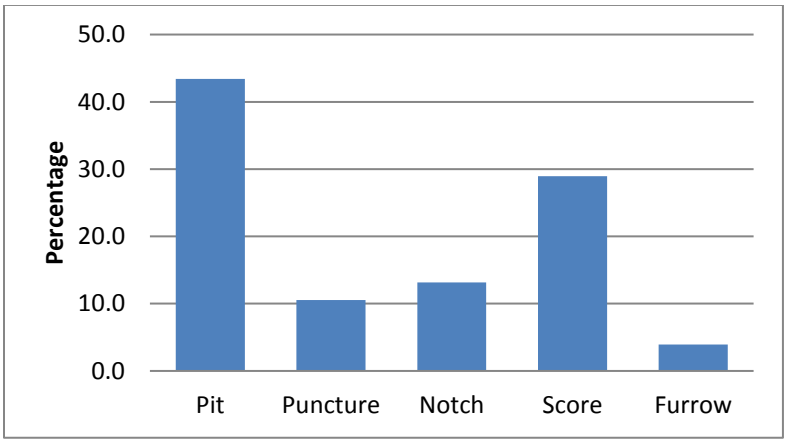


Figure 8.38. Relative frequency of carnivore tooth mark type in Profile One

Table 8.23. Digestive corrosion by taxonomic group in Profile One

	Mammals		Chelonia		Aves		Pisces		Totals	
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Stage 1	6	4.4	17	1.5	3	4.5	1	6.7	**27**	**2**
Stage 2	1	0.7	2	0.2	2	3	-	-	**5**	**0.4**
Stage 3	1	0.7	-	-	-	-	-	-	**1**	**0.1**
Total	**8**	**5.8**	**19**	**1.7**	**5**	**7.5**	**1**	**6.7**	**33**	**2.5**

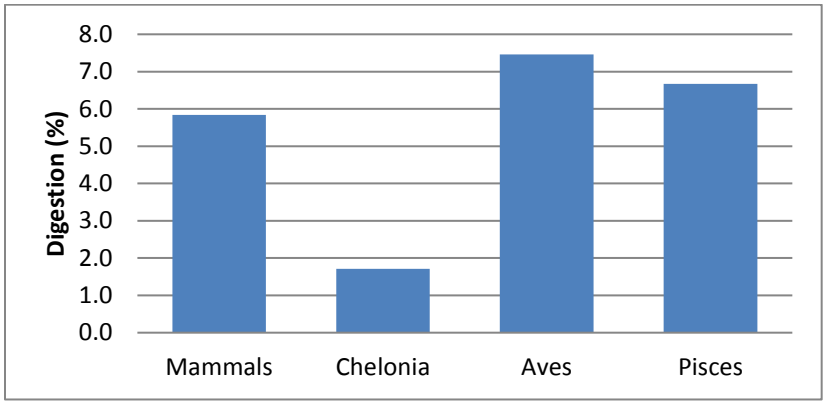


Figure 8.39. Relative frequency of digestive corrosion by taxonomic groups in Profile One

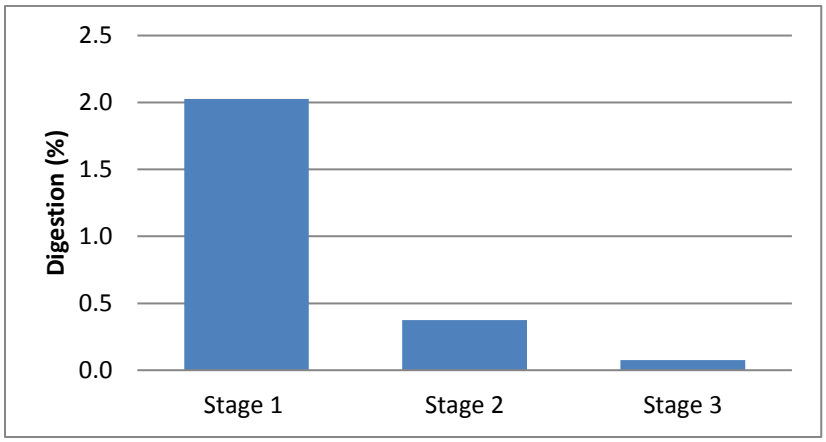


Figure 8.40. Digestive corrosion intensity in remains from Profile One

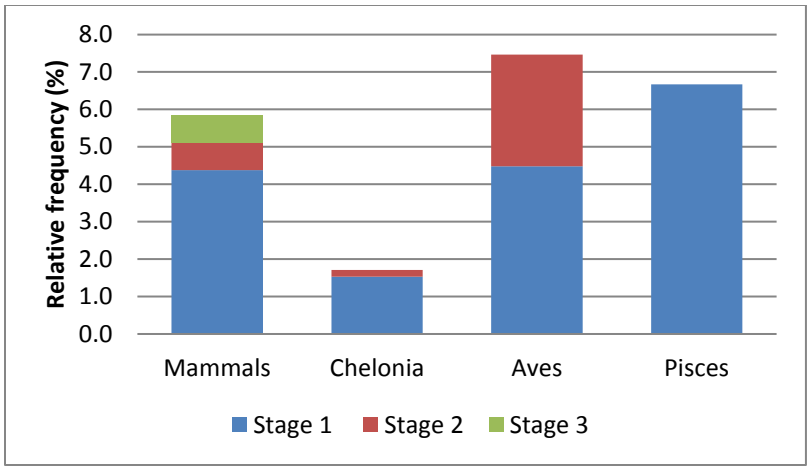


Figure 8.41. Intensity of digestive corrosion by taxonomic group from Profile One

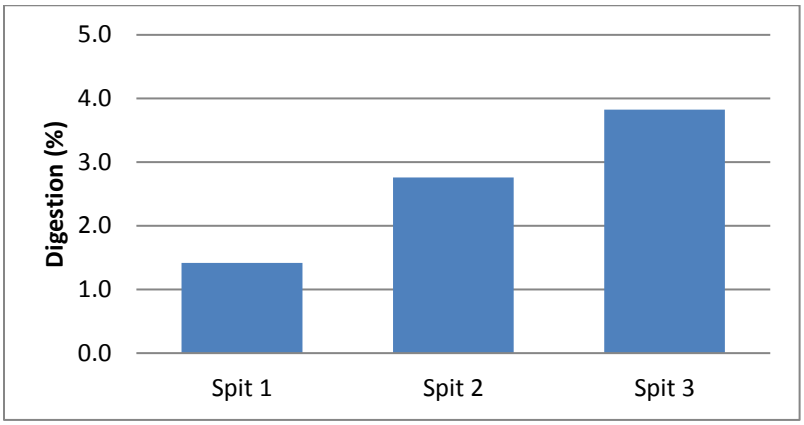


Figure 8.42. Relative frequency of digestive corrosion by spit in Profile One

Table 8.24. Digestive corrosion by spit in Profile One

	Spit 1		Spit 2		Spit 3		Totals	
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Stage 1	4	0.9	17	2.5	6	2.9	**27**	**2**
Stage 2	1	0.2	2	0.3	2	1.0	**5**	**0.4**
Stage 3	1	0.2	-	-	-	-	**1**	**0.1**
Total	**6**	**1.4**	**19**	**2.8**	**8**	**3.8**	**33**	**2.5**

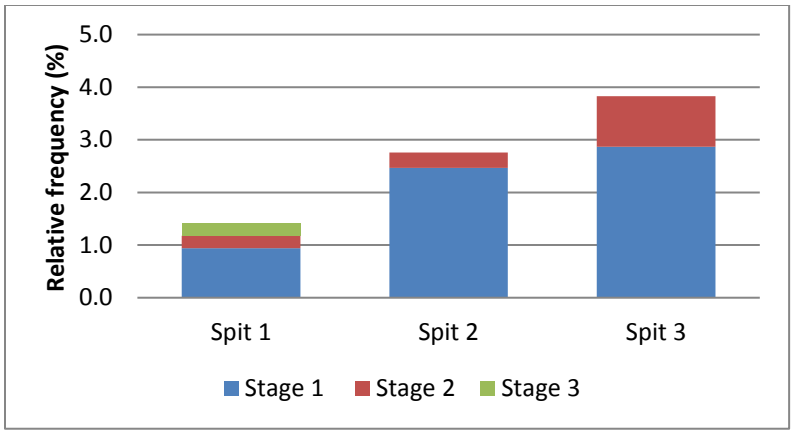


Figure 8.43. Intensity of digestive corrosion by spit in Profile One

Table 8.25. Type of digestive corrosion in remains from Profile One

	Pitting		Surface Etching		Foramen Excavation		Totals	
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Stage 1	17	77.3	14	82.4	1	33.3	**32**	**76.2**
Stage 2	4	18.2	2	11.8	1	33.3	**7**	**16.7**
Stage 3	1	4.5	1	5.9	1	33.3	**3**	**7.1**
Total	**22**	**52.4**	**17**	**40.5**	**3**	**7.1**	**42**	

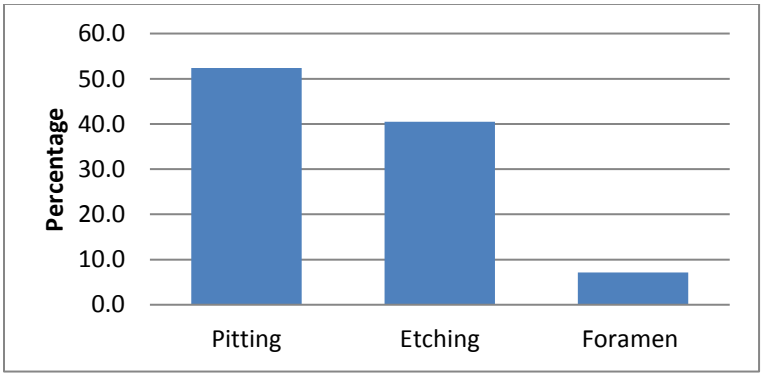


Figure 8.44. Relative frequency of digestive corrosion type in Profile One

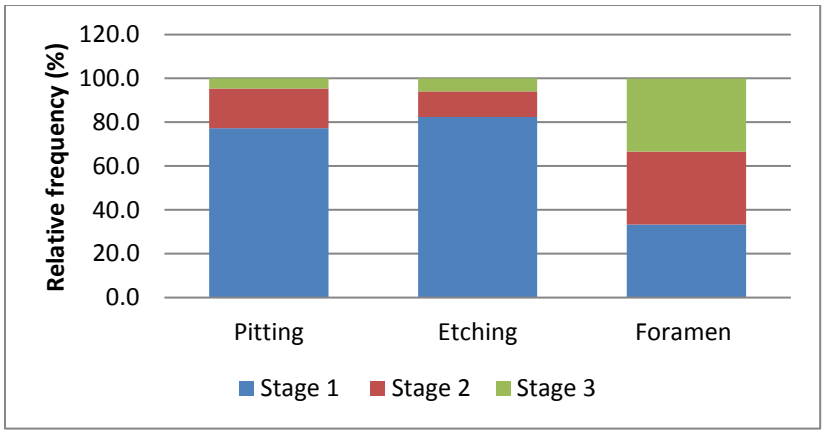


Figure 8.45. Type of digestive corrosion in remains from Profile One

Table 8.26. Root etching in remains from Profile One

	Mammals		Chelonia		Aves		Totals	
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Stage 1	12	8.8	182	16.4	8	11.9	**202**	**15.2**
Stage 2	4	2.9	78	7	2	3	**84**	**6.3**
Stage 3	1	0.7	5	0.4	-	-	**6**	**0.5**
Total	**17**	**12.4**	**265**	**23.8**	**10**	**14.9**	**292**	**21.9**

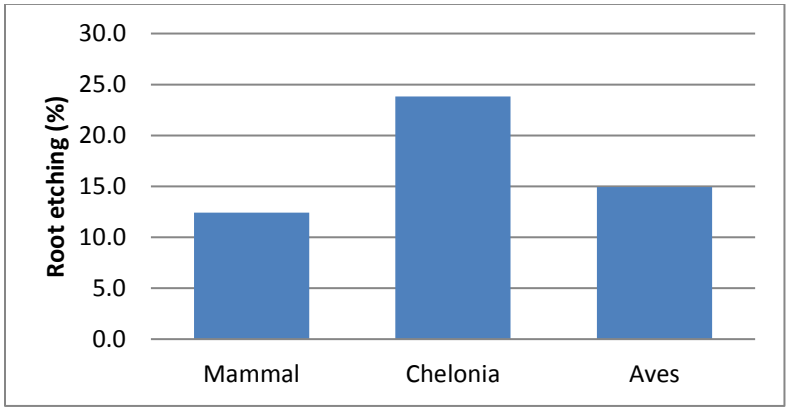


Figure 8.46. Root etching by taxonomic group from Profile One

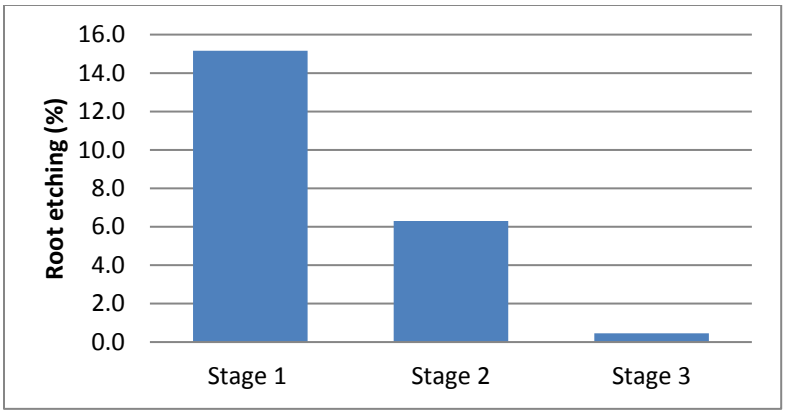


Figure 8.47. Intensity of root etching in remains from Profile One

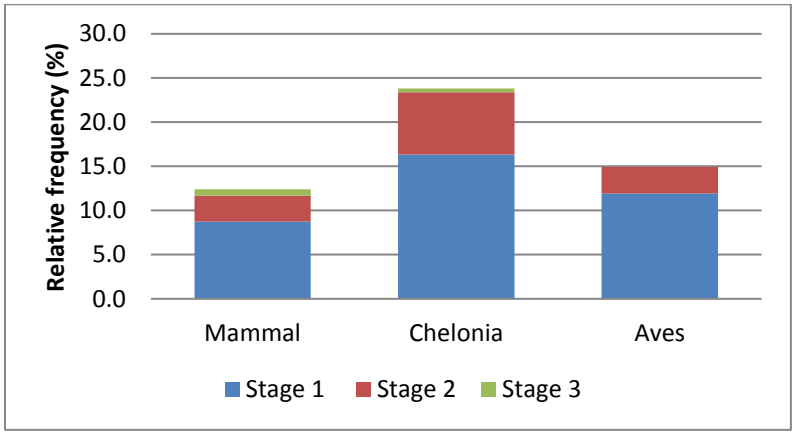


Figure 8.48. Intensity of root etching by taxonomic group from Profile One

Table 8.27. Root etching by spit from Profile One

	Spit 1		Spit 2		Spit 3		Spit 4		Totals	
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Stage 1	110	25.9	76	11	15	7.2	1	10	**202**	**15.2**
Stage 2	47	11.1	30	4.4	7	3.3	-	-	**84**	**6.3**
Stage 3	3	0.7	3	0.4	-	-	-	-	**6**	**0.5**
Total	**160**	**37.7**	**109**	**15.8**	**22**	**10.5**	**1**	**10**	**292**	**21.9**

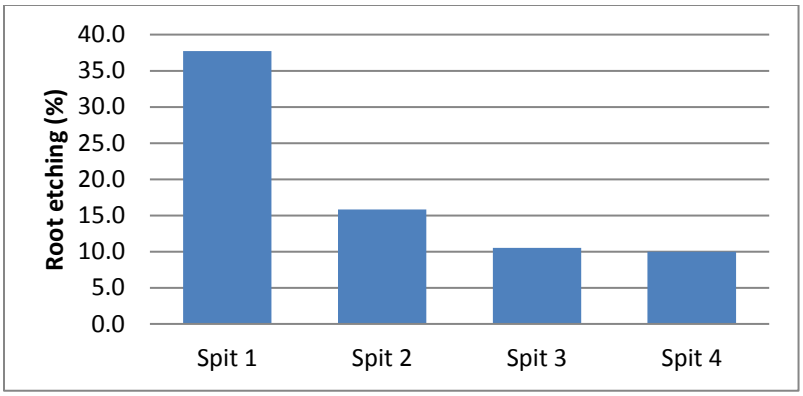


Figure 8.49. Root etching by spit from Profile One

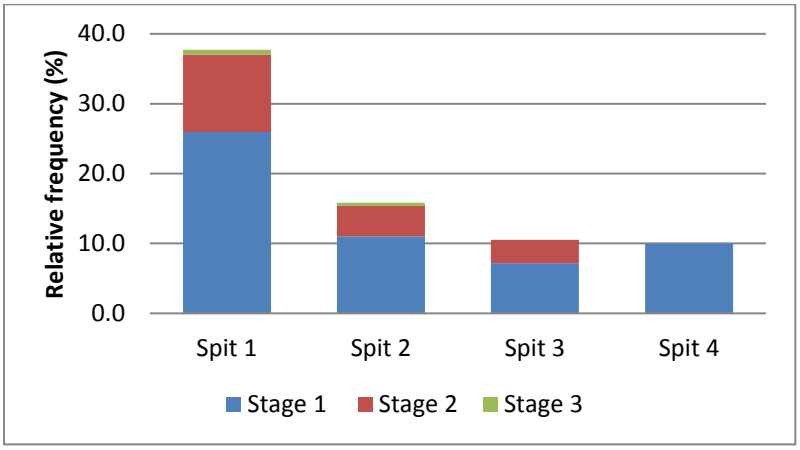


Figure 8.50. Intensity of root etching by spit in remains from Profile One

Table 8.28. Taxonomic composition and body size class in mammal remains from Profile One

		Size Class 1		Size Class 2		Size Class 3		Size Class 4		Size Class 5		Total	
		N	%	N	%	N	%	N	%	N	%	N	%
Bovidae	Bovidae	3	33.3	3	33.3	-	-	3	33.3	-	-	**9**	**6.6**
Carnivora	Felidae	-	-	-	-	2	100	-	-	-	-	**2**	**1.5**
Carnivora	Hyaenidae	-	-	-	-	1	100	-	-	-	-	**1**	**0.7**
Carnivora	aff. Mellivorinae	-	-	1	100	-	-	-	-	-	-	**1**	**0.7**
Carnivora	Indet. Carnivora	2	28.6	4	57.1	1	14.3	-	-	-	-	**7**	**5.1**
Leporidae	aff. Leporidae	5	100	-	-	-	-	-	-	-	-	**5**	**3.6**
Rodentia	Rodentia	1	100	-	-	-	-	-	-	-	-	**1**	**0.7**
	Unid. mammal	23	20.7	33	29.7	31	27.9	19	17.1	5	4.5	**111**	**81**
	Total	**34**	**24.8**	**41**	**29.9**	**35**	**25.5**	**22**	**16.1**	**5**	**3.6**	**137**	

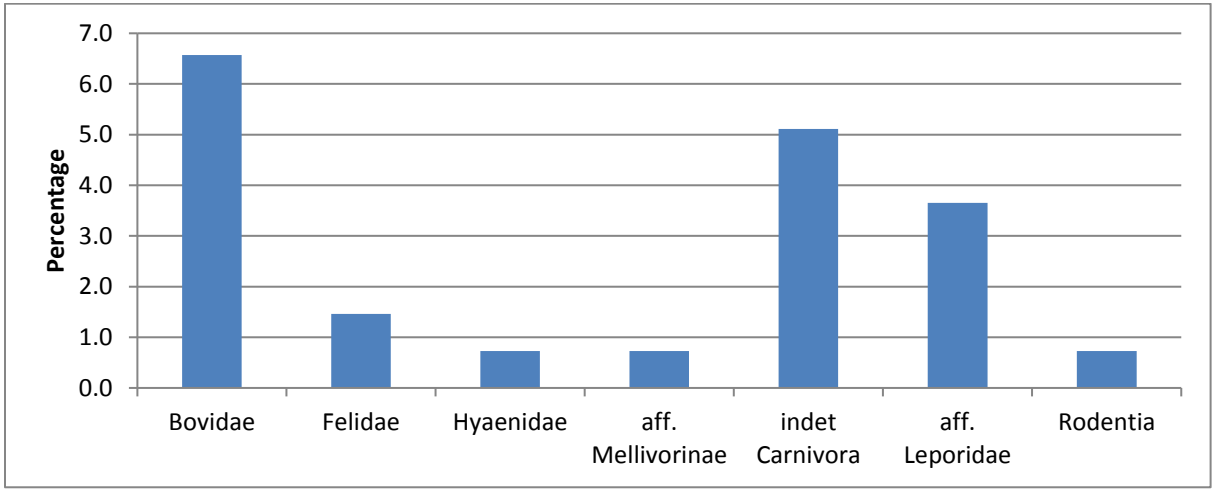


Figure 8.51. Relative frequency of mammalian families from Profile One

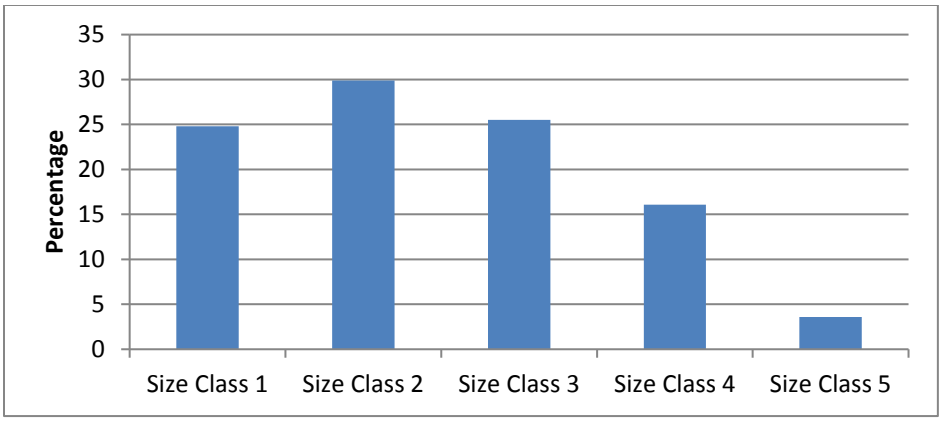


Figure 8.52. Relative frequency of body size class in mammal remains from Profile One

Table 8.29. Mammal representation by spit in Profile One

		Spit1		Spit2		Spit3		Spit4		Total	
		N	%	N	%	N	%	N	%	N	%
Bovidae	Bovidae	3	33.3	4	44.4	2	22.2	-	-	**9**	**6.6**
Carnivora	Felidae	-	-	1	50	1	50	-	-	**2**	**1.5**
Carnivora	Hyaenidae	-	-	1	100	-	-	-	-	**1**	**0.7**
Carnivora	aff. Mellivorinae	-	-	1	100	-	-	-	-	**1**	**0.7**
Carnivora	Indet. Carnivora	2	28.6	2	28.6	3	42.9	-	-	**7**	**5.1**
Leporidae	aff. Leporidae	-	-	4	80	1	20	-	-	**5**	**3.6**
Rodentia	Rodentia	-	-	1	100	-	-	-	-	**1**	**0.7**
	Unid. mammal	27	24.3	48	43.2	35	31.5	1	0.9	**111**	**81**
	Total	**32**	**7.5**	**62**	**9**	**42**	**20.1**	**1**	**10**	**137**	

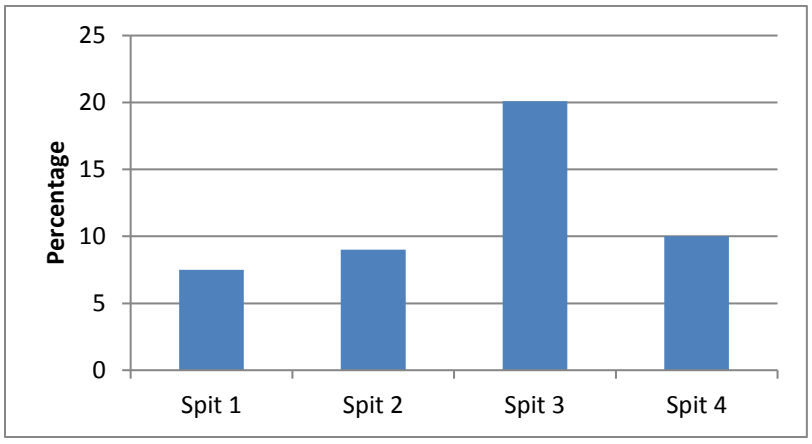


Figure 8.53. Relative frequency of mammals by spit from Profile One

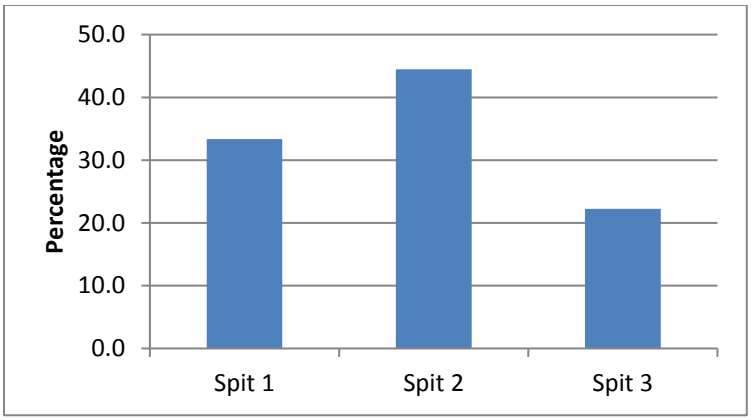


Figure 8.54. Relative frequency of bovid remains by spit in Profile One

Table 8.30. Skeletal frequencies of mammal remains from Profile One

Taxon	Element	NISP	MNE	MAU	%MAU	MNI
Bovidae	Incisor deciduous	1	1	1	50	1
	Premolar	2	2	2	100	2
	Molar	1	1	1	50	1
	Metatarsal	1	1	1	50	1
	Metapodial	1	1	1	50	1
	Proximal phalange	1	1	1	50	1
	Distal Phalange	1	1	1	50	1
	Phalange indet	1	1	1	50	1
	Total	**9**				**2**
Felidae	Innominate	1	1	1	50	1
	Rib	1	1	1	50	1
Hyaenidae	Metacarpal	1	1	1	50	1
aff. Mellivorinae	Metapodial	1	1	1	50	1
Indet. Carnivora	Metatarsal	1	1	1	50	1
	Sesamoid	1	1	1	50	1
	Tarsal	1	1	1	50	1
	Proximal phalange	4	4	2	100	2
	Total	**11**				**3**
Leporidae	Humerus	1	1	1	100	1
	Proximal phalange	3	3	1	100	1
	Total	**4**				**1**
Rodentia	Humerus (Rodent)	1	1	1	100	1
	Distal Phalange	1	1	1	100	1
	Total	**2**				**1**
Unid. Mammal	Cranial Fragment	1	1	1	20	1
	Scapula	1	1	1	20	1
	Humerus	1	1	1	20	1
	Radius	1	1	1	20	1
	Innominate	1	1	1	20	1
	Femur	2	2	2	40	2
	Tibia	2	2	2	40	2
	Metapodial	8	6	2	40	2
	Calcaneous	1	1	1	20	1
	Tarsal	5	5	3	60	3
	Sesamoid	3	3	1	20	1
	Phalange	1	1	1	20	1

	Proximal phalange	4	4	1	20	1
	Thoracic vertebra	1	1	1	20	1
	Caudal vertebra	3	2	2	40	2
	Vertebra	6	5	5	100	5
	Rib	3	1	2	40	2
	Tooth	2	1	1	20	1
	Long bone fragment	65	4	4	80	4
	Total	**111**				**5**

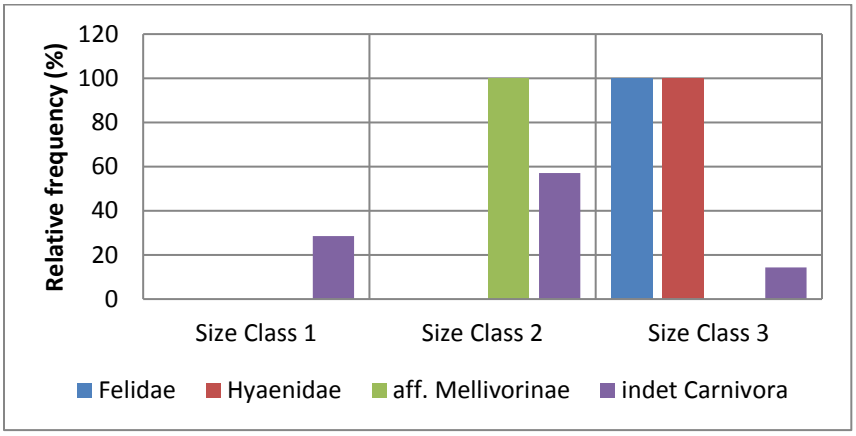


Figure 8.55. Body size class in carnivores from Profile One

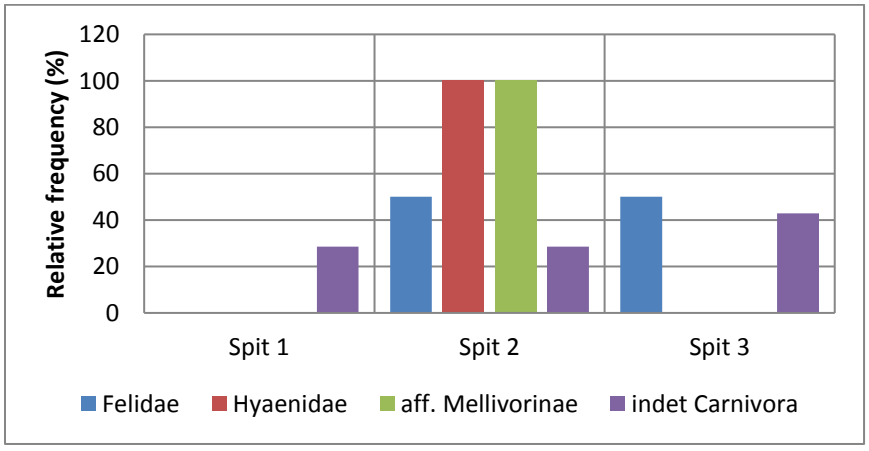


Figure 8.56. Carnivore remains by spit in Profile One

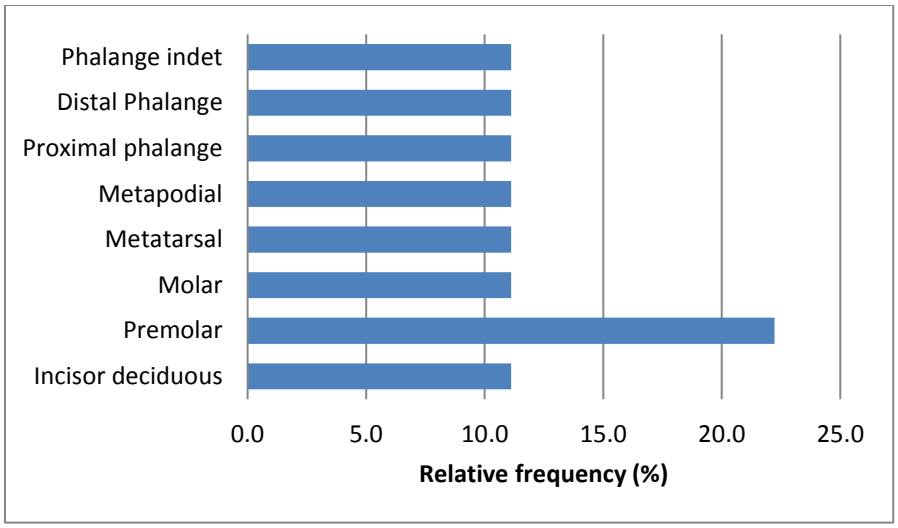


Figure 8.57. Anatomical composition in Bovidae from Profile One

Table 8.31 Anatomical composition and body size in Bovidae from Profile One

	Size Class 1		Size Class 2		Size Class 4		Total	
Element	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Incisor deciduous	-	-	1	100	-	-	**1**	**11.1**
Premolar	-	-	1	50	1	50	**2**	**22.2**
Molar	-	-	-	-	1	100	**1**	**11.1**
Metatarsal	-	-	1	100	-	-	**1**	**11.1**
Metapodial	1	100	-	-	-	-	**1**	**11.1**
Proximal phalange	1	100	-	-	-	-	**1**	**11.1**
Distal Phalange	1	100	-	-	-	-	**1**	**11.1**
Phalange indet.	-	-	-	-	1	100	**1**	**11.1**
Total	**3**	**33.3**	**3**	**33.3**	**3**	**33.3**	**9**	

Table 8.32. Anatomical composition by spit in Bovidae from Profile One

	Spit1		Spit2		Spit3		Total	
Element	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Incisor deciduous	-	-	-	-	1	100	**1**	**11.1**
Premolar	-	-	1	50	1	50	**2**	**22.2**
Molar	1	100	-	-	-	-	**1**	**11.1**
Metatarsal	1	100	-	-	-	-	**1**	**11.1**
Metapodial	1	100	-	-	-	-	**1**	**11.1**
Proximal phalange	-	-	1	100	-	-	**1**	**11.1**
Distal Phalange	-	-	1	100	-	-	**1**	**11.1**
Phalange indet.	-	-	1	100	-	-	**1**	**11.1**
Total	**3**	**0.7**	**4**	**0.6**	**2**	**1**	**9**	

Table 8.32. Anatomical composition and body size in carnivores from Profile One

		Size Class 1		Size Class 2		Size Class 3		Total	
Taxon	**Element**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Felidae	Innominate	-	-	-	-	1	100	**1**	**9.1**
	Rib	-	-	-	-	1	100	**1**	**9.1**
Hyaenidae	Metacarpal	-	-	-	-	1	100	**1**	**9.1**
aff. Mellivorinae	Metapodial	-	-	1	100	-	-	**1**	**9.1**
Indet. Carnivora	Metatarsal	1	100	-	-	-	-	**1**	**9.1**
	Sesamoid	-	-	-	-	1	100	**1**	**9.1**
	Tarsal	-	-	1	100	-	-	**1**	**9.1**
	Proximal phalange	1	25	3	75	-	-	**4**	**36.4**
	Total	**2**	**18.2**	**5**	**45.5**	**4**	**36.4**	**11**	

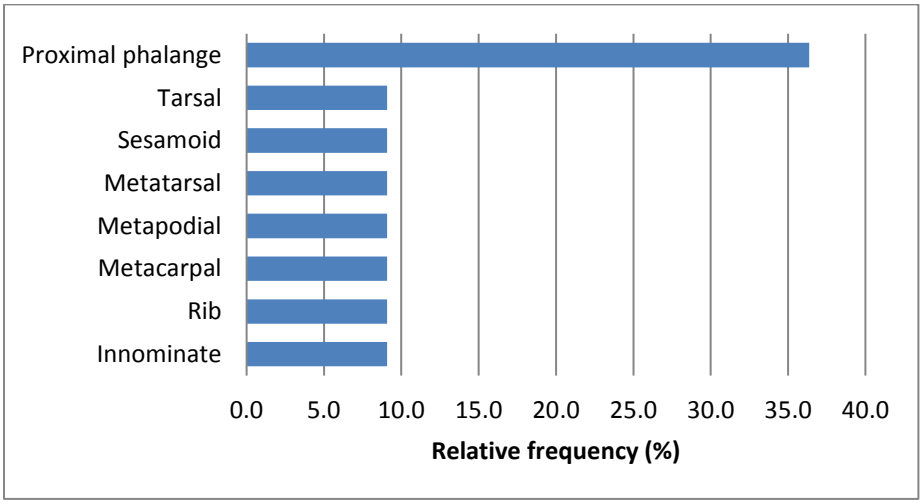


Figure 8.58. Anatomical composition of carnivores in Profile One

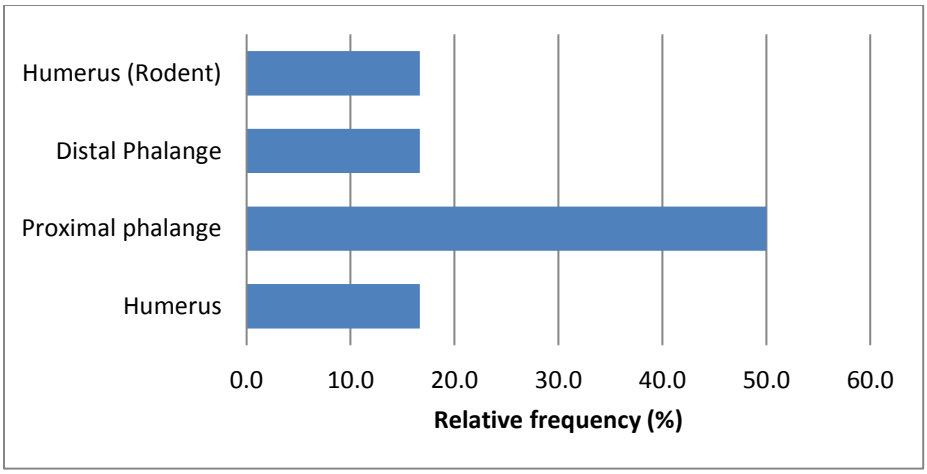


Figure 8.59. Anatomical composition of small mammals from Profile One

Table 8.34. Anatomical composition by spit in small mammals from Profile One

		Spit2		Spit3		Total	
Taxon	**Element**	**N**	**%**	**N**	**%**	**N**	**%**
Leporidae	Humerus	-	-	1	100	**1**	**16.7**
	Proximal phalange	3	100	-	-	**3**	**50**
	Distal Phalange	1	100	-	-	**1**	**16.7**
Rodentia	Humerus	1	100	-	-	**1**	**16.7**
	Total	**5**	**0.7**	**1**	**0.5**	**6**	

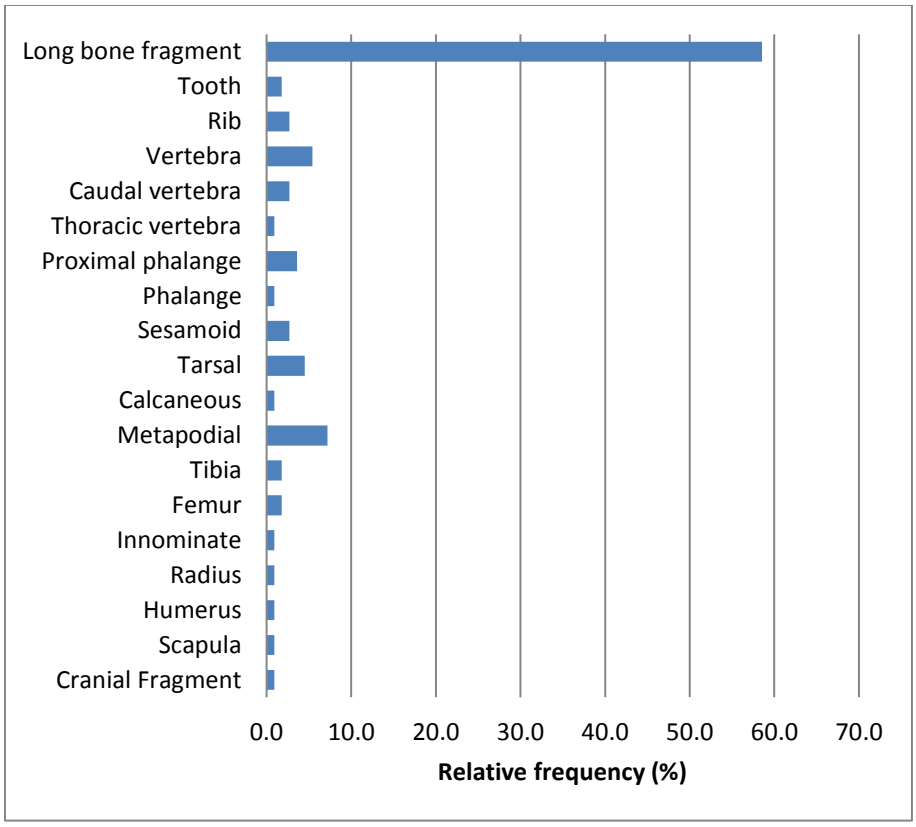


Figure 8.60. Anatomical composition in unidentifiable mammals from Profile One

Table 8.35. Anatomical composition and body size in unidentifiable mammals from Profile One

	Size Class 1		Size Class 2		Size Class 3		Size Class 4		Size Class 5		Total	
Element	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Cranial Fragment	-	-	1	100	-	-	-	-	-	-	**1**	**0.9**
Scapula	1	100	-	-	-	-	-	-	-	-	**1**	**0.9**
Humerus	1	100	-	-	-	-	-	-	-	-	**1**	**0.9**
Radius	-	-	1	100	-	-	-	-	-	-	**1**	**0.9**
Innominate	-	-	1	100	-	-	-	-	-	-	**1**	**0.9**
Femur	1	50	1	50	-	-	-	-	-	-	**2**	**1.8**
Tibia	1	50	1	50	-	-	-	-	-	-	**2**	**1.8**
Metapodial	5	62.5	3	37.5	-	-	-	-	-	-	**8**	**7.2**
Calcaneous	1	100	-	-	-	-	-	-	-	-	**1**	**0.9**
Tarsal	2	40	2	40	1	20	-	-	-	-	**5**	**4.5**
Sesamoid	-	-	3	100	-	-	-	-	-	-	**3**	**2.7**
Phalange	-	-	-	-	-	-	-	-	1	100	**1**	**0.9**
Proximal phalange	4	100	-	-	-	-	-	-	-	-	**4**	**3.6**
Thoracic vertebra	-	-	-	-	1	100	-	-	-	-	**1**	**0.9**
Caudal vertebra	1	33.3	2	66.6	-	-	-	-	-	-	**3**	**2.7**
Vertebra	3	50	1	16.7	1	16.7	1	16.7	-	-	**6**	**5.4**
Rib	-	-	2	66.6	1	33.3	-	-	-	-	**3**	**2.7**
Tooth	-	-	-	-	-	-	2	100	-	-	**2**	**1.8**
Long bone fragment	3	4.6	15	23.1	27	41.5	16	24.6	4	6.2	**65**	**58.6**
Total	**23**	**20.7**	**33**	**29.7**	**31**	**27.9**	**19**	**17.1**	**5**	**4.5**	**111**	

Table 8.36. Anatomical composition by spit in unidentifiable mammals from Profile One

	Spit1		Spit2		Spit3		Spit4		Total	
Element	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Cranial Fragment	-	-	1	100	-	-	-	-	**1**	**0.9**
Scapula	1	100	-	-	-	-	-	-	**1**	**0.9**
Humerus	1	100	-	-	-	-	-	-	**1**	**0.9**
Radius	-	-	-	-	1	100	-	-	**1**	**0.9**
Innominate	1	100	-	-	-	-	-	-	**1**	**0.9**
Femur	1	50	-	-	1	50	-	-	**2**	**1.8**
Tibia	-	-	1	50	1	50	-	-	**2**	**1.8**
Metapodial	4	50	1	12.5	3	37.5	-	-	**8**	**7.2**
Calcaneous	-	-	1	100	-	-	-	-	**1**	**0.9**
Tarsal	3	60	1	20	1	20	-	-	**5**	**4.5**
Sesamoid	2	66.6	1	33.3	-	-	-	-	**3**	**2.7**
Phalange	-	-	1	100	-	-	-	-	**1**	**0.9**
Proximal phalange	1	25	3	75	-	-	-	-	**4**	**3.6**
Thoracic vertebra	1	100	-	-	-	-	-	-	**1**	**0.9**
Caudal vertebra	1	33.3	1	33.3	1	33.3	-	-	**3**	**2.7**
Vertebra	1	16.7	3	50	2	33.3	-	-	**6**	**5.4**
Rib	-	-	1	33.3	1	33.3	1	33.3	**3**	**2.7**
Tooth	-	-	-	-	2	100	-	-	**2**	**1.8**
Long bone fragment	10	15.4	33	50.8	22	33.8	-	-	**65**	**58.6**
Total	**27**	**6.4**	**48**	**7**	**35**	**16.7**	**1**	**10**	**111**	

Table 8.37. Descriptive Statistics of maximum length in mammal remains from Profile One

	Combined	Size Class 1	Size Class 2	Size Class 3	Size Class 4	Size Class 5
N	137	34	41	35	22	5
Minimum	3	6	3	12	19	32
Maximum	63	25	54	49	41	63
Mean	21.7	18.4	25.5	29.3	20.8	45.4
Standard Deviation	10.76	9.86	8.16	6.74	9.69	11.55

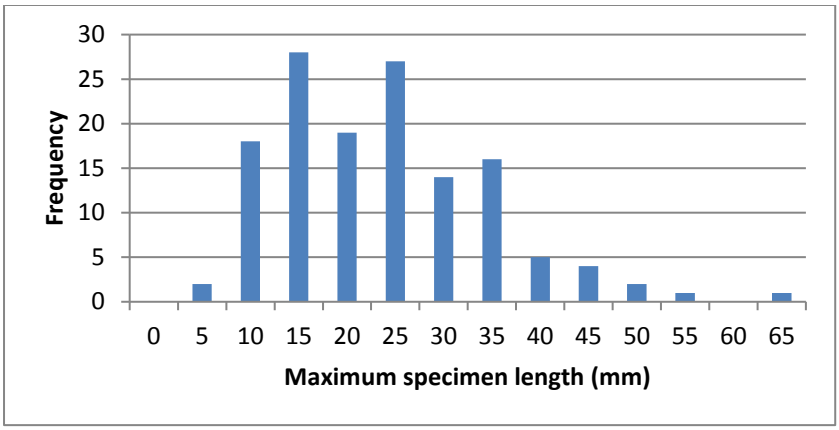


Figure 8.61. Histogram of maximum length in combined mammal assemblage from Profile One

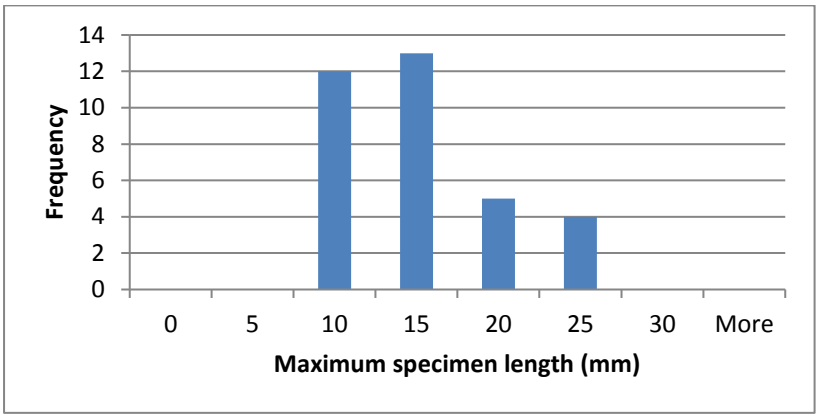


Figure 8.62. Histogram of maximum length in size class one mammals from Profile One

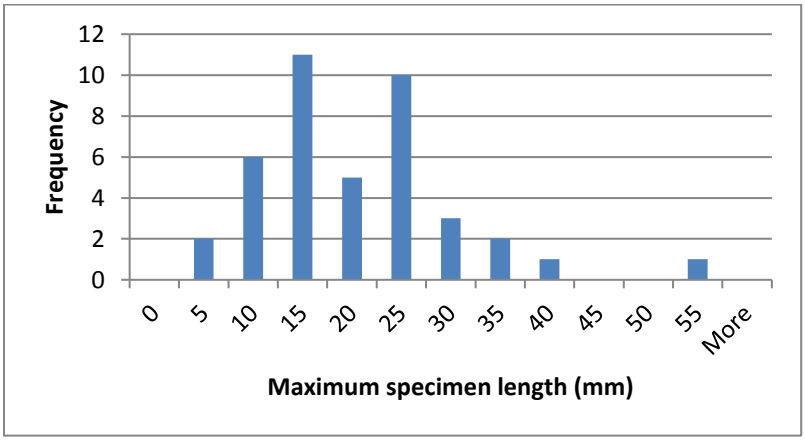


Figure 8.63. Histogram of maximum length in size class two mammals from Profile One

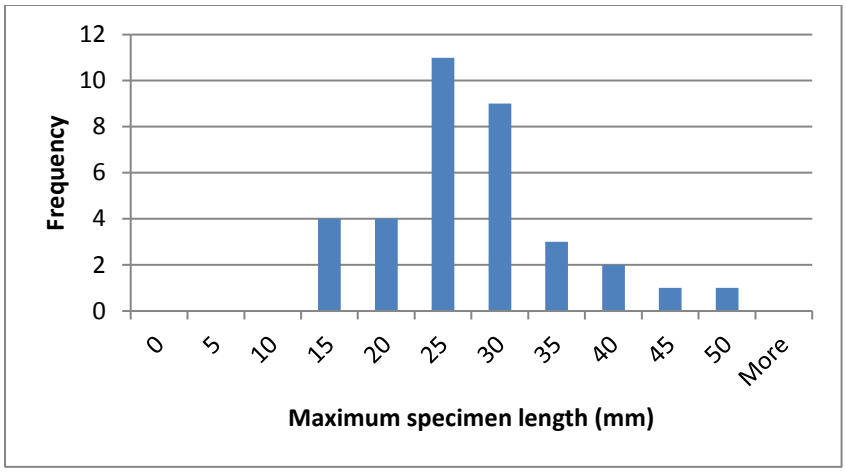


Figure 8.64. Histogram of maximum length in size class three mammals from Profile One

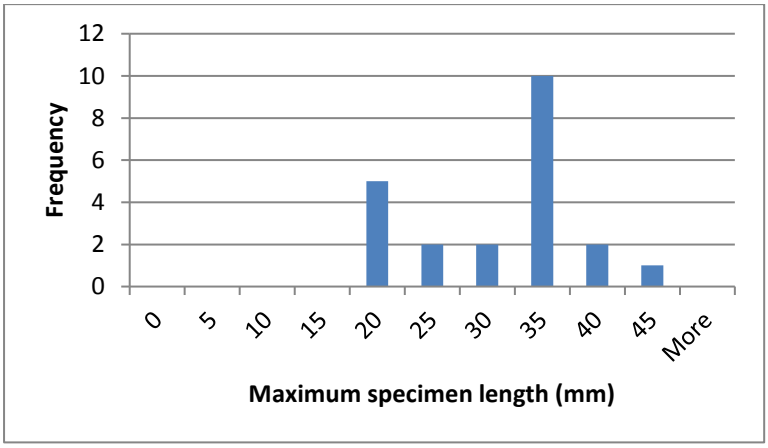


Figure 8.65. Histogram of maximum length in size class four mammals from Profile One

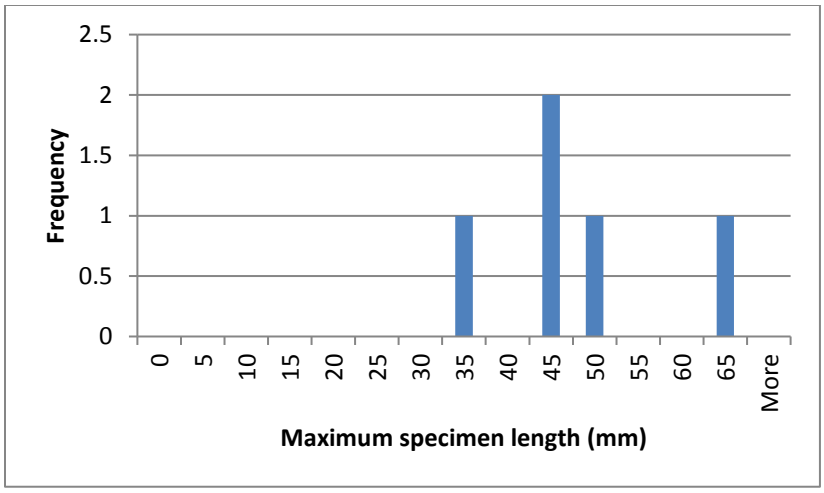


Figure 8.66. Histogram of maximum length in size class five mammals from Profile One

Table 8.38. Epiphyseal fusion in mammal remains from Profile One

	Size class 1		Size class 2		Size class 3		Size class 4		Size class 5		Total	
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Adult	16	64	6	24	1	4	2	8	-	-	**25**	**75.8**
Subadult	2	50	1	25	-	-	-	-	1	25	**4**	**12.1**
Juvenile	3	75	-	-	1	25	-	-	-	-	**4**	**12.1**
Total	**21**	**63.6**	**7**	**21.2**	**2**	**6.1**	**2**	**6.1**	**1**	**3**	**33**	**24.1**

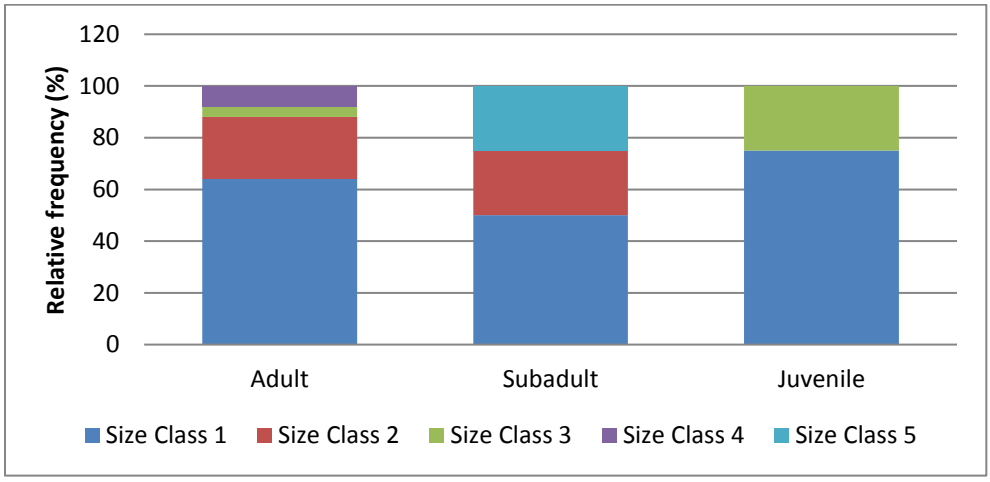


Figure 8.67. Epiphseal fusion and body size in mammal remains from Profile One

Table 8.39. Completeness and element in mammal remains from Profile One

		Size Class 1		Size Class 2		Size Class 3		Total	
Family	Element	N	%	N	%	N	%	N	%
Bovidae	Premolar	-	-	1	100	-	-	**1**	**3.8**
aff. Mellivorinae	Metapodial	-	-	1	100	-	-	**1**	**3.8**
Indet. Carnivora	Proximal Phalange	1	25	3	75	-	-	**4**	**15.4**
	Metatarsal	1	-	-	-	-	-	**1**	**3.8**
	Tarsal/carpal	-	-	1	100	-	-	**1**	**3.8**
aff. Leporidae	Proximal Phalange	2	100	-	-	-	-	**2**	**7.7**
	Distal phalange	1	100	-	-	-	-	**1**	**3.8**
Rodentia	Humerus	1	100	-	-	-	-	**1**	**3.8**
Unid. mammal	Proximal Phalange	4	100	-	-	-	-	**4**	**15.4**
	Metapodial	2	100	-	-	-	-	**2**	**7.7**
	Sesamoid	-	-	2	100	-	-	**2**	**7.7**
	Tarsal/carpal	2	40	2	40	1	20	**5**	**19.2**
	Caudal vertebra	-	-	1	100	-	-	**1**	**3.8**
Total		**14**	**53.8**	**11**	**42.3**	**1**	**3.8**	**26**	**19**

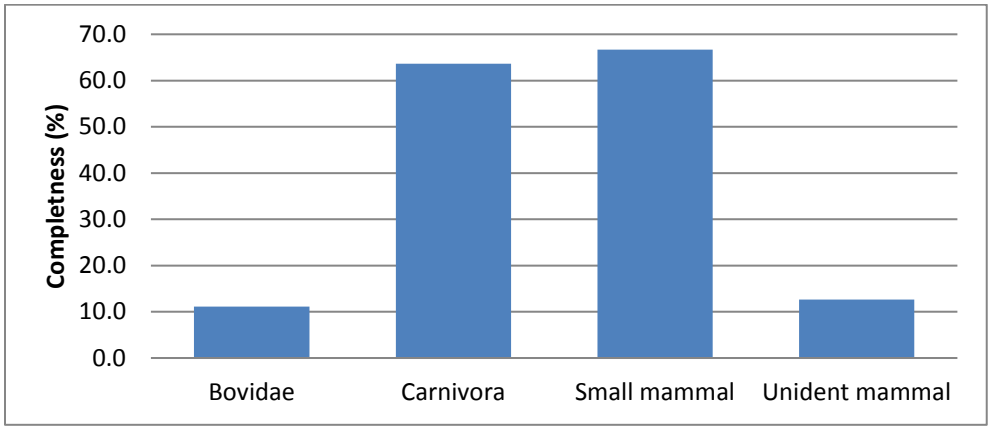


Figure 8.68. Relative percentage of complete bones in mammal families from Profile One



Figure 8.69. Completeness and body size class in mammals from Profile One

Table 8.40. Completeness and element by spit in mammal remains from Profile One

		Spit1		Spit2		Spit3		Total	
Family	Element	N	%	N	%	N	%	N	%
Bovidae	Premolar	-	-	1	100	-	-	**1**	**3.8**
aff. Mellivorinae	Metapodial	-	-	1	100	-	-	**1**	**3.8**
Indet.. Carnivora	Proximal Phalange	2	50	1	25	1	25	**4**	**15.4**
	Metatarsal	-	-	-	-	1	100	**1**	**3.8**
	Tarsal/carpal	-	-	-	-	1	100	**1**	**3.8**
aff. Leporidae	Proximal Phalange	-	-	2	100	-	-	**2**	**7.7**
	Distal phalange	-	-	1	100	-	-	**1**	**3.8**
Rodentia	Humerus	-	-	1	100	-	-	**1**	**3.8**
Unid mammal	Proximal Phalange	1	25	3	75	-	-	**4**	**15.4**
	Metapodial	-	-	1	5	1	50	**2**	**7.7**
	Sesamoid	1	50	1	50	-	-	**2**	**7.7**
	Tarsal/carpal	3	60	1	20	1	20	**5**	**19.2**
	Caudal vertebra	1	100	-	-	-	-	**1**	**3.8**
Total		**8**	**1.9**	**13**	**1.9**	**5**	**2.4**	**26**	**19**

Table 8.41. Breakage categories in mammal remains from Profile One

	Complete		Proximal		Shaft		Distal	
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Humerus	1	33.3	1	33.3	-	-	1	33.3
Radius	-	-	-	-	1	100	-	-
Femur	-	-	2	100	-	-	-	-
Tibia	-	-	1	50	1	50	-	-
Metapodial	4	33.3	3	25.0	4	33.3	1	8.3
Phalange	8	61.5	2	15.4	1	7.7	2	15.4
Long bone fragment	-	-	-	-	65	100	-	-
Total	**13**	**13.3**	**9**	**9.2**	**72**	**73.5**	**4**	**4.1**

	Complete		Centrum		Epiphysis		Spinous Process		Fragment	
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Vertebra	1	10	4	40	2	20	1	10	2	20

	Glenoid		Blade	
	N	**%**	**N**	**%**
Scapula	-	-	1	100

	Ilium		Ischium	
	N	**%**	**N**	**%**
Innominate	1	50	1	50

	Complete		Fragment	
	N	**%**	**N**	**%**
Rib	-	-	4	100
Sesamoid	2	50	2	50
Tarsal/carpal	6	85.7	1	14.3
Cranium	-	-	1	100
Dentition	1	16.7	5	83.3

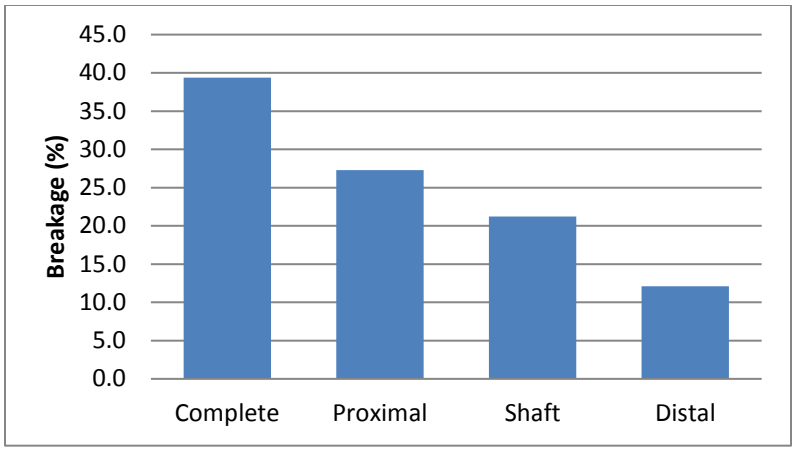


Figure 8.70. Breakage categories in long bones from mammals in Profile One

Table 8.42. Fracture Outline and body size class in mammal remains from Profile One

	Spiral (fresh)		Transverse (dry)		Splintered		Eroded		Irregular		Total	
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Size Class 1	13	24.1	4	7.4	-	-	-	-	-	-	**17**	**31.5**
Size Class 2	33	63.5	6	11.5	2	3.8	-	-	1	1.9	**42**	**80.8**
Size Class 3	43	77	8	14	3	5	2	4	-	-	**56**	**100**
Size Class 4	25	73.5	4	11.8	2	5.9	-	-	-	-	**31**	**91.2**
Size Class 5	7	70	1	10	-	-	1	10	-	-	**9**	**90**
Total	**121**	**77.6**	**23**	**14.7**	**7**	**4.5**	**3**	**1.9**	**1**	**0.6**	**155**	**75.2**

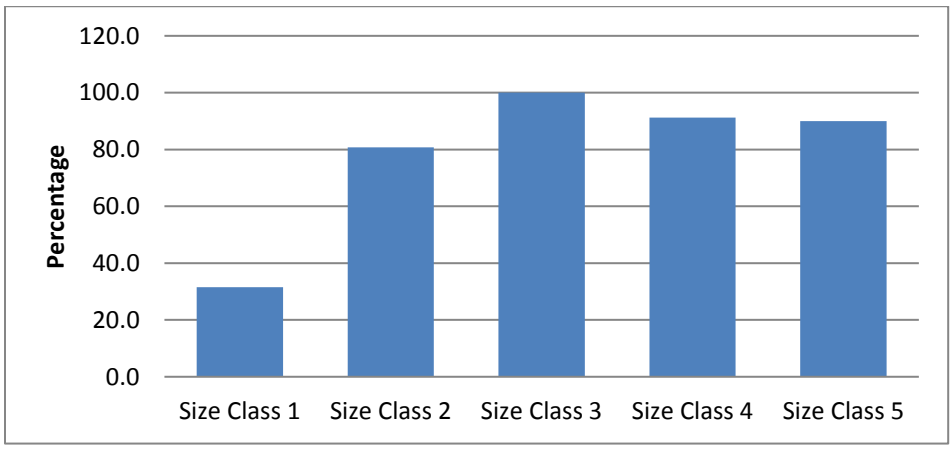


Figure 8.71. Relative frequency of long bone fractures with body size class in mammals from Profile One

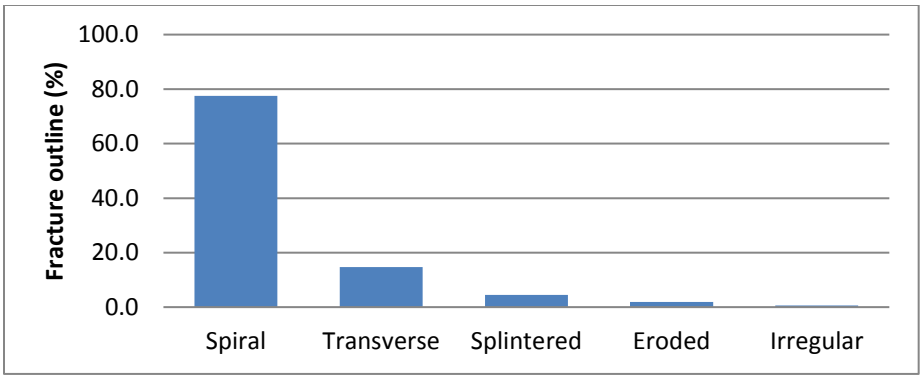


Figure 8.72. Relative frequency of fracture outline type in mammal remains from Profile One

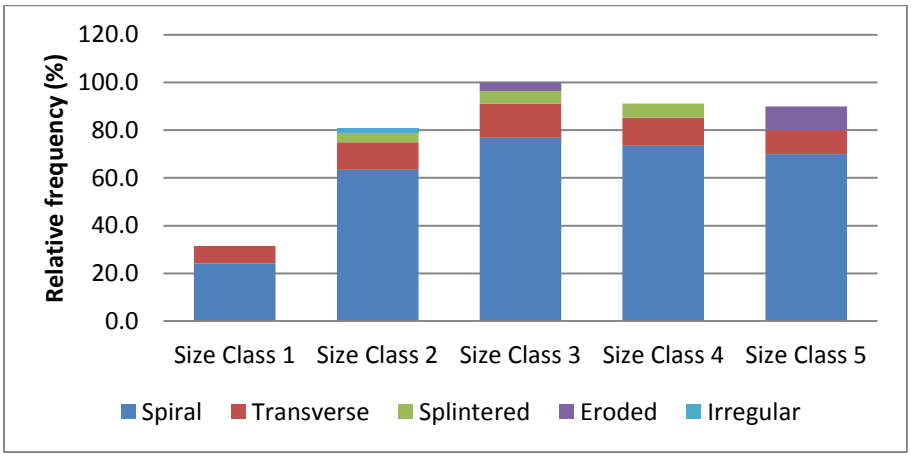


Figure 8.73. Fracture outline type with body size class in mammal remains from Profile One

Table 8.43. Fracture outline by spit in mammal remains from Profile One

	Spiral (fresh)		Transverse (dry)		Splintered		Eroded		Irregular		Total	
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Spit 1	27	64.3	2	4.8	1	2.4	-	-	1	2.4	**31**	**73.8**
Spit 2	54	54	12	12	2	2	3	3	-	-	**71**	**71**
Spit 3	41	66.1	9	14.5	4	6.5	-	-	-	-	**54**	**87.1**
Total	**122**	**78.2**	**23**	**14.7**	**7**	**4.5**	**3**	**1.9**	**1**	**0.6**	**156**	**75.7**

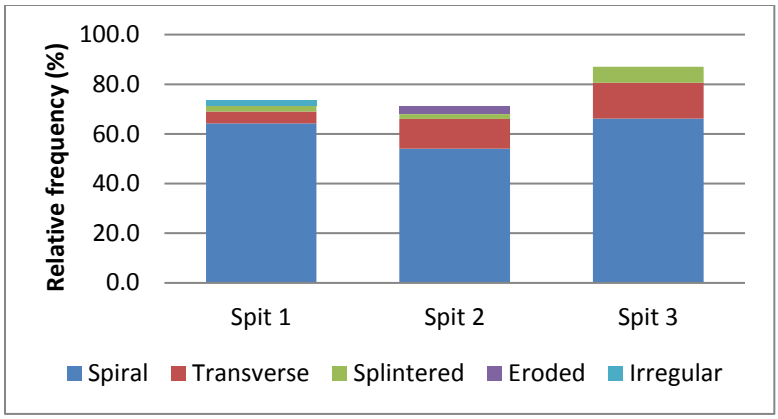


Figure 8.74. Fracture outline type by spit in mammal remains from Profile One

Table 8.44. Fracture angle in mammal remains from Profile One

	Oblique		Right		Mixed		Total	
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Size Class 1	7	13	6	11.1	4	7.4	**17**	**31.5**
Size Class 2	11	21.2	7	13.5	9	17.3	**27**	**51.9**
Size Class 3	12	21	12	21	13	23	**37**	**66**
Size Class 4	6	17.6	9	26.5	13	38.2	**28**	**82.4**
Size Class 5	4	40	-	-	2	20	**6**	**60**
Total	**40**	**29.4**	**34**	**25**	**41**	**30.1**	**115**	**55.8**

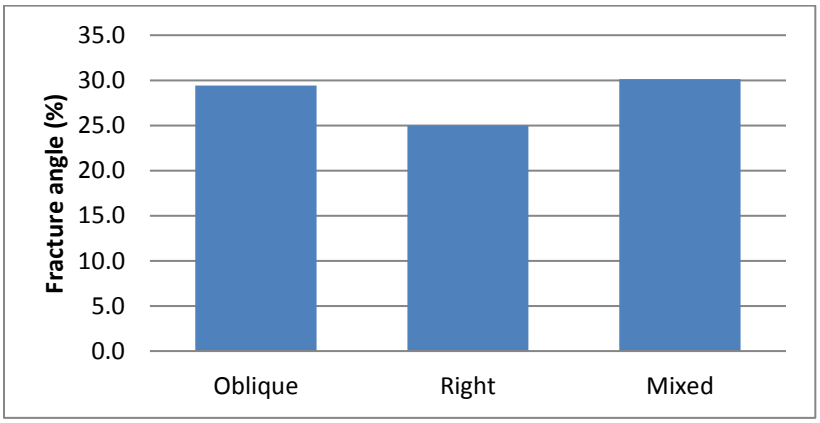


Figure 8.75. Relative frequency of fracture angle type in mammal remains from Profile One



Figure 8.76. Fracture angle with body size class in mammal remains from Profile One

Table 8.45. Fracture angle by spit in mammal remains from Profile One

	Oblique		Right		Mixed		Total	
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Spit 1	6	14.3	9	21.4	7	16.7	**22**	**52.4**
Spit 2	20	20	16	16	18	18	**54**	**54**
Spit 3	14	23	9	14.5	16	25.8	**39**	**62.9**
Spit 4	-	-	-	-	-	-	**-**	**-**
Total	**40**	**19.4**	**34**	**16.5**	**41**	**19.9**	**115**	**56**

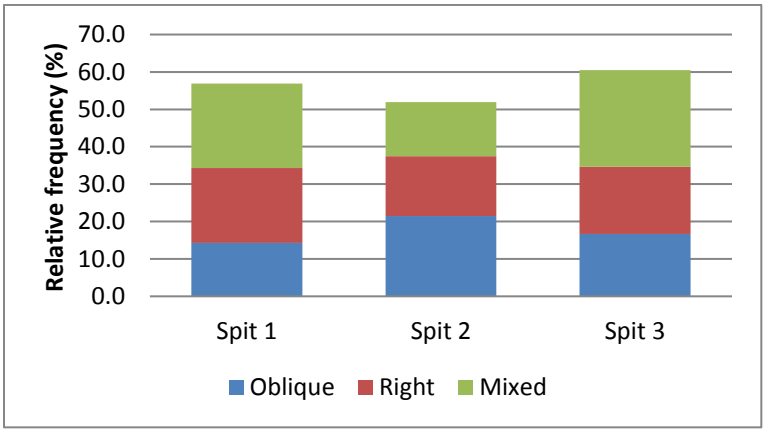


Figure 8.77. Fracture angle by spit in mammal remains from Profile One

Table 8.46. Weathering in mammal families from Profile One

	Bovid		Carnivore		Mammal unid		Total	
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Stage 1	3	33.3	2	18.2	11	9.9	**16**	**11.7**
Stage 2	-	-	-	-	5	4.5	**5**	**3.6**
Total	**3**	**33.3**	**2**	**18.2**	**16**	**14.4**	**21**	**15.3**

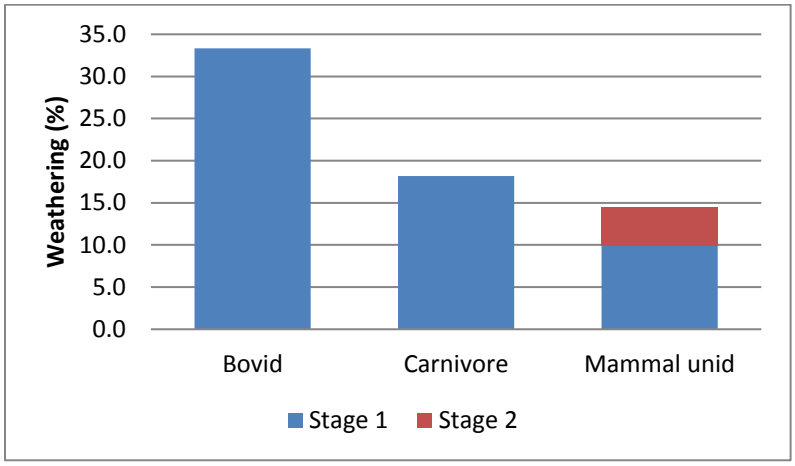


Figure 8.78. Weathering intensity in mammal families from Profile One

Table 8.47. Burning in mammal remains from Profile One

	Small mammals		Mammal unid		Total	
	N	**%**	**N**	**%**	**N**	**%**
Stage 2	1	16.7	5	**4.5**	**6**	**4.4**
Stage 3	-	-	3	**2.7**	**3**	**2.2**
Total	**1**	**16.7**	**8**	**7.2**	**9**	**6.6**

Table 8.48. Staining in mammal families from Profile One

	Bovid		Carnivore		Small mammals		Mammal unid		Total	
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Stage 1	-	-	3	27.3	2	33.3	56	50.5	**61**	**44.5**
Stage 2	2	22.2	4	36.4	2	33.3	17	15.3	**25**	**18.2**
Stage 3	6	66.7	3	27.3	1	16.7	17	15.3	**27**	**19.7**
Totals	**8**	**88.9**	**10**	**90.9**	**5**	**83.3**	**90**	**81.1**	**113**	**82.5**

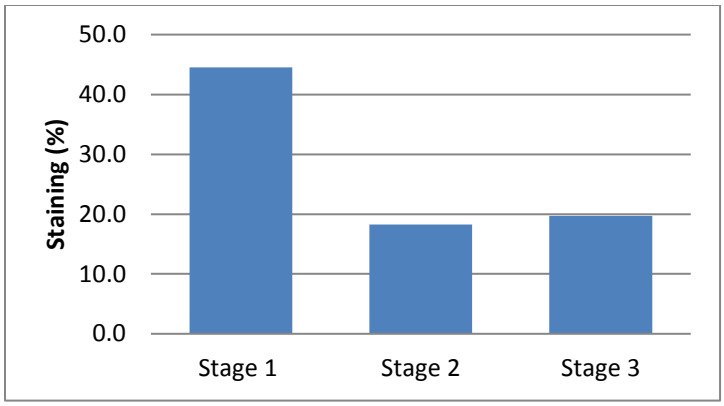


Figure 8.79. Staining intensity in mammal remains from Profile One

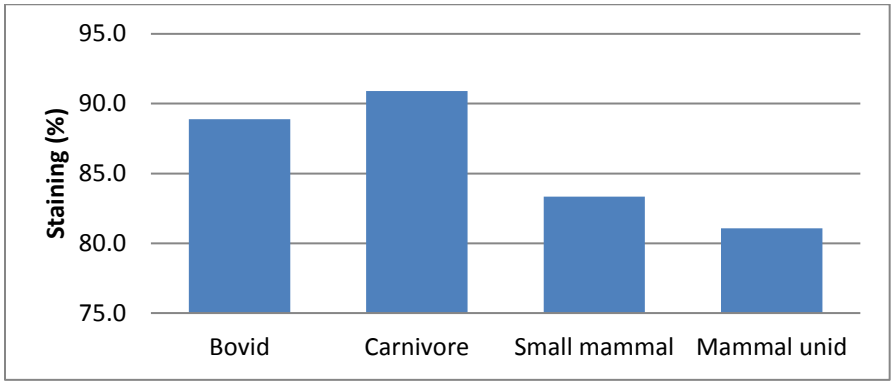


Figure 8.80. Relative frequency of staining in mammals from Profile One

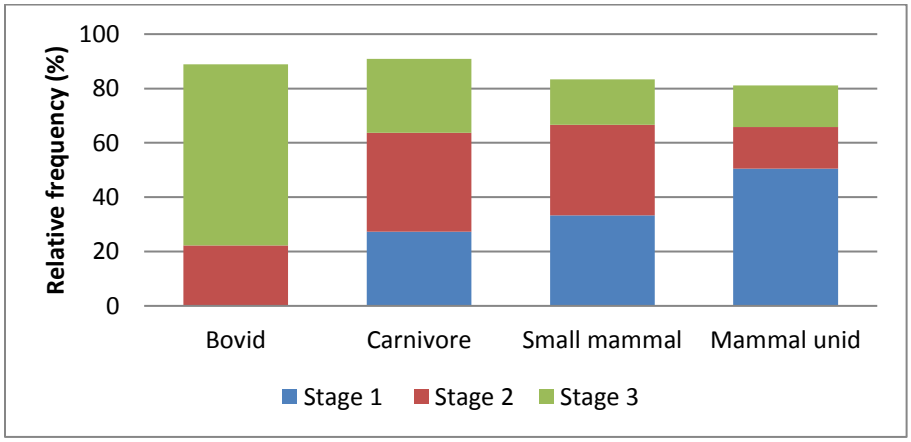


Figure 8.81. Intensity of staining in mammal families from Profile One

Table 8.49. Staining colour in mammal families from Profile One

	Brown		Purple		Black		Total	
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Bovid	8	7.8	-	-	-	-	**8**	**7.1**
Carnivore	9	8.7	-	-	-	-	**9**	**8**
Small mammals	5	4.9	-	-	-	-	**5**	**4.5**
Mammal unid.	81	78.6	1	100	8	100	**90**	**80.4**
Totals	**103**	**92**	**1**	**0.9**	**8**	**7.1**	**112**	

Table 8.50. Abrasion in mammal families from Profile One

	Bovid		Carnivore		Small mammal		Mammal unid		Total	
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Stage 1	5	55.6	6	54.5	3	50	36	32.4	**47**	**34.3**
Stage 2	2	22.2	-	-	-	-	20	18	**22**	**16.1**
Stage 3	-	-	-	-	-	-	20	18	**20**	**14.6**
Stage 4	-	-	-	-	-	-	16	14.4	**16**	**11.7**
Total	**7**	**77.8**	**6**	**54.5**	**3**	**50**	**92**	**82.9**	**105**	**76.6**

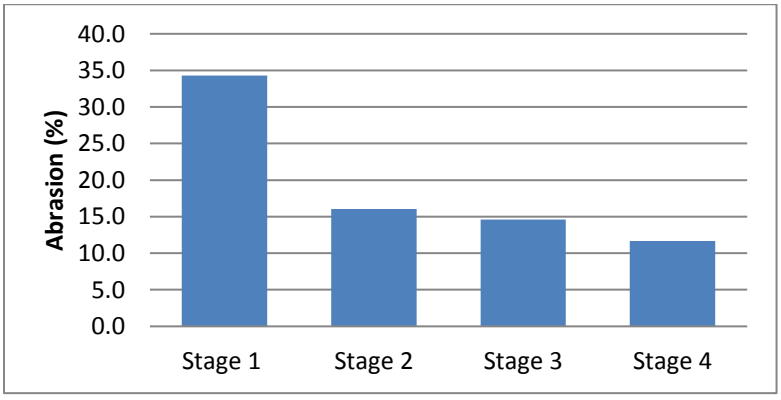


Figure 8.82. Abrasion intensity in mammal remains from Profile One

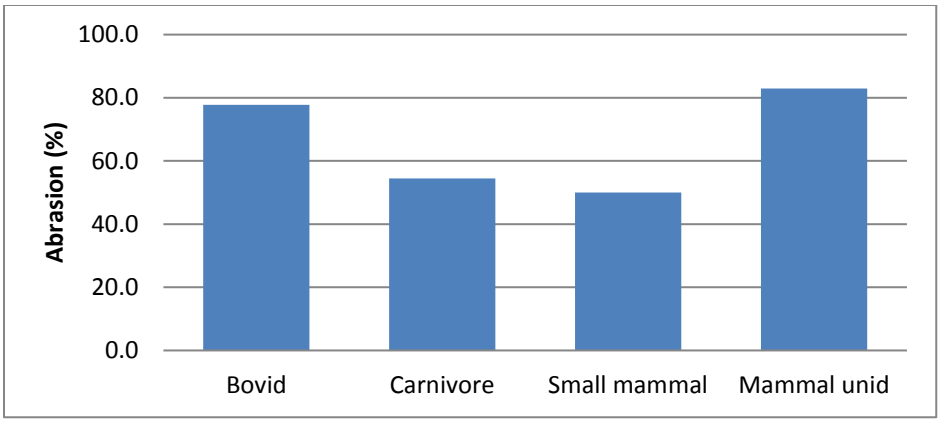


Figure 8.83. Relative frequency of abrasion in mammal families from Profile One

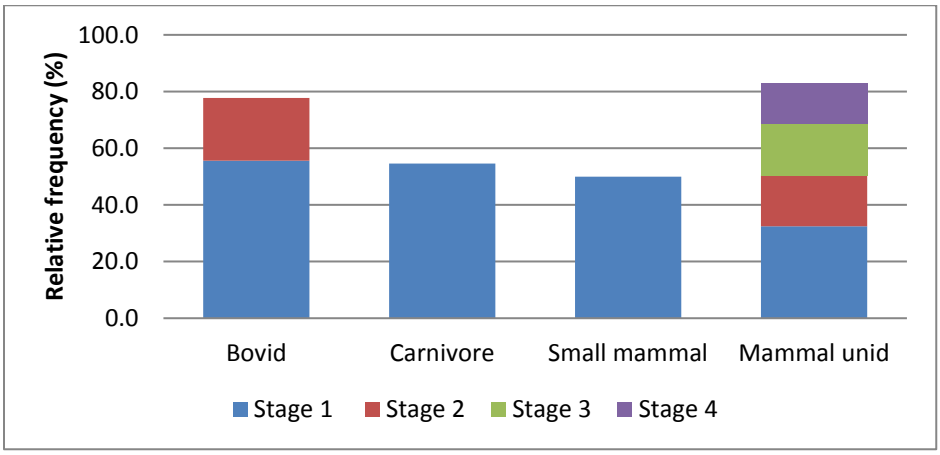


Figure 8.84. Intensity of abrasion in mammal families from Profile One

Table 8.51. Sheen in mammal remains from Profile One

	Bovid		Carnivore		Small mammal		Mammal unid		Total	
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Stage 1	2	22.2	4	36.4	1	16.7	22	19.8	**29**	**21.2**
Stage 2	-	-	3	27.3	-	-	14	12.6	**17**	**12.4**
Stage 3	3	33.3	1	9.1	-	-	14	12.6	**18**	**13.1**
Stage 4	1	11.1	-	-	-	-	-	-	**1**	**0.7**
Total	**6**	**66.7**	**8**	**72.7**	**1**	**16.7**	**50**	**45**	**65**	**47.4**

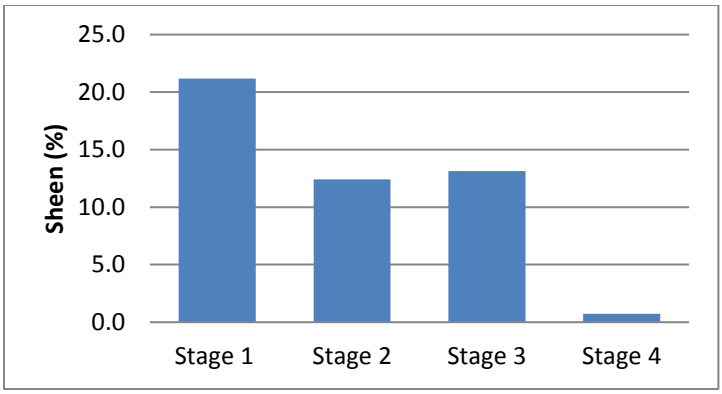


Figure8.85. Sheen intensity in mammal remains from Profile One

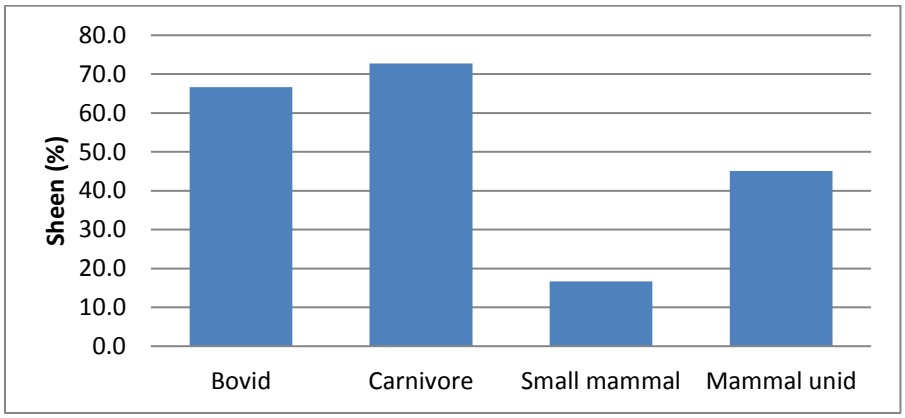


Figure 8.86. Relative frequency of sheen in mammal families from Profile One

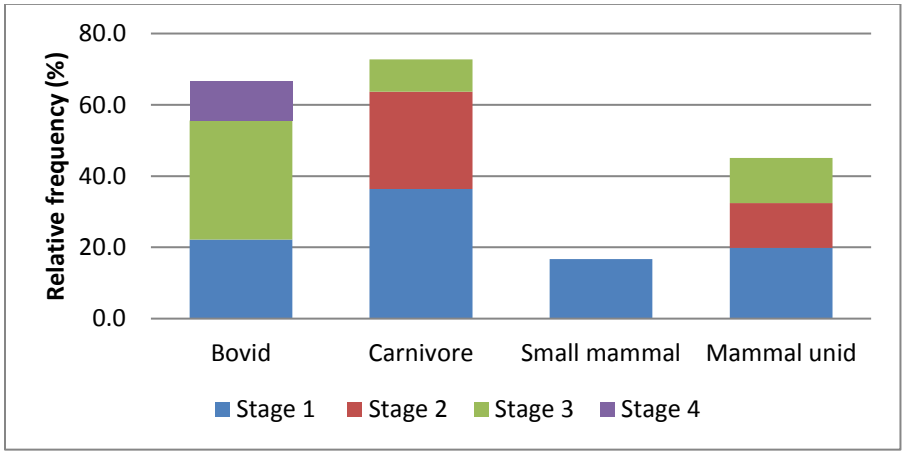


Figure 8.87. Intensity of sheen in mammal families from Profile One

Table 8.52. Trampling in mammal remains from Profile One

	Bovid		Small mammal		Mammal unid		Total	
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Stage 1	2	22.2	1	16.7	21	18.9	**24**	**17.5**
Stage 2					2	1.8	**2**	**1.5**
Total	**2**	**22.2**	**1**	**16.7**	**23**	**20.7**	**26**	**19**

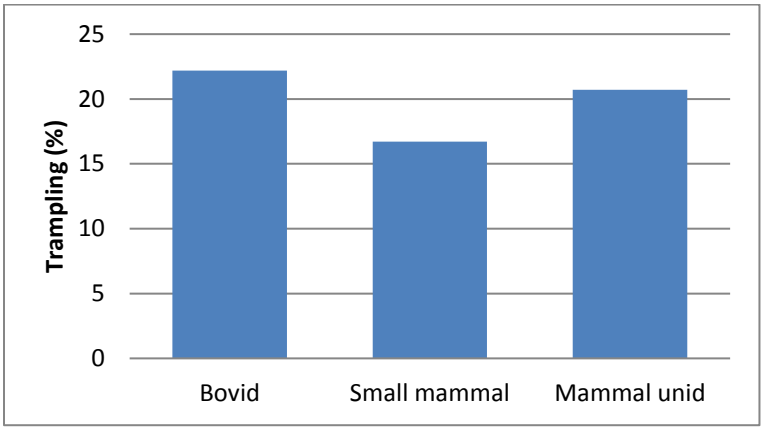


Figure 8.88. Relative frequency of trampling in mammal families from Profile One

Table 8.53. Digestive corrosion in mammal remains from Profile One

	Carnivore		Small mammal		Mammal unid		Total	
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Stage 1	2	18.2	1	16.7	3	2.7	**6**	**75**
Stage 2	-	-	1	16.7	-	-	**1**	**12.5**
Stage 3	-	-	1	16.7	-	-	**1**	**12.5**
Total	**2**	**18.2**	**3**	**50**	**3**	**2.7**	**8**	**5.8**

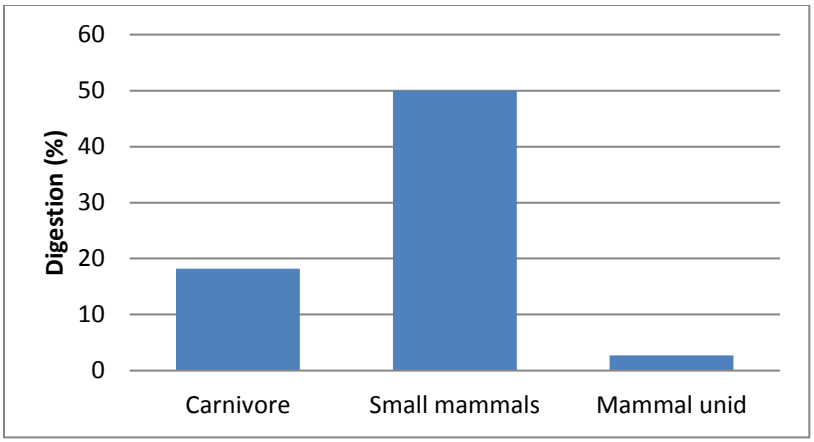


Figure 8.89. Relative frequency of digestive corrosion in mammal families from Profile One

Table 8.54. Root etching in mammalian families from Profile One

	Bovid		Small mammal		Mammal unid		Total	
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Stage 1	1	11.1	1	16.7	10	9	**12**	**8.8**
Stage 2	-	-	-	-	4	3.6	**4**	**2.9**
Stage 3	-	-	-	-	1	0.9	**1**	**0.7**
Total	**1**	**11.1**	**1**	**16.7**	**15**	**13.5**	**17**	**12.4**

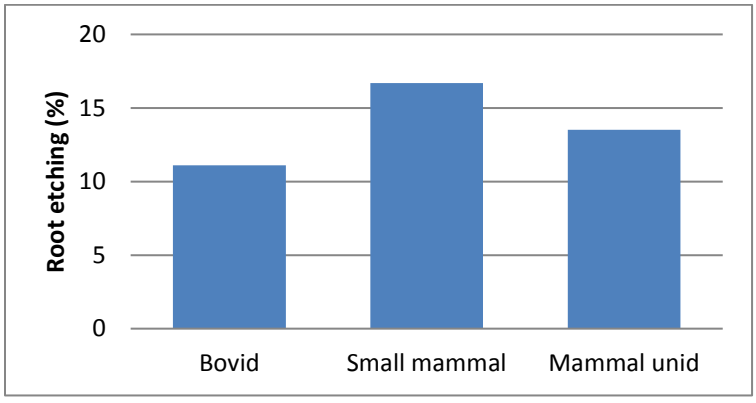


Figure 8.90. Relative frequency of root etching in mammalian families from Profile One

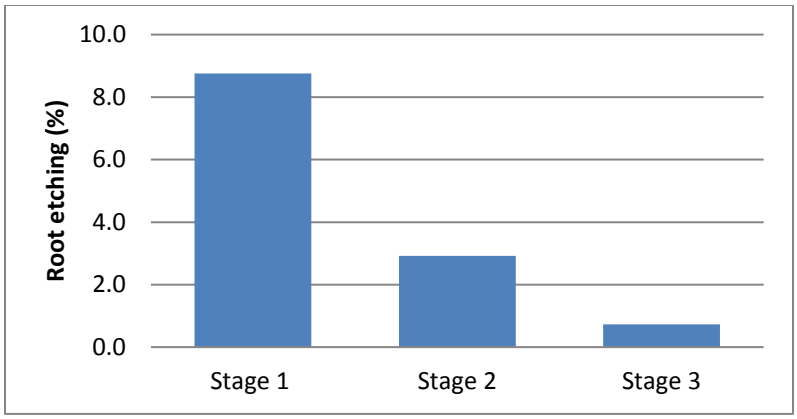


Figure 8.91. Root etching intensity in mammalian remains from Profile One

Table 8.55. Body size in chelonia remains from Profile One

	N	%
Size Class 1	168	15.1
Size Class 2	284	25.5
Size Class 3	438	39.4
Size Class 4	222	20
Total	**1112**	

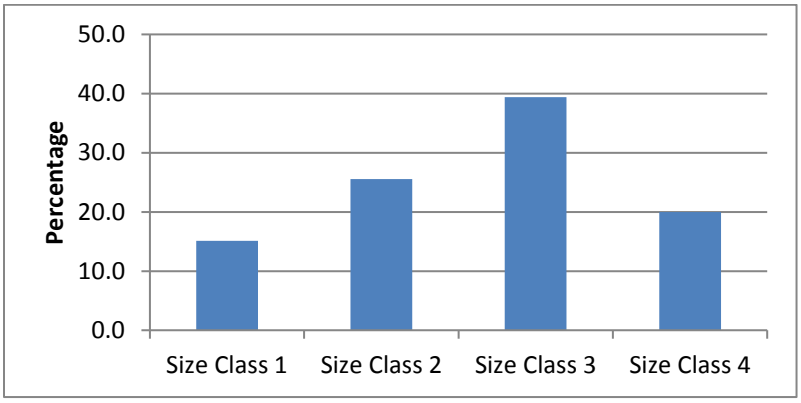


Figure 8.92. Relative frequency of body size class in chelonia from Profile One

Table 8.56. Chelonia remains by spit in Profile One

	N	%
Spit 1	374	88.2
Spit 2	579	84
Spit 3	152	72.7
Spit 4	7	70
Total	**1112**	

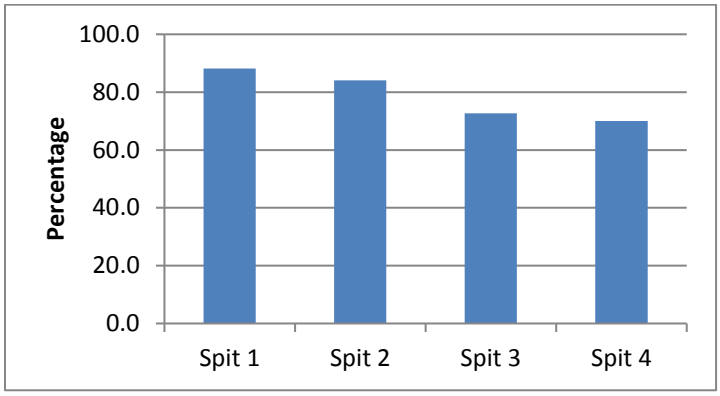


Figure 8.93. Relative frequency of chelonian remains by spit in Profile One

Table 8.57. Appendicular and axial elements in chelonia from Profile One

	Size Class 1		Size Class 2		Size Class 3		Size Class 4		Total	
Element	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Cranium	-	-	1	100	-	-	-	-	**1**	**0.4**
Mandible	-	-	4	100	-	-	-	-	**4**	**1.6**
Scapula	-	-	8	38.1	10	47.6	3	14.3	**21**	**8.5**
Coracoid	2	14.3	5	35.7	7	50	-	-	**14**	**5.7**
Humerus	-	-	7	26.9	17	65.4	2	7.7	**26**	**10.5**
Radius	-	-	2	25	6	75	-	-	**8**	**3.2**
Ulna	-	-	3	27.3	5	45.5	3	27.3	**11**	**4.5**
Ilium	-	-	15	51.7	12	41.4	2	7.1	**29**	**11.7**
Ischium	-	-	2	25	6	75	-	-	**8**	**3.2**
Publis	-	-	2	28.6	5	71.4	-	-	**7**	**2.8**
Femur	1	4	3	12	20	80	1	4	**25**	**10.1**
Tibia	1	6.7	2	13.3	12	80	-	-	**15**	**6.1**
Fibula	-	-	-	-	5	100	-	-	**5**	**2**
Metacarpal	-	-	-	-	1	100	-	-	**1**	**0.4**
Tarsal/carpal	-	-	1	33.3	2	66.6	-	-	**3**	**1.2**
Proximal phalange	-	-	1	50	1	50	-	-	**2**	**0.8**
Middle phalange	-	-	1	50	1	50	-	-	**2**	**0.8**
Distal phalange	1	4.3	15	65.2	4	17.4	3	13	**23**	**9.3**
Phalange	-	-	6	60	4	40	-	-	**10**	**4**
Thoracic vertebra	-	-	-	-	1	100	-	-	**1**	**0.4**
vertebra	1	4.3	11	47.8	6	26.1	5	21.7	**23**	**9.3**
Long bone fragment	-	-	-	-	6	75	2	25	**8**	**3.2**
Total	**6**	**2.4**	**89**	**36**	**131**	**53**	**21**	**8.5**	**247**	**22.2**

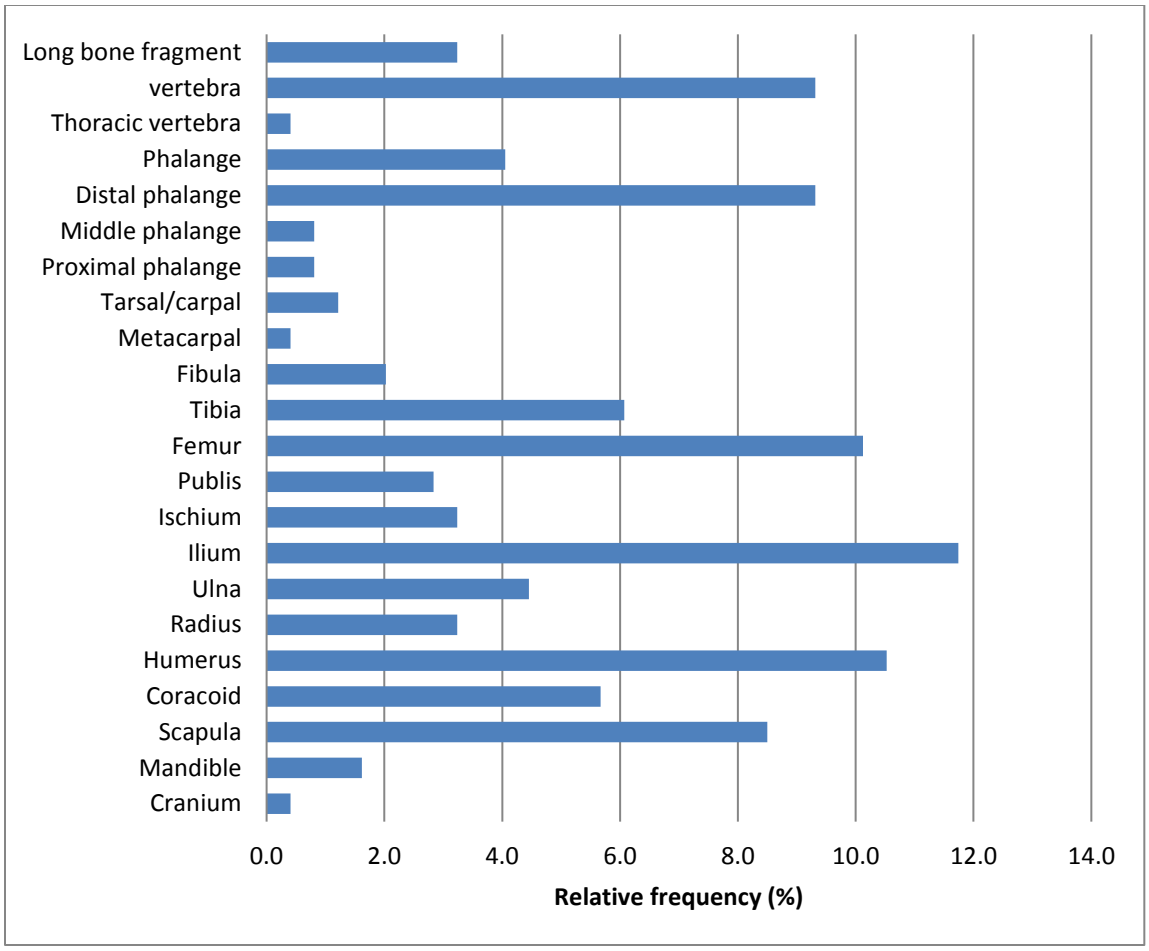


Figure 8.94. Chelonia appendicular and axial elements from Profile One

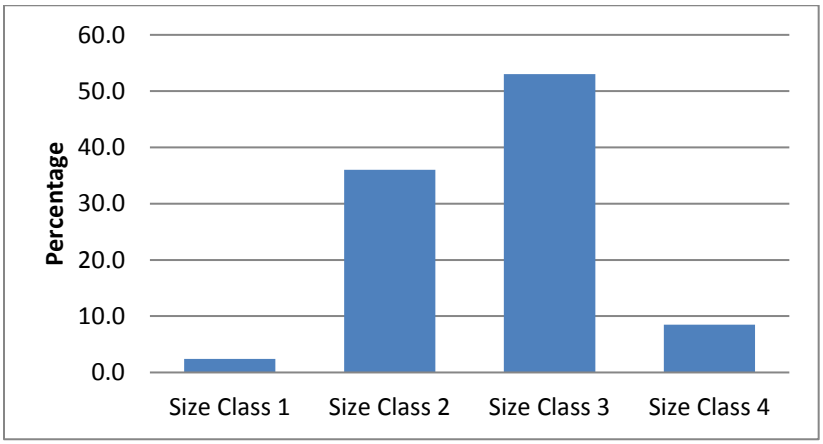


Figure 8.95. Chelonia appendicular and axial elements with body size from Profile One

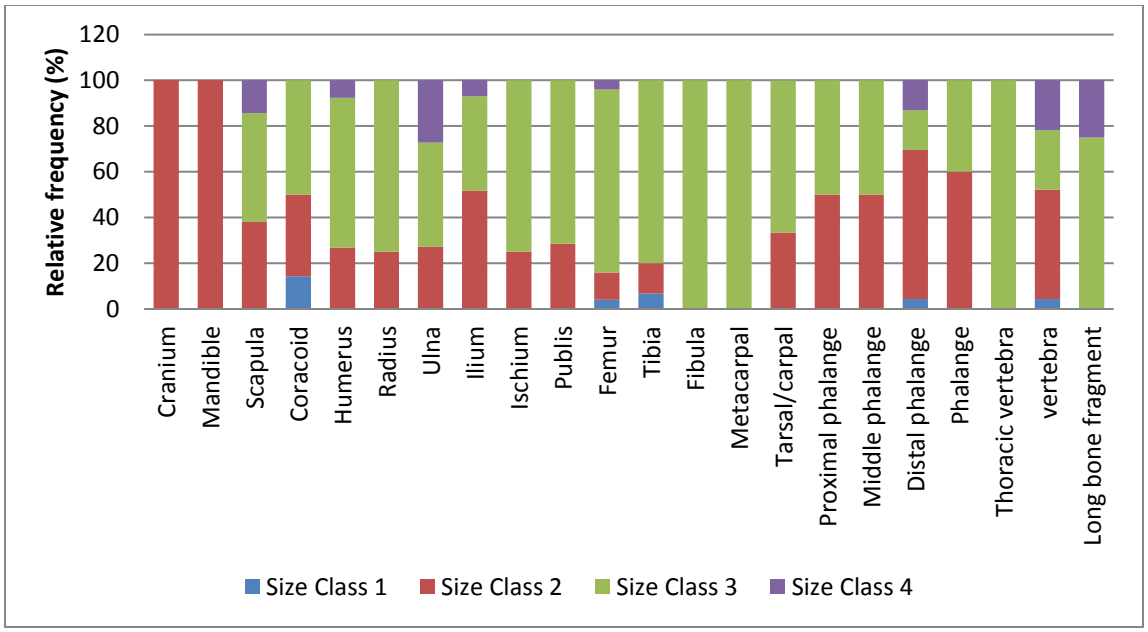


Figure 8.96. Chelonia appendicular and axial elements and by body size class in Profile One

Table 8.58. Chelonia appendicular and axial elements by spit from Profile One

	Spit1		Spit2		Spit3		Spit4		Total	
Element	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Cranium	-	-	1	100	-	-	-	-	**1**	**0.4**
Mandible	1	25	3	75	-	-	-	-	**4**	**1.6**
Scapula	9	42.9	9	42.9	3	14.3	-	-	**21**	**8.5**
Coracoid	5	35.71	6	42.9	3	21.4	-	-	**14**	**5.7**
Humerus	12	46.2	12	46.2	2	7.7	-	-	**26**	**10.5**
Radius	3	37.5	4	50	1	12.5	-	-	**8**	**3.2**
Ulna	4	36.4	6	54.5	1	9.1	-	-	**11**	**4.5**
Ilium	7	24.1	19	65.5	2	6.9	1	3.4	**29**	**11.7**
Ischium	1	12.5	6	75	1	12.5	-	-	**8**	**3.2**
Publis	2	28.6	3	42.9	2	28.6	-	-	**7**	**2.8**
Femur	6	24	14	56	5	20	-	-	**25**	**10.1**
Tibia	1	6.7	10	66.7	4	26.7	-	-	**15**	**6.1**
Fibula	1	20	3	60	1	20	-	-	**5**	**2**
Metacarpal	1	100	-	-	-	-	-	-	**1**	**0.4**
Tarsal/carpal	-	-	2	66.6	1	33.3	-	-	**3**	**1.2**
Proximal phalange	-	-	1	50	1	50	-	-	**2**	**0.8**
Middle phalange	-	-	2	100			-	-	**2**	**0.8**
Distal phalange	5	21.7	12	52.2	6	26.1	-	-	**23**	**9.3**
Phalange	1	10	6	60	2	20	1	10	**10**	**4**
Thoracic vertebra	-	-	1	100	-	-	-	-	**1**	**0.4**
vertebra	13	56.5	10	43.5	-	-	-	-	**23**	**9.3**
Long bone fragment	3	37.5	2	25	3	37.5	-	-	**8**	**3.2**
Total	**75**	**17.7**	**132**	**19.2**	**38**	**18.2**	**2**	**20**	**247**	

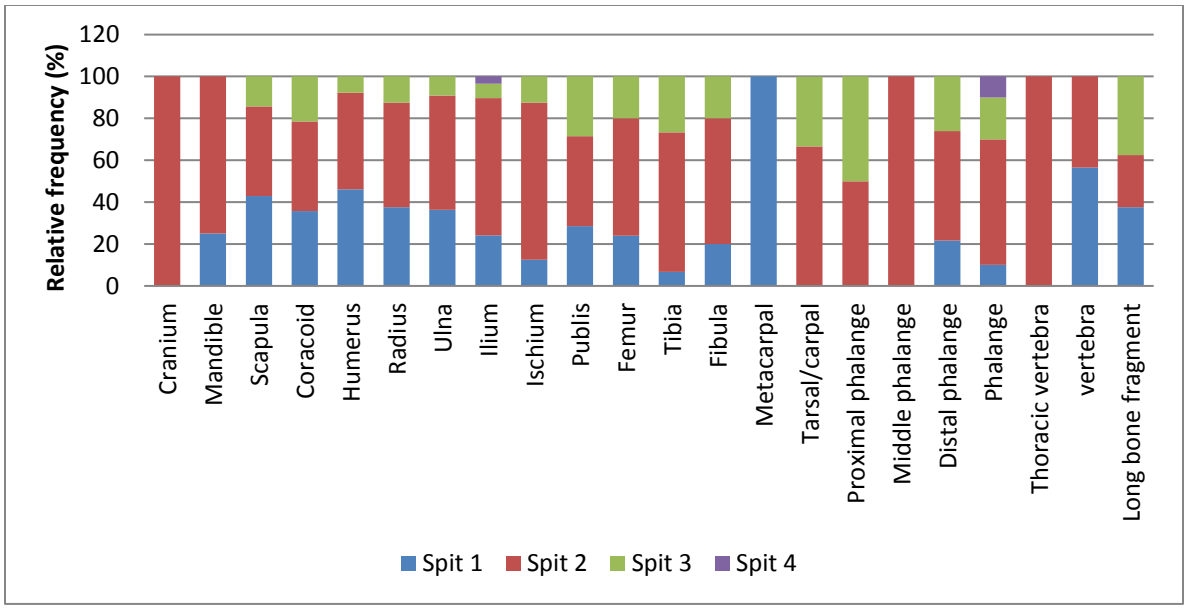


Figure 8.97. Chelonia appendicular and axial elements by spit in Profile One

Table 8.59. Skeletal frequencies in chelonia appendicular remains from Profile One

Element	NISP	MNE	MAU	%MAU	MNI
Cranium	1	1	1	20	1
Mandible	4	2	1	20	1
Scapula	21	5	3	60	3
Coracoid	14	9	5	100	5
Humerus	26	9	5	100	5
Radius	8	2	3	60	3
Ulna	11	4	4	80	4
Ilium	29	7	4	80	4
Ischium	8	3	3	60	3
Publis	7	5	3	60	2
Femur	25	9	5	100	5
Tibia	15	8	4	80	4
Fibula	5	3	3	60	3
Metacarpal	1	1	1	20	1
Tarsal/carpal	3	3	3	60	2
Proximal phalange	2	2	2	40	2
Middle phalange	2	2	2	40	2
Distal phalange	23	23	2	40	4
Phalange	10	10	1	20	3
Thoracic vertebra	1	1	1	20	1
vertebra	23	18	2	40	4
Long bone fragment	8	1	1	20	1
Total	**247**				**5**

Table 8.60. Chelonia shell remains and body size class from Profile One

	Size Class 1		Size Class 2		Size Class 3		Size Class 4		Total	
Element	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Neural	6	23.1	1	3.8	9	34.6	10	38.5	**26**	**8**
Nuchal	-	-	-	-	3	75	1	25	**4**	**1.2**
Costal 1	-	-	-	-	-	-	1	100	**1**	**0.3**
Costal 5	-	-	-	-	1	100	-	-	**1**	**0.3**
Costal 6	-	-	-	-	1	100	-	-	**1**	**0.3**
Costal	8	26.7	5	16.7	9	30	8	26.7	**30**	**9.2**
Marginal 1	-	-	-	-	-	-	2	100	**2**	**0.6**
Marginal 2	-	-	-	-	-	-	1	100	**1**	**0.3**
Marginal 7	-	-	-	-	-	-	1	100	**1**	**0.3**
Marginal 8	-	-	-	-	-	-	1	100	**1**	**0.3**
Marginal 9	-	-	-	-	-	-	1	100	**1**	**0.3**
Marginal	61	31.8	44	22.9	53	27.6	34	17.7	**192**	**58.9**
Carapace	30	46.2	9	13.8	13	20	13	20	**65**	**19.9**
Total Carapace	**105**	**32.2**	**59**	**18.1**	**89**	**27.3**	**73**	**22.4**	**326**	**37.7**
Xiphiplatron	1	5.6	2	11.1	9	50	6	33.3	**18**	**10.3**
Hypoplastron	1	5.6	1	5.6	9	50	7	38.9	**18**	**10.3**
Hyoplastron	-	-	2	18.2	5	45.5	4	36.4	**11**	**6.3**
Entoplastron	-	-	-	-	4	80	1	20	**5**	**2.9**
Epiplastron	1	6.3	1	6.3	7	43.8	7	43.8	**16**	**9.2**
Plastron	1	0.9	6	5.7	34	32.1	65	61.3	**106**	**60.9**
Total Plastron	**4**	**2.3**	**12**	**6.9**	**68**	**39.1**	**90**	**51.7**	**174**	**20.1**
Carapace/plastron	**53**	**14.5**	**124**	**34**	**149**	**40.8**	**39**	**10.7**	**365**	**42.2**
Total Shell	**162**	**18.7**	**195**	**22.5**	**306**	**35.4**	**202**	**23.4**	**865**	**77.8**

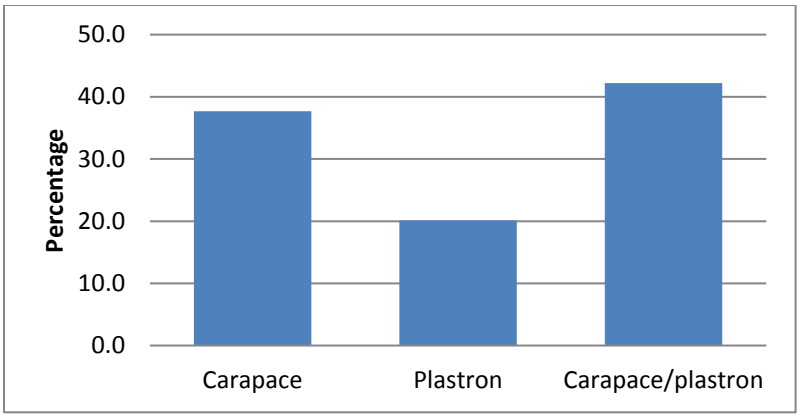


Figure 8.98. Relative frequency of chelonia shell remains from Profile One

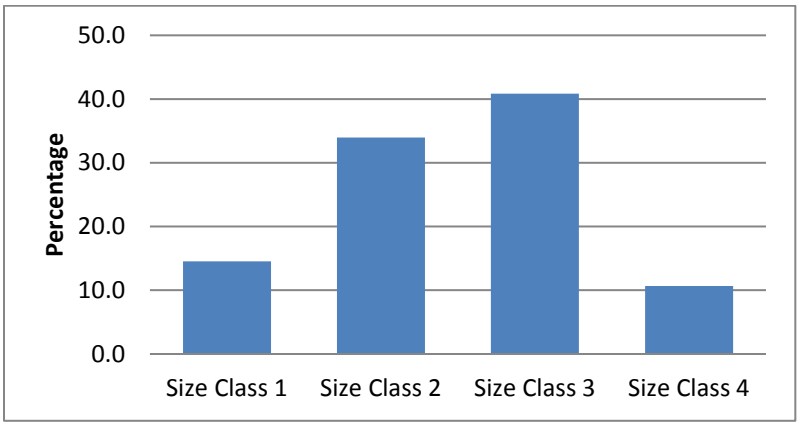


Figure 8.99. Body size classes in undiagnostic shell (carapace/plastron) remains from Profile One

Table 8.61. Chelonia carapace elements by spit in Profile One

	Spit1		Spit2		Spit3		Spit4		Total	
Element	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Neural	11	42.3	13	50	2	7.7	-	-	**26**	**8**
Nuchal	4	100	-	-	-	-	-	-	**4**	**1.2**
Costal 1	-	-	1	100	-	-	-	-	**1**	**0.3**
Costal 5	-	-	1	100	-	-	-	-	**1**	**0.3**
Costal 6	-	-	1	100	-	-	-	-	**1**	**0.3**
Costal	7	23.3	17	56.7	5	16.7	1	3.3	**30**	**9.2**
Marginal 1	-	-	2	100	-	-	-	-	**2**	**0.6**
Marginal 2	1	100	-	-	-	-	-	-	**1**	**0.3**
Marginal 7	-	-	1	100	-	-	-	-	**1**	**0.3**
Marginal 8	-	-	1	100	-	-	-	-	**1**	**0.3**
Marginal 9	-	-	1	100	-	-	-	-	**1**	**0.3**
Marginal	53	27.6	106	55.2	32	16.7	1	0.5	**192**	**58.9**
Carapace	13	20	46	70.7	6	9.2	-	-	**65**	**19.9**
Total Carapace	**89**	**21**	**190**	**27.6**	**45**	**21.5**	**2**	**60**	**326**	**37.7**
Xiphiplatron	4	22.2	10	55.6	4	22.2	-	-	**18**	**10.3**
Hypoplastron	9	50	8	44.4	1	5.6	-	-	**18**	**10.3**
Hyoplastron	4	36.4	6	54.5	1	9.1	-	-	**11**	**6.3**
Entoplastron	3	60	2	40	-	-	-	-	**5**	**2.9**
Epiplastron	8	50	6	37.5	2	12.5	-	-	**16**	**9.2**
Plastron	47	44.3	53	50	6	5.7	-	-	**106**	**60.9**
Total Plastron	**75**	**17.7**	**85**	**12.3**	**14**	**6.7**	**-**	**-**	**174**	**20.1**
Carapace/plastron	**134**	**31.6**	**173**	**25.1**	**56**	**26.8**	**2**	**20**	**365**	**42.2**
Total Shell	**298**	**70.3**	**448**	**65**	**115**	**55**	**4**	**40**	**865**	

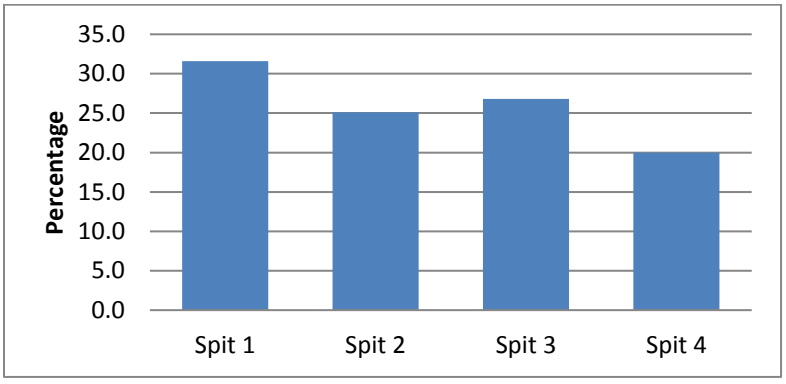


Figure 8.100. Relative frequency of undiagnostic shell (carapace/plastron) remains by spit in Profile One

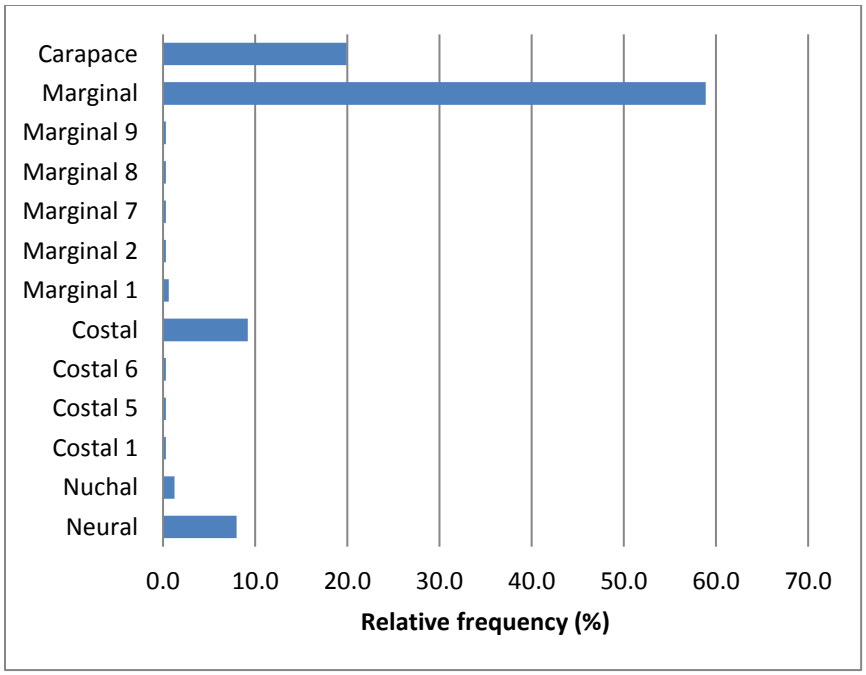


Figure 8.101. Relative frequency of chelonia carapace elements from Profile One

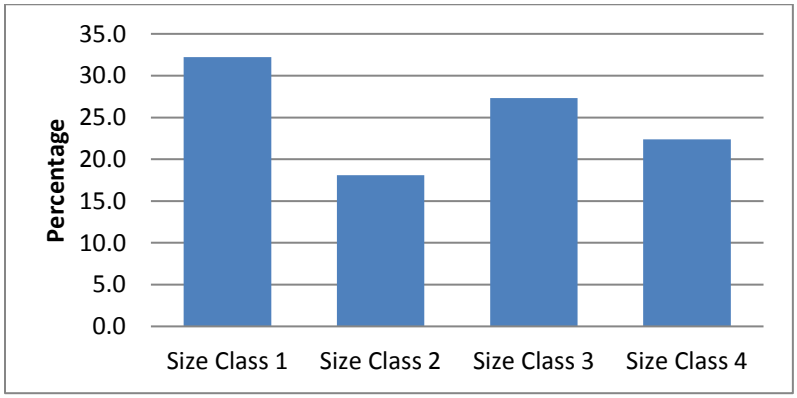


Figure 8.102. Relative frequency of carapace remains with body size class from Profile One

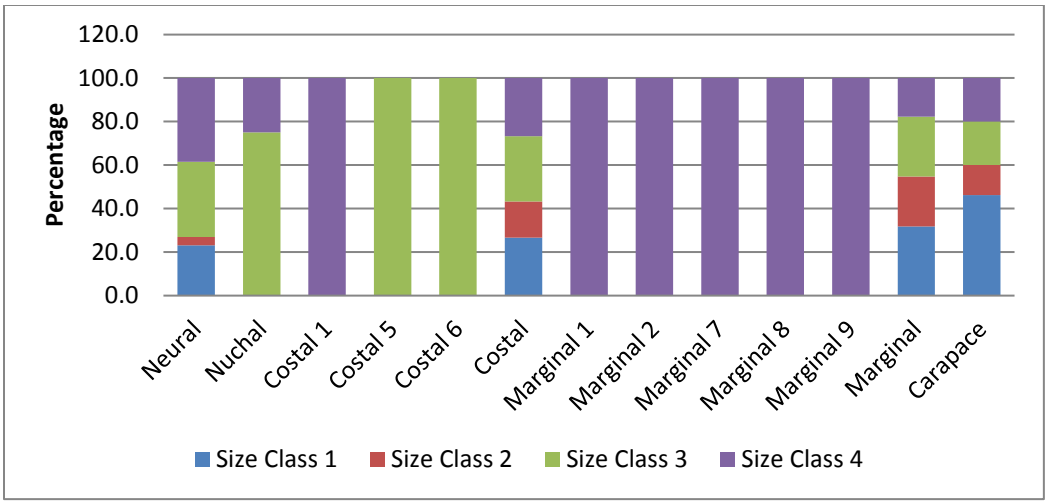


Figure 8.103. Body size in carapace elements from Profile One

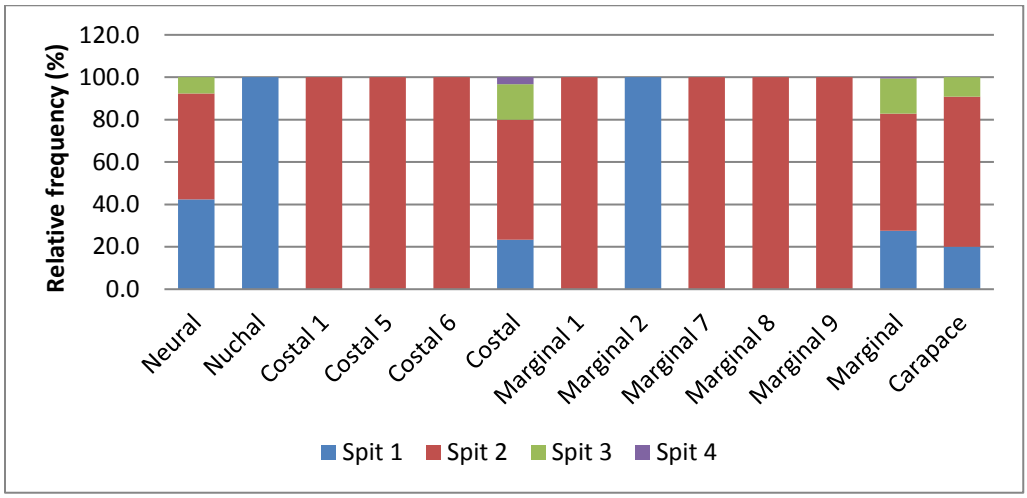


Figure 8.104. Carapace elements by spit from Profile One

Table 8.62.Skeletal frequencies in chelonia shell remains from Profile One

Element	NISP	MNE	MAU	%MAU	MNI
Neural	26	26	4	100	4
Nuchal	4	3	2	50	2
Costal 1	1	1	1	25	1
Costal 5	1	1	1	25	1
Costal 6	1	1	1	25	1
Costal	30	8	3	75	3
Marginal 1	2	2	1	25	1
Marginal 2	1	1	1	25	1
Marginal 7	1	1	1	25	1
Marginal 8	1	1	1	25	1
Marginal 9	1	1	1	25	1
Marginal	192	49	3	75	3
Carapace	65	65	2	50	2
Total Carapace	**326**				**4**
Xiphiplatron	18	4	6	75	6
Hypoplastron	18	13	8	100	8
Hyoplastron	11	2	5	62.5	5
Entoplastron	5	4	4	50	4
Epiplastron	16	5	3	37.5	3
Plastron	106	106	4	50	4
Total Plastron	**174**				**8**

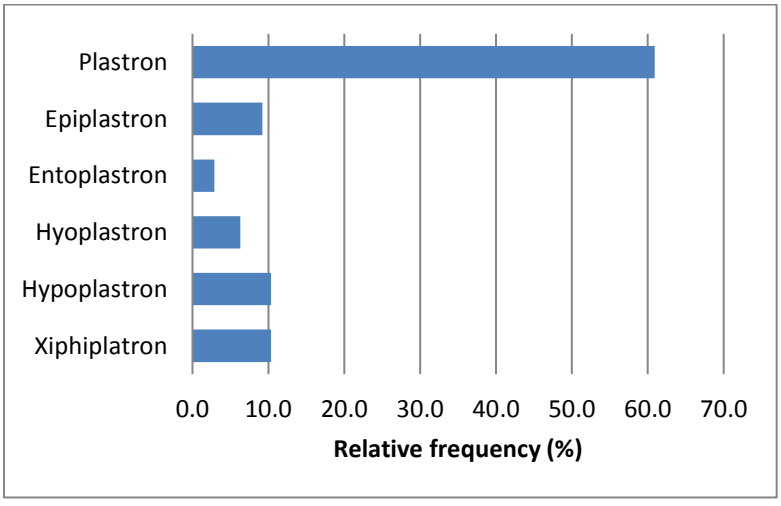


Figure 8.105. Chelonia plastron elements from Profile One

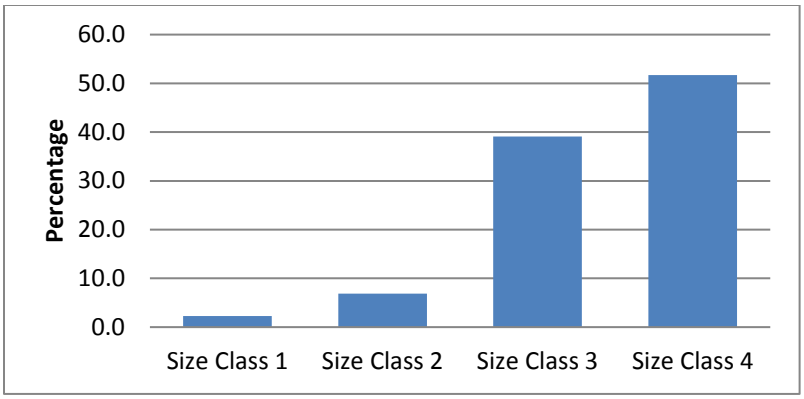


Figure 8.106. Chelonia plastron remains with body size from Profile One

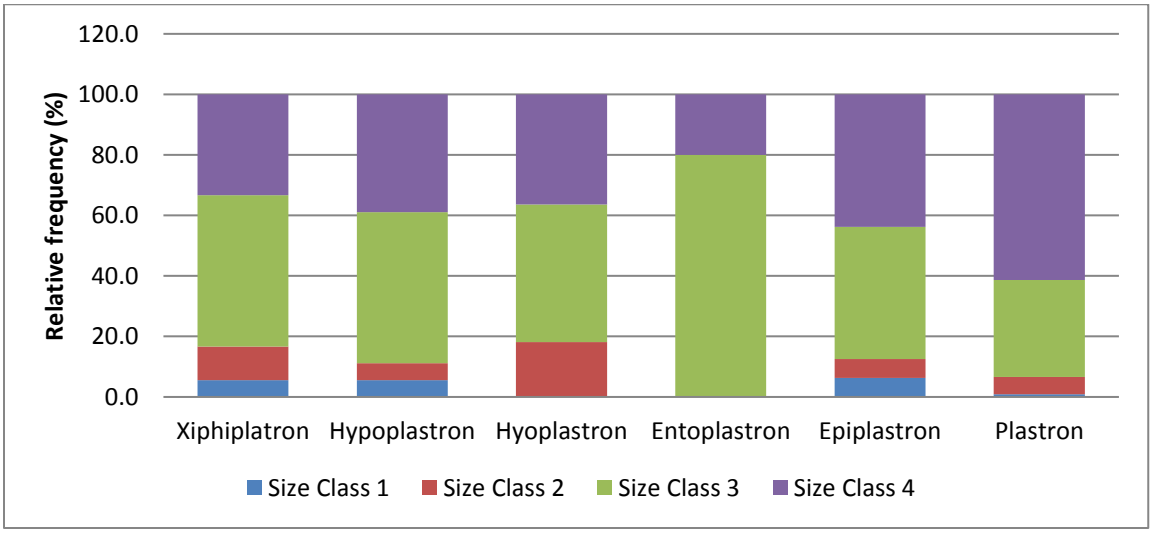


Figure 8.107. Plastron elements by body size class in Profile One

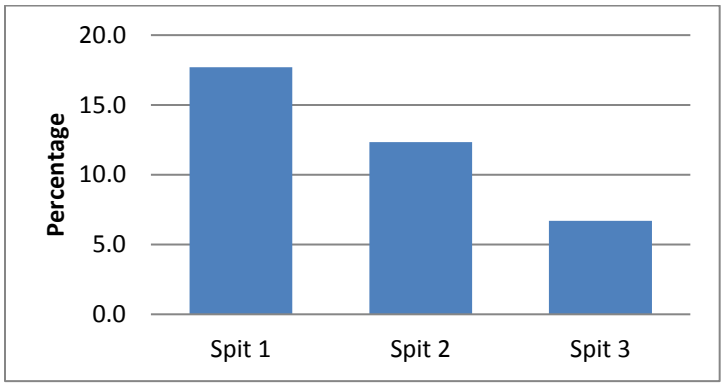


Figure 8.108. Relative frequency of chelonia plastron remains by spit in Profile One

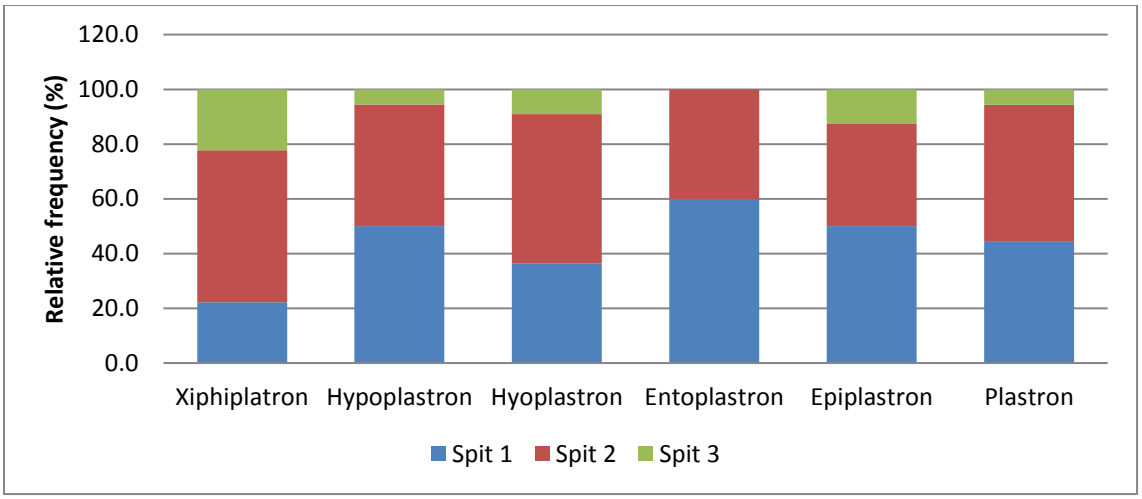


Figure 8.108. Plastron elements by spit in Profile One

Table 8.63. Descriptive statistics of maximum length in chelonia remains from Profile One

	Combined	Size Class 1	Size Class 2	Size Class 3	Size Class 4
N	1109	168	284	436	221
Minimum	3	5	4	3	10
Maximum	69	23	46	69	59
Mean	21.8	12.6	18	24.6	28.3
Standard Deviation	8.57	3.42	6.67	7.17	7.81

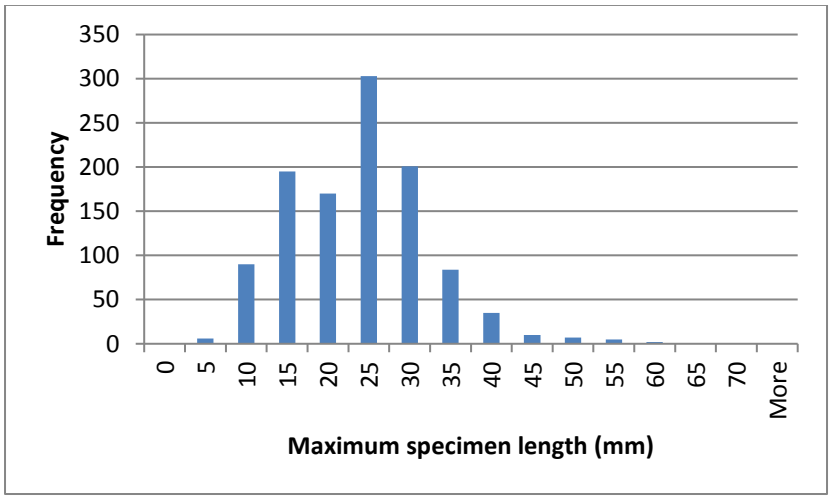


Figure 8.110. Histogram of maximum length in combined Chelonia sample from profile One

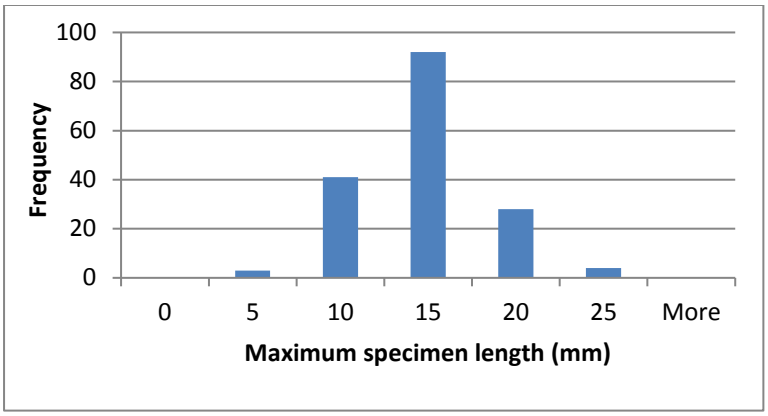


Figure 8.111. Histogram of maximum length in size class one Chelonia from Profile One

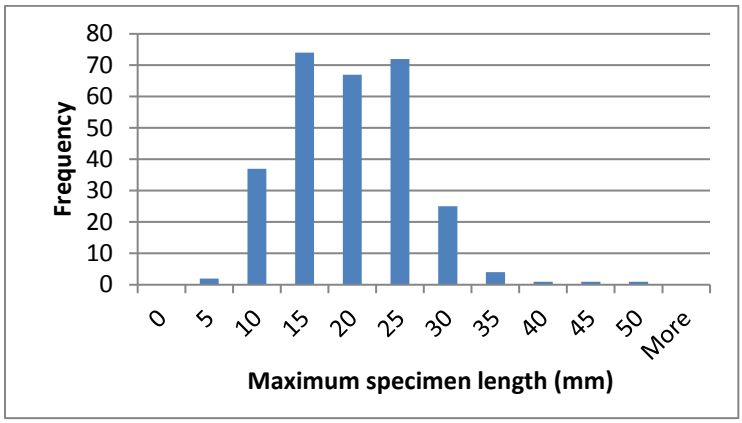


Figure 8.112. Histogram of maximum length in size class two Chelonia from Profile One

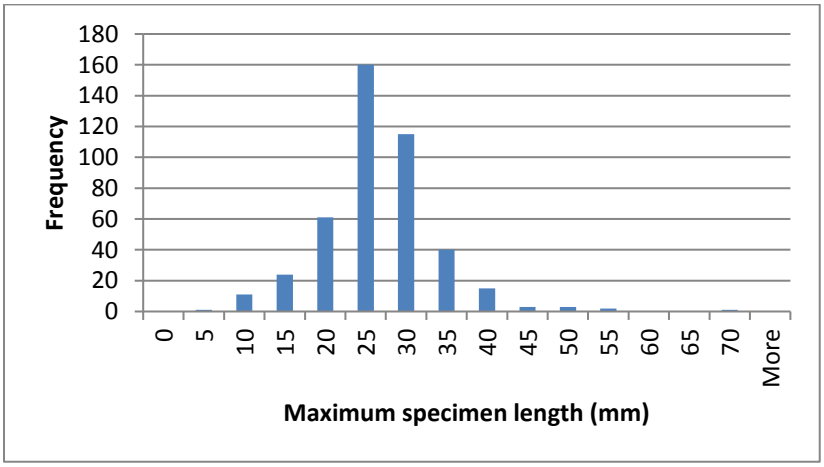


Figure 8.113. Histogram of maximum length in size class three Chelonia from Profile One

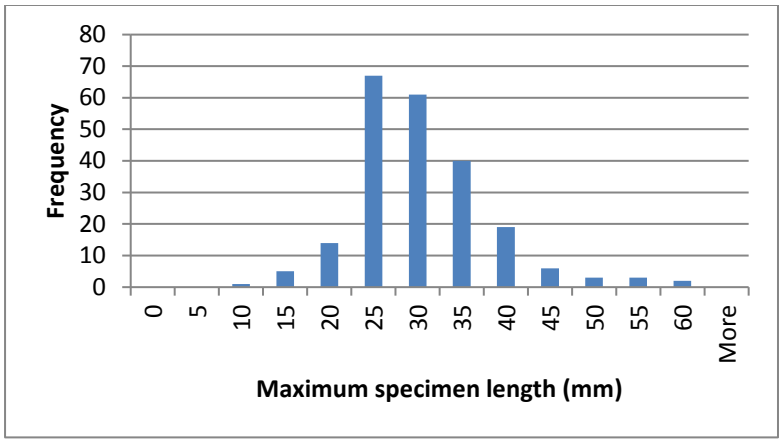


Figure 8.114. Histogram of maximum length in size class four Chelonia from Profile One

Table 8.64. Fusion in Chelonia remains from Profile One

	Size class 1		Size class 2		Size class 3		Size class 4		Total	
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Adult	4	3.8	27	26	61	58.7	12	11.5	**104**	**75.4**
Subadult	-	-	-	-	3	100	-	-	**3**	**2.2**
Juvenile	1	3.2	15	48.4	15	48.4	-	-	**31**	**22.5**
Total	**5**	**3.8**	**42**	**31.8**	**79**	**59.8**	**12**	**9.1**	**138**	**55.9**

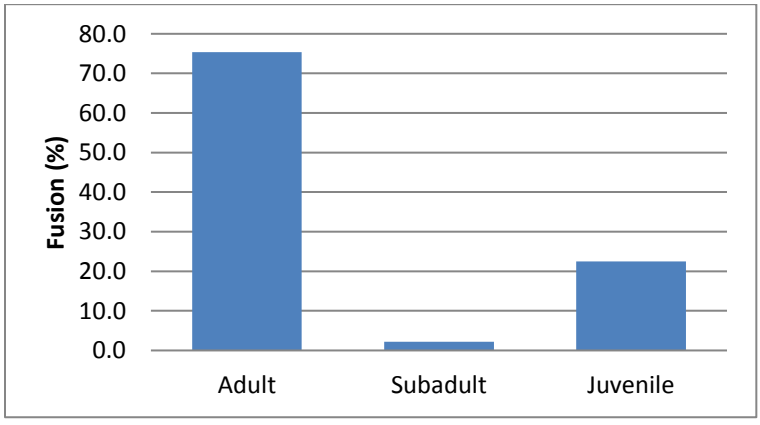


Figure 8.115. Epiphyseal fusion in chelonia from Profile One

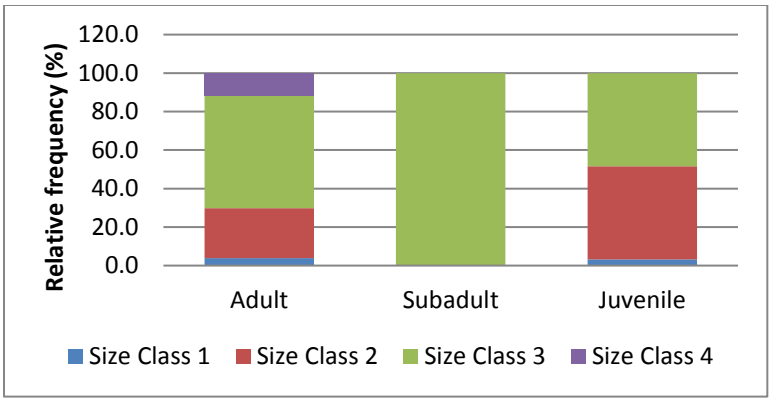


Figure 8.116. Epiphyseal fusion with body size in chelonia from Profile One

Table 8.65. Completeness in chelonia skeletal elements from Profile One

	Size Class 1		Size Class 2		Size Class 3		Size Class 4		Total	
Element	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Coracoid	1	33.3	-	-	2	66.6	-	-	**3**	**6.7**
Ischium	-	-	-	-	1	100	-	-	**1**	**2.2**
Metacarpal	-	-	-	-	1	100	-	-	**1**	**2.2**
Tarsal/carpal	-	-	1	33.3	2	66.6	-	-	**3**	**6.7**
Proximal phalange	-	-	1	5	1	50	-	-	**2**	**4.4**
Middle phalange	-	-	1	50	1	50	-	-	**2**	**4.4**
Distal phalange	1	4.5	14	63.6	4	18.2	3	13.6	**22**	**48.9**
Phalange	-	-	5	55.6	4	44.4	-	-	**9**	**20**
Vertebra	1	50	-	-	1	50	-	-	**2**	**4.4**
Total	**3**	**6.7**	**22**	**48.9**	**17**	**37.8**	**3**	**6.7**	45	**18.2**

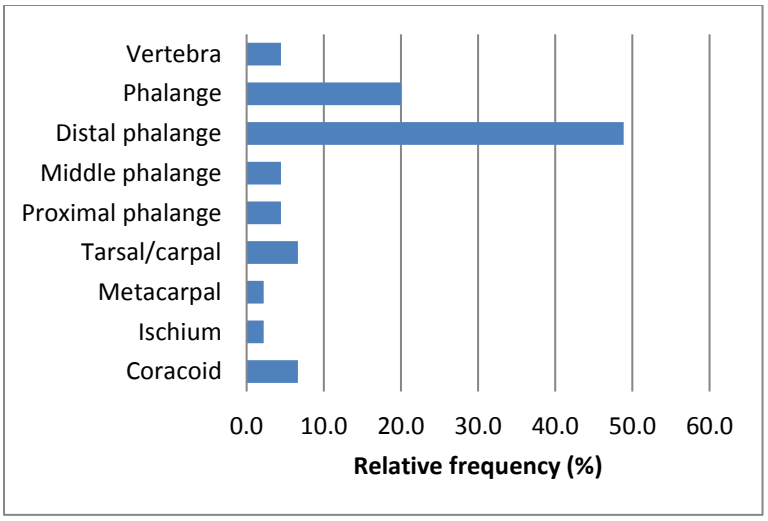


Figure 8.117. Relative frequency of completeness of chelonia skeletal elements in Profile One

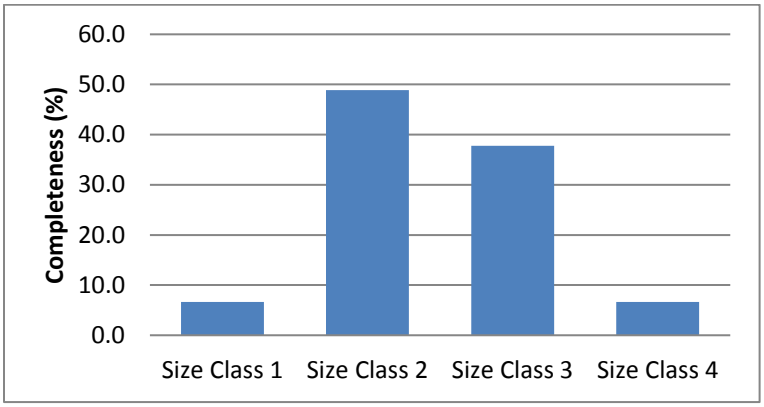


Figure 8.118. Relative frequency of completeness with body size class in chelonia remains from Profile One

Table 8.66. Completeness by spit in chelonia remains from Profile One

	Spit1		Spit2		Spit3		Spit4		Total	
Element	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Coracoid	2	66.6	1	33.3	-	-	-	-	**3**	**6.7**
Ischium	-	-	1	100	-	-	-	-	**1**	**2.2**
Metacarpal	1	100	-	-	-	-	-	-	**1**	**2.2**
Tarsal/carpal	-	-	2	66.6	1	33.3	-	-	**3**	**6.7**
Proximal phalange	-	-	1	50	1	50	-	-	**2**	**4.4**
Middle phalange	-	-	2	100	-	-	-	-	**2**	**4.4**
Distal phalange	4	18.2	12	54.5	6	27.3	-	-	**22**	**48.9**
Phalange	-	-	6	66.7	2	22.2	1	11.1	**9**	**20**
Vertebra	1	50	1	50	-	-	-	-	**2**	**4.4**
Total	**8**	**1.9**	**26**	**3.8**	**10**	**4.8**	**1**	**10**	**45**	**18.2**

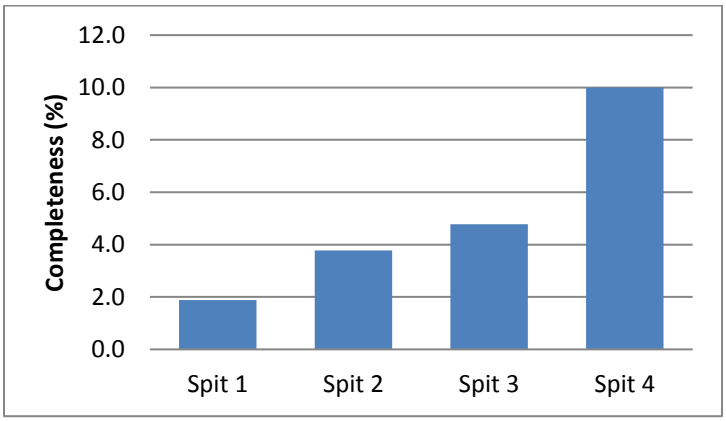


Figure 8.119. Relative frequency of completeness by spit in chelonia remains from Profile One

Table 8.66. Breakage categories in chelonia remains from Profile One

	Complete		Centrum		Vertebral Arch		Transverse Process	
	N	%	N	%	N	%	N	%
Vertebra	2	8.3	19	79.2	2	8.3	1	4.2
	Complete		**Anterior**		**Fragment**			
	N	%	N	%	N	%		
Coracoid	3	21.4	3	21.4	8	57.1		
	Proximal		**Shaft**		**Distal**			
	N	%	N	%	N	%		
Scapula	7	63.6	3	27.3	1	9.1		
	Premolar row		**Molar row**					
	N	%	N	%				
Mandible	2	50	2	50				
	Ilium		**Ischium**		**Pubis**			
	N	%	N	%	N$	%		
Innominate	29	65.9	8	18.2	7	15.9		
	Complete		**Fragment**					
	N	%	N	%				
Cranium	-	-	1	100				
Tarsal/carpal	3	100	-	-				
Phalange	35	94.6	2	5.4				

Table 8.68. Fracture outline in chelonian appendicular elements with body size class in Profile One

	Spiral (fresh)		Transverse (dry)		Splintered		Eroded		Irregular		Total	
	N	%	N	%	N	%	N	%	N	%	N	%
Size Class 1	2	20	1	10	-	-	-	-	-	-	**3**	**30**
Size Class 2	42	29.2	11	7.6	-	-	-	-	-	-	**53**	**36.8**
Size Class 3	95	38.9	23	9.4	3	1.2	6	2.5	1	0.4	**128**	**52.5**
Size Class 4	7	35	1	5	-	-	1	5	-	-	**9**	**45**
Total	**146**	**75.6**	**36**	**18.7**	**3**	**1.6**	**7**	**3.6**	**1**	**0.5**	**193**	**44.9**

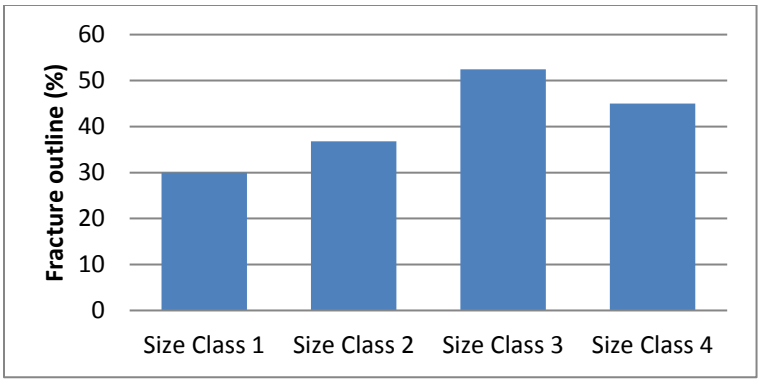


Figure 8.120. Relative frequency of fracture outline with chelonia body size class in Profile One

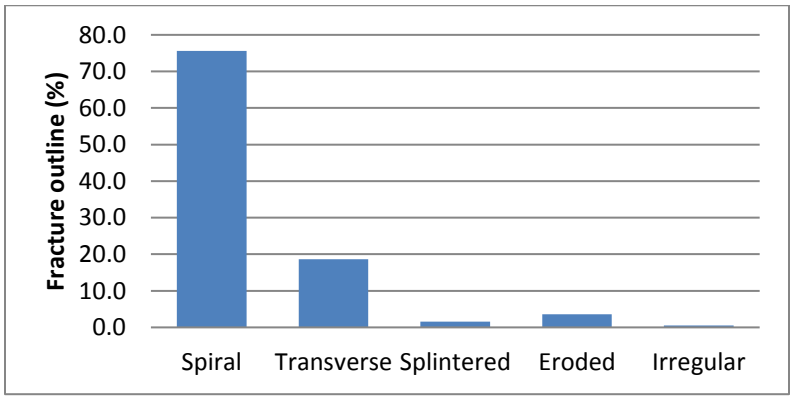


Figure 8.121. Relative frequency of fracture outline type in chelonia appendicular elements from Profile One

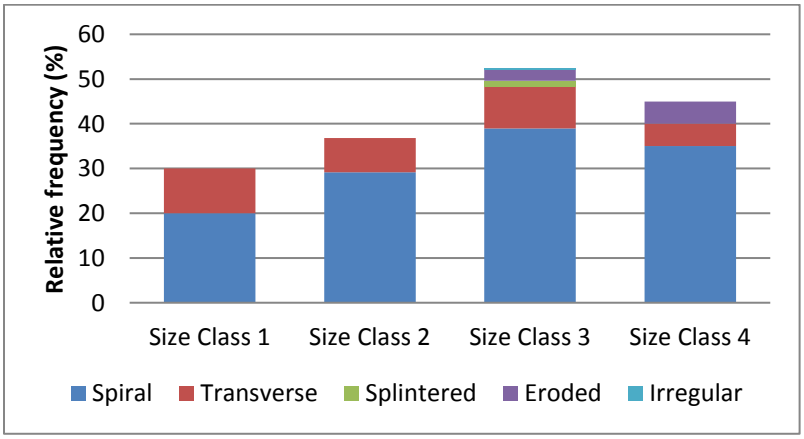


Figure 8.122. Fracture outline type with body size class in chelonia appendicular elements from Profile One

Table 8.69. Fracture outline by spit in chelonia appendicular elements from Profile One

	Spiral (fresh)		Transverse (dry)		Splintered		Eroded		Irregular		Total	
	N	%	N	%	N	%	N	%	N	%	N	%
Spit 1	46	37.1	11	8.9	-	-	3	2.4	-	-	**60**	**48.4**
Spit 2	76	33.3	15	6.6	2	0.9	4	1.8	1	0.4	**98**	**43**
Spit 3	22	30.6	10	13.9	1	1.4	-	-	-	-	**33**	**45.8**
Spit 4	**2**	33.3	**-**	-	**-**	-	-	-	-	-	**2**	**33.3**
Total	**146**	**75.6**	**36**	**18.7**	**3**	**1.6**	**7**	**3.6**	**1**	**0.5**	**193**	**44.9**

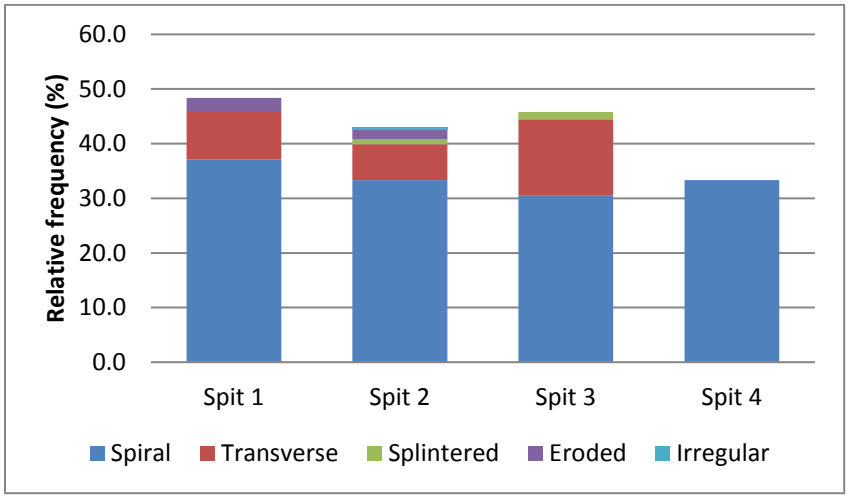


Figure 8.123. Relative frequency of fracture outline type by spit in chelonia appendicular elements from Profile One

Table 8.70. Fracture outline with body size class in chelonia shell from Profile One

	Spiral (fresh)		Transverse (dry)		Splintered		Eroded		Irregular		Total	
	N	%	N	%	N	%	N	%	N	%	N	%
Size Class 1	105	32.4	55	17	2	0.6	1	0.3	1	0.3	**164**	**51**
Size Class 2	152	39	69	17.7	-	-	1	0.3	-	-	**222**	**57**
Size Class 3	192	35.6	125	23.1	-	-	3	0.6	-	-	**320**	**59**
Size Class 4	85	21	52	12.9	1	0.2	7	1.7	-	-	**145**	**36**
Total	**534**	**62.7**	**301**	**35.4**	**3**	**0.4**	**12**	**1.4**	**1**	**0.1**	**851**	**49.2**

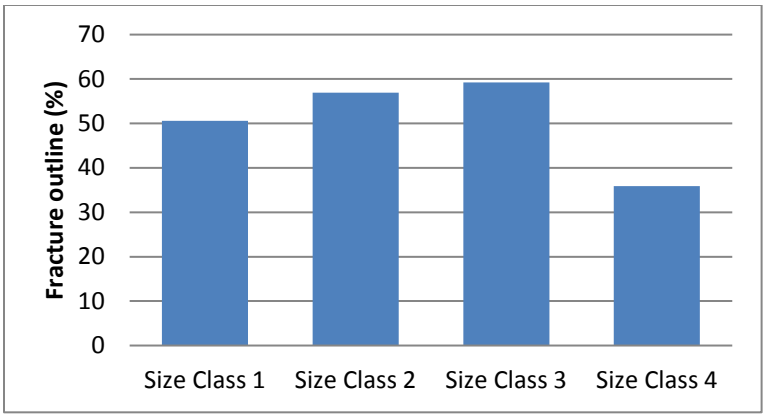


Figure 8.124. Relative frequency of fracture outline type with body size class in chelonia shell from Profile One

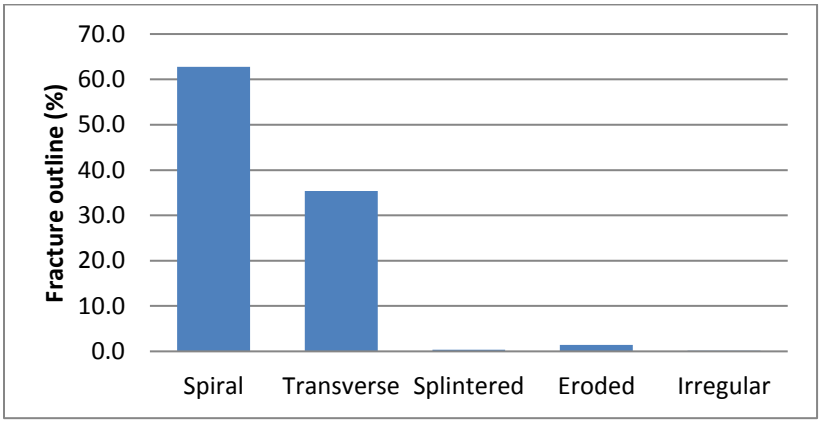


Figure 8.125. Relative frequency of fracture outline type in chelonia shell from Profile One

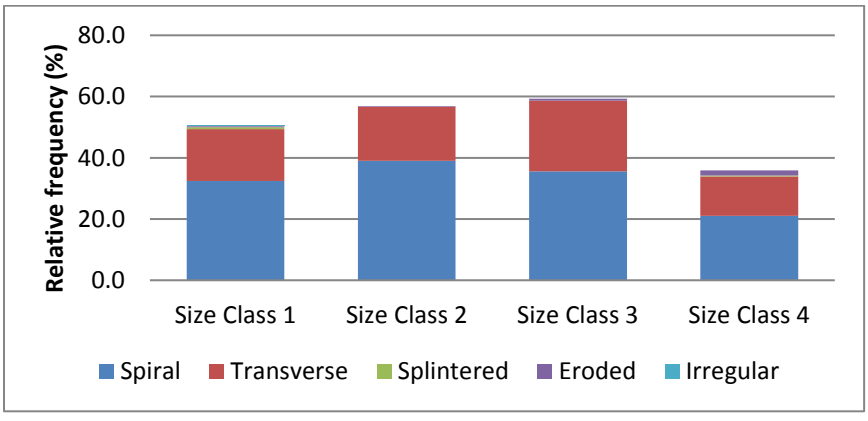


Figure 8.126. Fracture outline with body size class in chelonia shell from Profile One

Table 8.71. Fracture outline by spit in chelonia shell remains from Profile One

	Spiral (fresh)		Transverse (dry)		Splintered		Eroded		Irregular		Total	
	N	%	N	%	N	%	N	%	N	%	N	%
Spit 1	190	31.9	102	17.1	-	-	4	0.7	-	-	**296**	**49.7**
Spit 2	262	30.1	148	17	2	0.2	7	0.8	1	0.1	**420**	**46.9**
Spit 3	79	34.3	50	21.7	1	0.4	1	0.4	-	-	**131**	**57**
Spit 4	3	37.5	1	12.5	-	-	-	-	-	-	**4**	**50**
Total	**534**	**62.7**	**301**	**35.4**	**3**	**0.4**	**12**	**1.4**	**1**	**0.1**	**851**	**49.2**

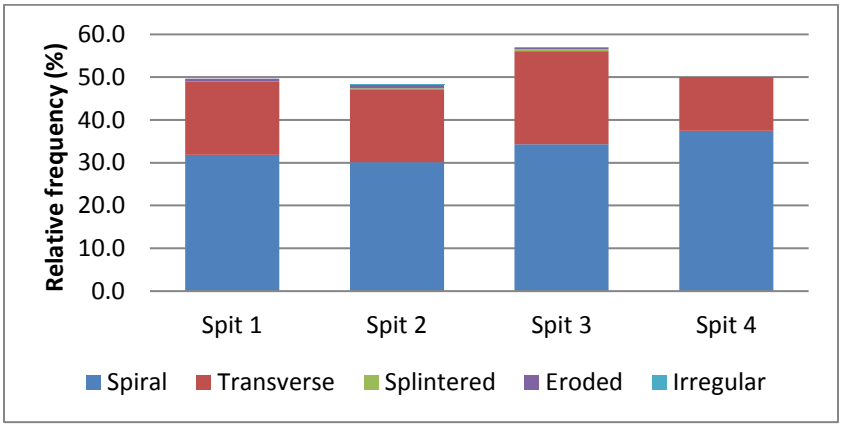


Figure 8.127. Relative frequency of fracture outline type by spit in chelonia shell remains from Profile One

Table 8.72. Fracture angle in chelonia appendicular elements from Profile One

	Oblique		Right		Mixed		Total	
	N	%	N	%	N	%	N	%
Size Class 1	1	10	-	-	2	20	**3**	**30**
Size Class 2	17	11.8	26	18.1	19	13.2	**62**	**43.1**
Size Class 3	51	21	34	14	48	20	**133**	**54.5**
Size Class 4	6	30	2	10	4	20	**12**	**60**
Total	**75**	**35.7**	**62**	**29.5**	**73**	**34.8**	**210**	**48.8**

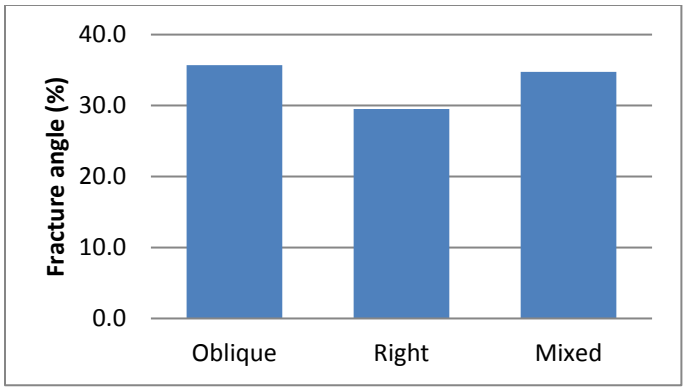


Figure 8.128. Relative frequency of fracture angle type in chelonia appendicular elements from Profile One



Figure 8.129. Relative frequency of fracture angle with body size class in chelonian appendicular elements from Profile One

Table 8.73. Fracture angle by spit in chelonian appendicular elements from Profile One

	Oblique		Right		Mixed		Total	
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Spit 1	23	18.5	21	16.9	23	18.5	**67**	**54**
Spit 2	41	18	26	11.4	38	16.7	**105**	**46.1**
Spit 3	10	13.9	13	18.1	12	16.7	**35**	**48.6**
Spit 4	1	16.7	2	33.3	**-**	-	**3**	**50**
Total	**75**	**35.7**	**62**	**29.5**	**73**	**34.8**	**210**	**48.8**

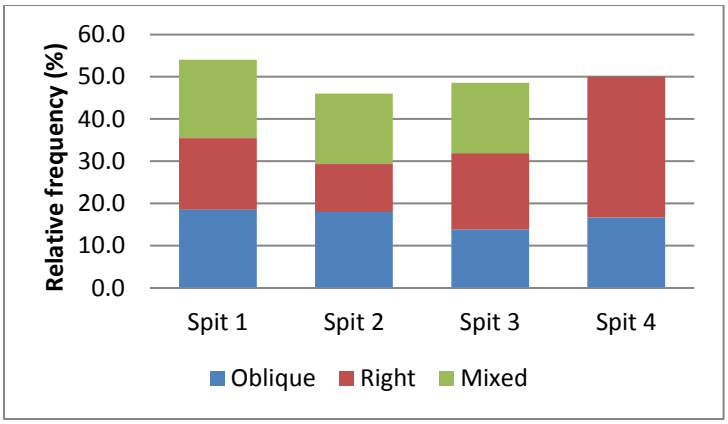


Figure 8.130. Relative frequency of fracture angle by spit in chelonian appendicular elements from Profile One

Table 8.74. Fracture angle in chelonia shell remains from Profile One

	Oblique		Right		Mixed		Total	
	N	%	N	%	N	%	N	%
Size Class 1	43	13.3	66	20.4	59	18.2	**168**	**51.9**
Size Class 2	41	10.5	109	27.9	79	20.3	**229**	**58.7**
Size Class 3	67	12.4	165	30.6	95	17.6	**327**	**60.6**
Size Class 4	34	8.4	69	17.1	48	11.9	**151**	**37.4**
Total	**185**	**21.1**	**409**	**46.7**	**281**	**32.1**	**875**	**50.6**

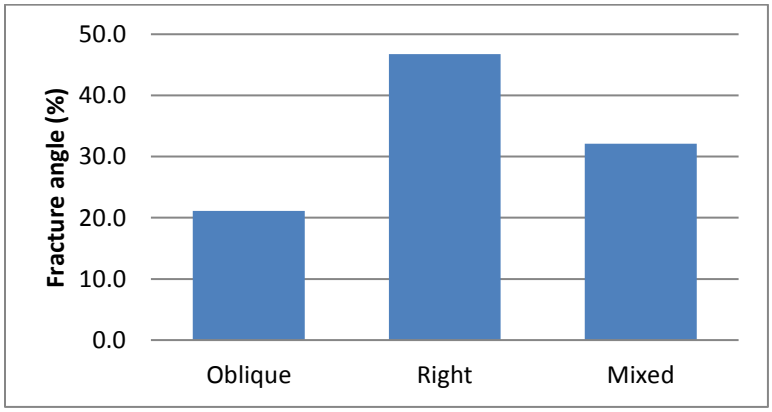


Figure 8.131. Relative frequency of fracture angle in chelonia shell from Profile One



Figure 8.132. Relative frequency of fracture angle in chelonia shell with body size class from Profile One

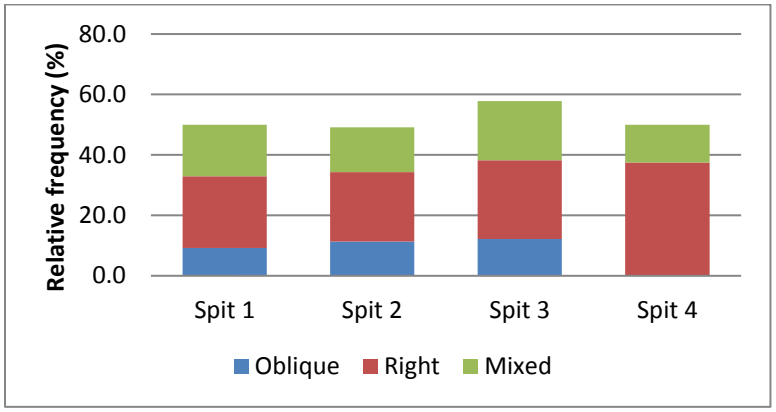


Figure 8.133. Relative frequency of fracture angle in chelonia shell by spit from Profile One

Table 8.75. Fracture angle in chelonia shell by spit from Profile One

	Oblique		Right		Mixed		Total	
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Spit 1	55	9.2	141	23.7	102	17.1	**298**	**50**
Spit 2	102	11	205	23	133	15	**440**	**49.1**
Spit 3	28	12.2	60	26.1	45	19.6	**133**	**57.8**
Spit 4	-	-	3	37.5	1	12.5	**4**	**50**
Total	**185**	**21.1**	**409**	**46.7**	**281**	**32.1**	**875**	**50.6**

Table 8.76. Weathering in chelonia parts from Profile One

	Appendicular/Axial		Carapace		Plastron		Carapace/Plastron		Total	
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Stage 1	39	15.8	48	14.7	38	21.8	54	14.8	**179**	**16.1**
Stage 2	5	2	6	1.8	14	8	12	3.3	**37**	**3.3**
Stage 3	-	-	-	-	2	1.1	-	-	**2**	**0.2**
Total	**44**	**17.8**	**54**	**16.6**	**54**	**31**	**66**	**18.1**	**218**	**19.6**

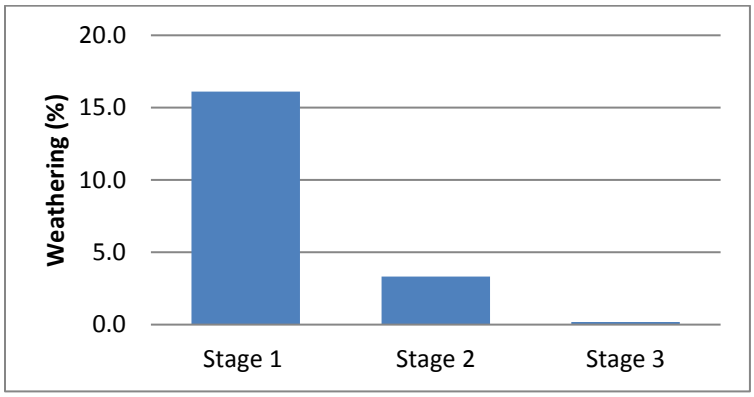


Figure 8.134. Weathering intensity in chelonia from Profile One

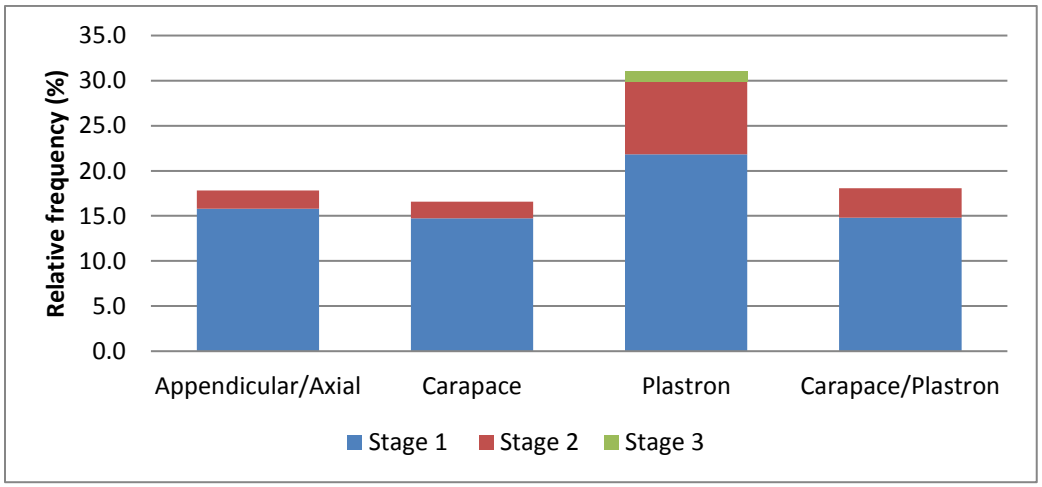


Figure 8.135. Intensity of weathering in chelonia parts from Profile One

Table 8.77. Weathering in chelonia appendicular elements from Profile One

	Stage 1		Stage 2		Total	
	N	%	**N**	%	**N**	%
Scapula	3	66.6	1	33.3	**4**	**19**
Coracoid	3	100	-	-	**3**	**21.4**
Humerus	7	87.5	1	12.5	**8**	**30.8**
Radius	2	100	-	-	**2**	**25**
Ulna	3	100	-	-	**3**	**27.3**
Ilium	2	100	-	-	**2**	**6.9**
Ischium	1	100	-	-	**1**	**12.5**
Publis	1	100	-	-	**1**	**14.3**
Femur	7	87.5	1	12.5	**8**	**32**
Tibia	5	100	-	-	**5**	**33.3**
Fibula	-	-	1	100	**1**	**20**
Long bone fragment	5	83.3	1	16.7	**6**	**75**
Total	**39**	**88.6**	**5**	**11.4**	**44**	**17.8**

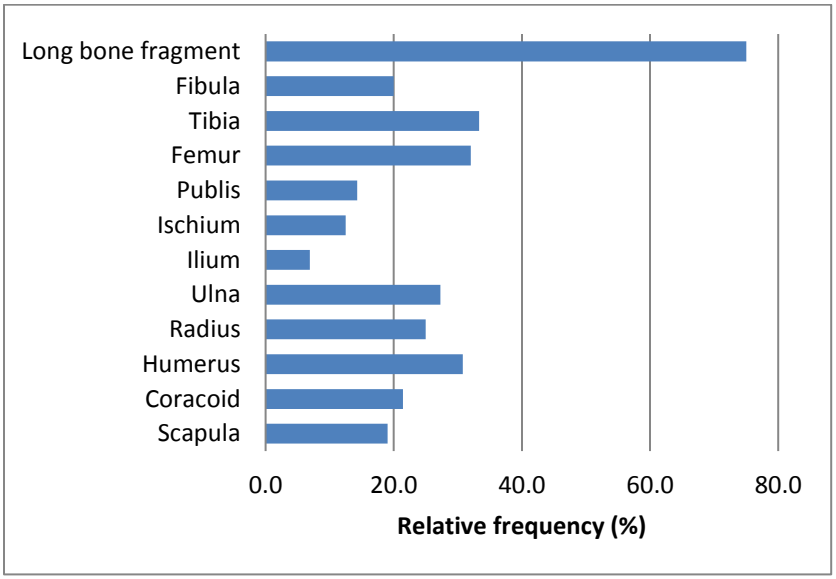


Figure 8.136. Relative frequency of weathering in chelonia appendicular elements from Profile One

Table 8.78. Weathering intensity with body size class in chelonia shell remains from Profile One

	Size Class 1		Size Class 2		Size Class 3		Size Class 4		Total	
	N	%	**N**	%	**N**	%	**N**	%	**N**	%
Stage 1	8	4.9	31	15.9	58	19	43	21.3	**140**	**16.2**
Stage 2	-	-	4	2.1	11	3.6	17	8.4	**32**	**3.7**
Stage 3	-	-	-	-	-	-	2	1	**2**	**0.2**
Total	**8**	**4.9**	**35**	**17.9**	**69**	**22.5**	**62**	**30.7**	**174**	**20.1**

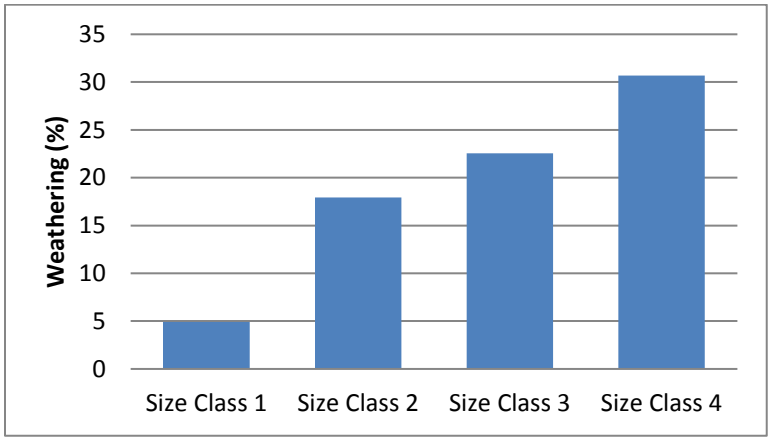


Figure8.137. Weathering intensity with body size class in chelonia shell remains from Profile One

Table 8.79. Burning in chelonia remains from Profile One

	Appendicular/Axial		Carapace		Plastron		Carapace/Plastron		Total	
	N	%	**N**	%	**N**	%	**N**	%	**N**	**%**
Stage 1	9	3.6	9	2.8	13	7.5	12	3.3	**43**	**3.9**
Stage 2	5	2	10	3.1	6	3.4	26	7.1	**47**	**4.2**
Stage 3	12	4.9	1	0.3	4	2.3	15	4.1	**32**	**2.9**
Stage 4	-	-	1	0.3	-	-	-	-	**1**	**0.1**
Stage 5	-	-	2	0.6	1	0.6	-	-	**3**	**0.3**
Total	**26**	**10.5**	**23**	**7.1**	**24**	**13.8**	**53**	**14.5**	**126**	**11.3**

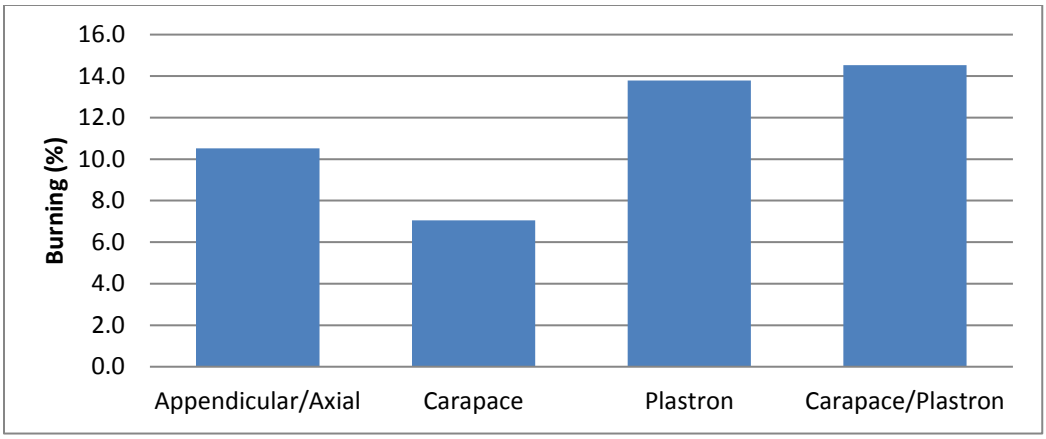


Figure 8.138. Relative frequency of burning in chelonia parts from Profile One

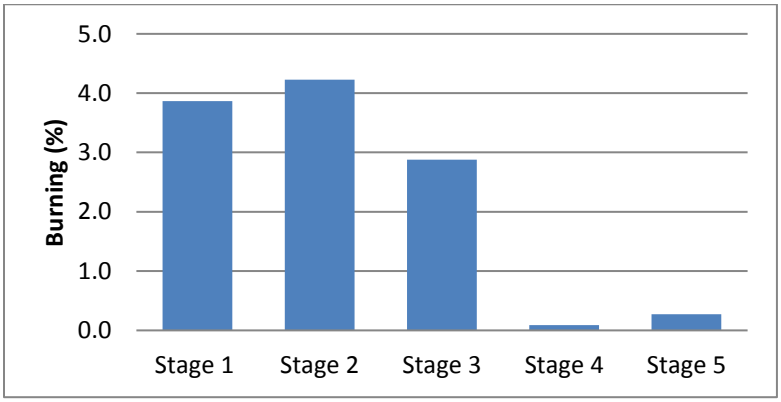


Figure 8.139. Burning intensity in chelonia remains from Profile One

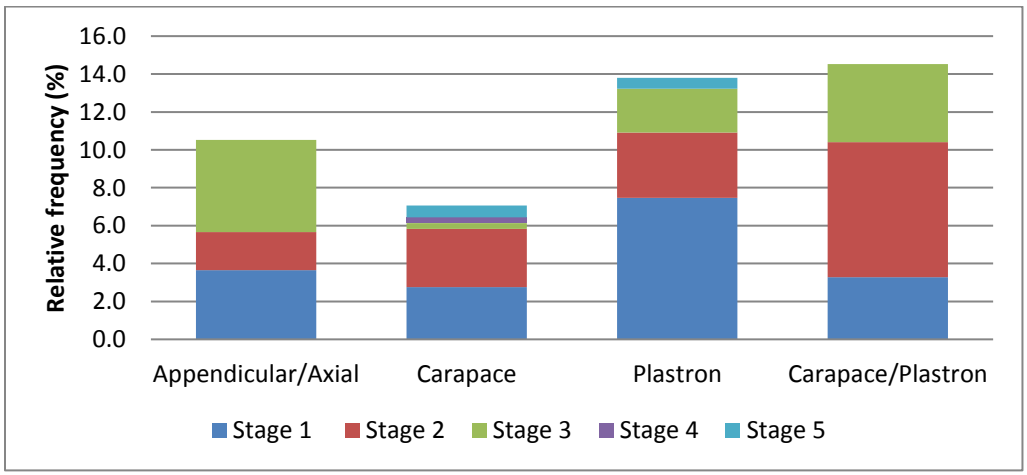


Figure 8.140. Burning intensity in chelonia parts from Profile One

Table 8.80. Burning in chelonia appendicular and axial remains from Profile One

	Stage 1		Stage 2		Stage 3		Total	
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Coracoid	-	-	1	100	-	-	**1**	**7.1**
Humerus	-	-	-	-	3	100	**3**	**11.5**
Radius	2	66.6	-	-	1	33.3	**3**	**37.5**
Ulna	1	100	-	-	-	-	**1**	**9.1**
Ilium	2	50	1	25	1	25	**4**	**13.8**
Publis	-	-	-	-	1	100	**1**	**14.3**
Femur	-	-	2	66.6	1	33.3	**3**	**12**
Tibia	2	66.6	-	-	1	33.3	**3**	**20**
Distal phalange	1	50	-	-	1	50	**2**	**8.7**
Phalange	-	-	-	-	1	100	**1**	**10**
Vertebra	1	25	1	25	2	50	**4**	**17.4**
Total	**9**	**34.6**	**5**	**19.2**	**12**	**46.2**	**26**	**10.5**

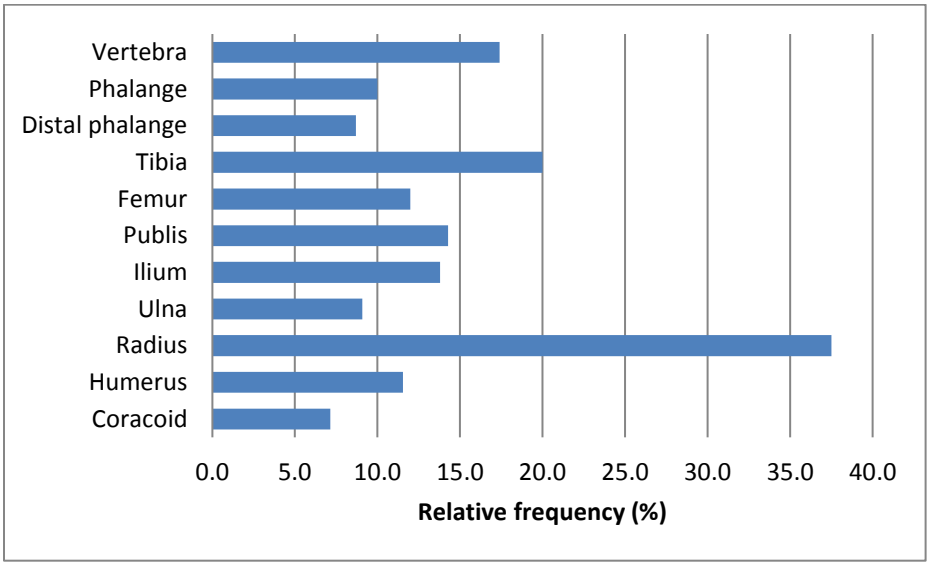


Figure 8.141. Relative frequency of burning on chelonia appendicular elements from Profile One

Table 8.81. Burning intensity by spit in chelonia shell remains from Profile One

	Size Class 1		Size Class 2		Size Class 3		Size Class 4		Total	
	N	%	N	%	N	%	N	%	N	%
Stage 1	1	0.6	7	3.6	19	6.2	14	6.9	**41**	**4.7**
Stage 2	7	4.3	13	6.7	17	5.6	10	5	**47**	**5.4**
Stage 3	6	3.7	10	5.1	12	3.9	4	2	**32**	**3.7**
Stage 4	-	-	-	-	1	0.3	-	-	**1**	**0.1**
Stage 5	-	-	1	0.5	1	0.3	1	0.5	**3**	**0.3**
Total	**14**	**8.6**	**31**	**15.9**	**50**	**16.3**	**29**	**14.4**	**124**	**14.3**

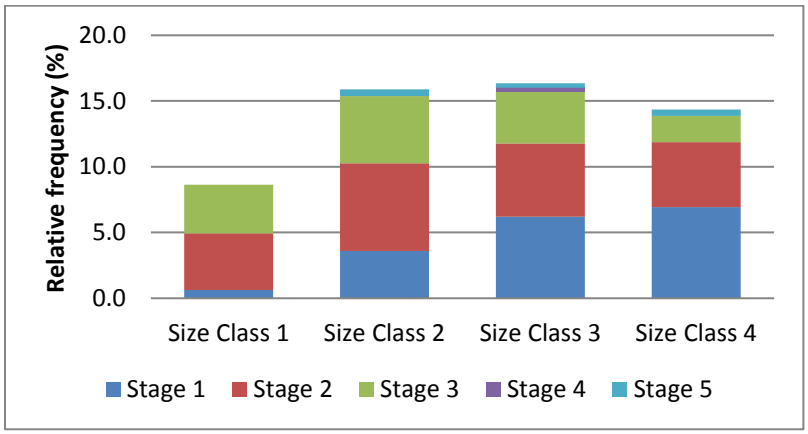


Figure 8.142. Burning intensity by spit in chelonia shell remains from Profile One

Table 8.82. Location of burning on chelonia shell remains from Profile One

	All Over		Outer		Inner		Totals	
	N	%	N	%	N	%	N	%
Carapace	19	82.6	2	8.7	2	8.7	**23**	**23**
Plastron	16	66.7	4	16.7	4	16.7	**24**	**24**
Carapace/Plastron	43	81.1	3	5.7	7	13.2	**53**	**53**
Totals	**78**	**78**	**9**	**9**	**13**	**13**	**100**	

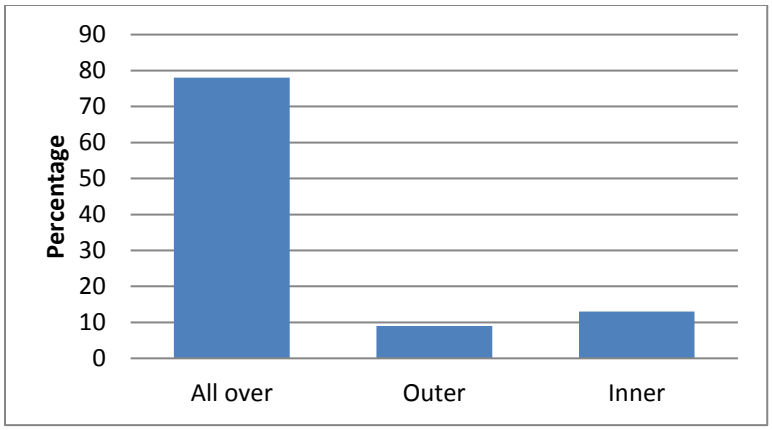


Figure 8.143. Location of burning on tortoise shell remains from Profile One

Table 8.83. Staining in chelonia remains from Profile One

	Appendicular/Axial		Carapace		Plastron		Carapace/Plastron		Total	
	N	%	N	%	N	%	N	%	N	%
Stage 1	118	47.8	186	57.1	66	37.9	227	62.2	**597**	**53.7**
Stage 2	59	23.9	58	17.8	10	5.7	52	14.2	**179**	**16.1**
Stage 3	13	5.3	12	3.7	3	1.7	18	4.9	**46**	**4.1**
Totals	**190**	**76.9**	**256**	**78.5**	**79**	**45.4**	**297**	**81.4**	**822**	**73.9**

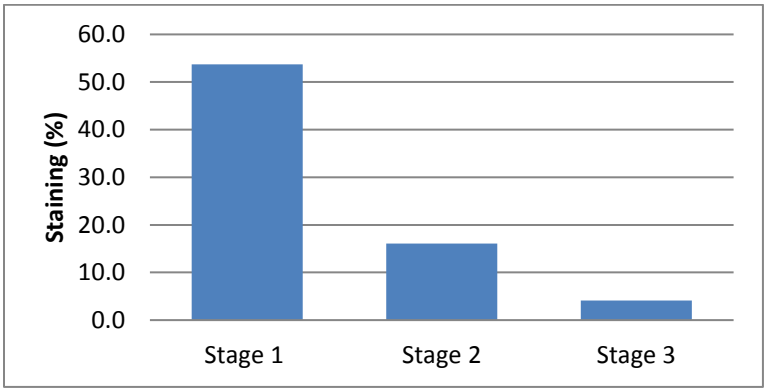


Figure 8.144. Staining intensity of chelonia remains from Profile One

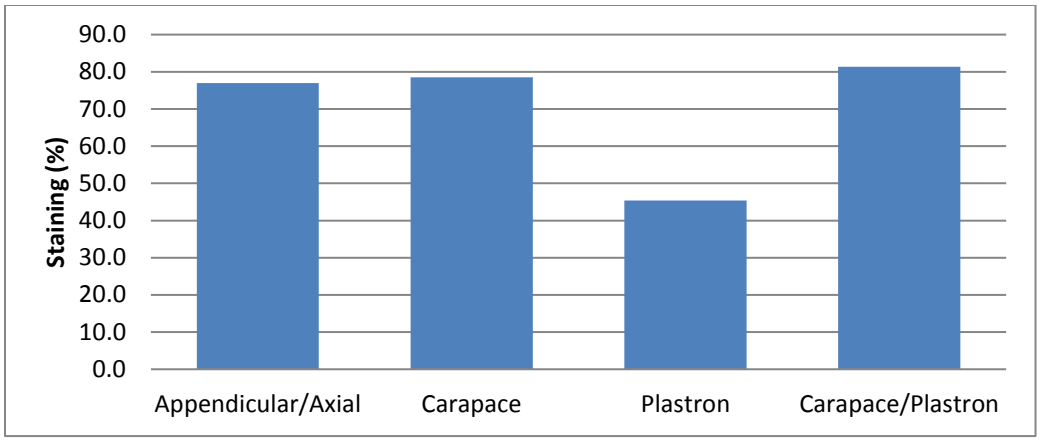


Figure 8.145. Staining in chelonia skeletal parts from Profile One

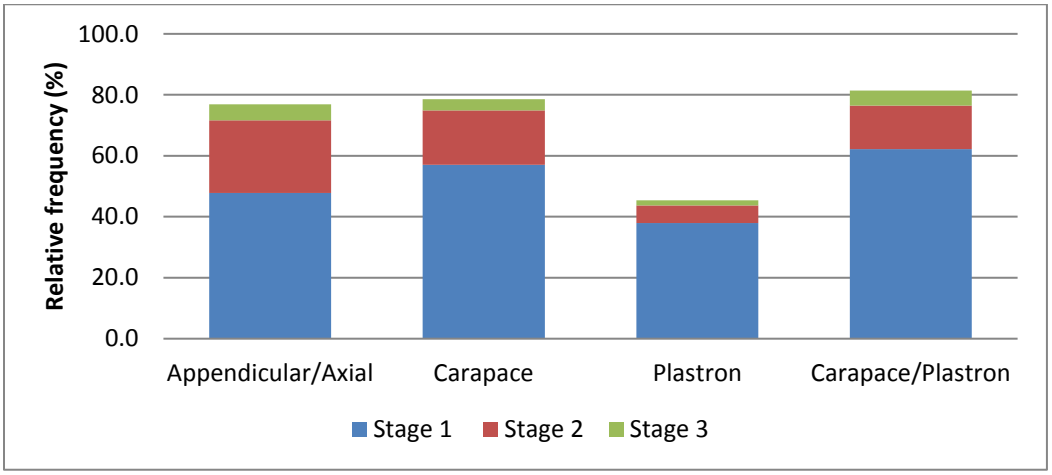


Figure 8.146. Intensity of staining on chelonia skeletal parts from Profile One

Table 8.84. Staining in chelonia appendicular and axial elements from Profile One

	Stage 1		Stage 2		Stage 3		Total	
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Cranium	1	100	-	-	-	-	**1**	**100**
Mandible	2	50	2	50	-	-	**4**	**100**
Scapula	10	58.8	4	23.5	3	17.6	**17**	**81**
Coracoid	4	33.3	7	58.3	1	8.3	**12**	**85.7**
Humerus	11	57.9	7	36.8	1	5.3	**19**	**73.1**
Radius	1	33.3	2	66.6	-	-	**3**	**37.5**
Ulna	3	37.5	4	50	1	12.5	**8**	**72.7**
Ilium	15	62.5	7	29.2	2	8.3	**24**	**82.8**
Ischium	4	57.1	3	42.9	-	-	**7**	**87.5**
Publis	3	60	2	40	-	-	**5**	**71.4**
Femur	13	68.4	6	31.6	-	-	**19**	**76**
Tibia	8	72.7	1	9.1	2	18.2	**11**	**73.3**
Fibula	4	100	-	-	-	-	**4**	**80**
Metacarpal	1	100	-	-	-	-	**1**	**100**
Tarsal/carpal	1	33.3	2	66.6	-	-	**3**	**100**
Proximal phalange	2	100	-	-	-	-	**2**	**100**
Middle phalange	2	100	-	-	-	-	**2**	**100**
Distal phalange	13	72.2	4	22.2	1	5.6	**18**	**78.3**
Phalange	6	75	2	25	-	-	**8**	**80**
Thoracic vertebra	1	100	-	-	-	-	**1**	**100**
vertebra	10	62.5	4	25	2	12.5	**16**	**69.6**
Long bone fragment	3	60	2	40	-	-	**5**	**62.5**
Total	**118**	**62.1**	**59**	**31.1**	**13**	**6.8**	**190**	**76.9**

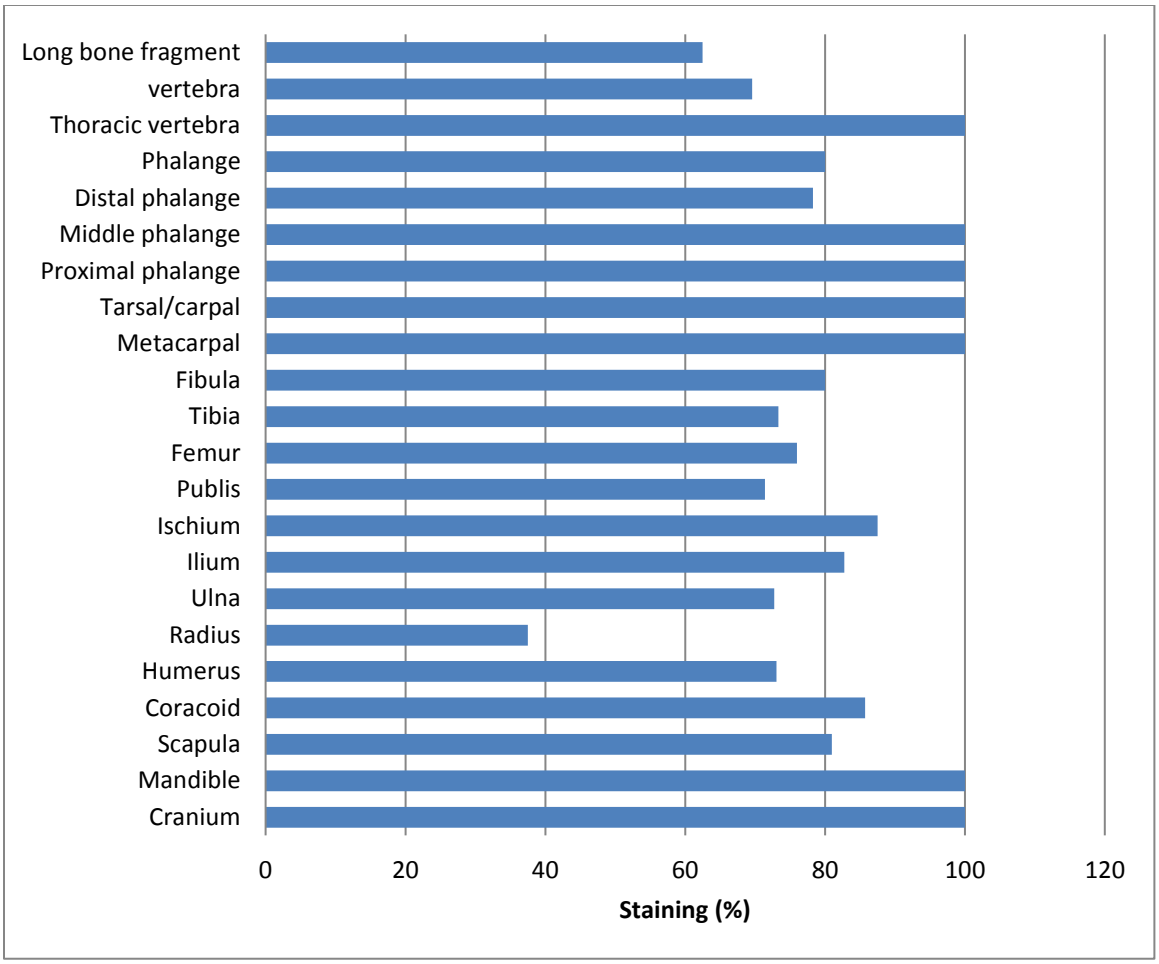


Figure 8.147. Staining in chelonia appendicular and axial elements from Profile One

Table 8.85. Staining intensity with body size class in chelonia shell remains from Profile One

	Size Class 1		Size Class 2		Size Class 3		Size Class 4		Total	
	N	%	**N**	%	**N**	%	**N**	%	**N**	%
Stage 1	93	57.4	118	60.5	180	58.8	88	43.6	**479**	**55.4**
Stage 2	33	20.4	36	18.5	30	9.8	21	10.4	**120**	**13.9**
Stage 3	5	3.1	10	5.1	14	4.6	4	2	**33**	**3.8**
Totals	**131**	**80.9**	**164**	**84.1**	**224**	**73.2**	**113**	**55.9**	**632**	**73.1**

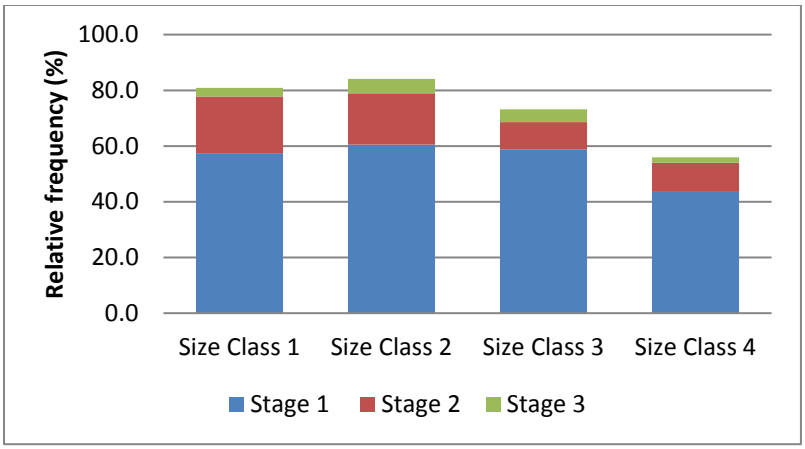


Figure 8.148. Intensity of staining with body size class in chelonia shell remains from Profile One

Table 8.86. Staining colour in chelonia skeletal parts from Profile One

	Brown		Black		Total	
	N	**%**	**N**	**%**	**N**	**%**
Appendicular/Axial	177	23	12	23.5	**189**	**23**
Carapace	241	31.3	15	29.4	**256**	**31.2**
Plastron	71	9.2	8	15.7	**79**	**9.6**
Carapace/Plastron	281	36.5	16	31.4	**297**	**36.2**
Totals	**770**	**93.8**	**51**	**6.2**	**821**	

Table 8.87. Abrasion in chelonia parts from Profile One

	Appendicular/Axial		Carapace		Plastron		Carapace/Plastron		Total	
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Stage 1	122	49.4	150	46	49	28.2	136	37.3	**457**	**41.1**
Stage 2	60	24.3	71	21.8	35	20.1	111	30.4	**277**	**24.9**
Stage 3	13	5.3	31	9.5	29	16.7	69	18.9	**142**	**12.8**
Stage 4	1	0.4	1	0.3	-	-	1	0.3	**3**	**0.3**
Total	**196**	**79.4**	**253**	**77.6**	**113**	**64.9**	**317**	**86.8**	**879**	**79**

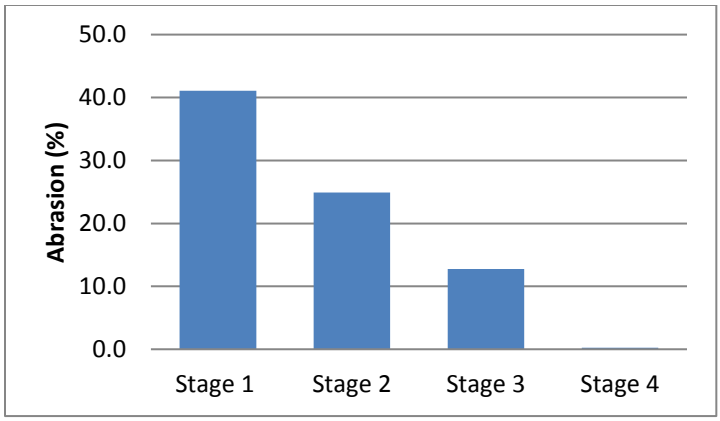


Figure 8.149. Abrasion intensity in chelonia remains from Profile One

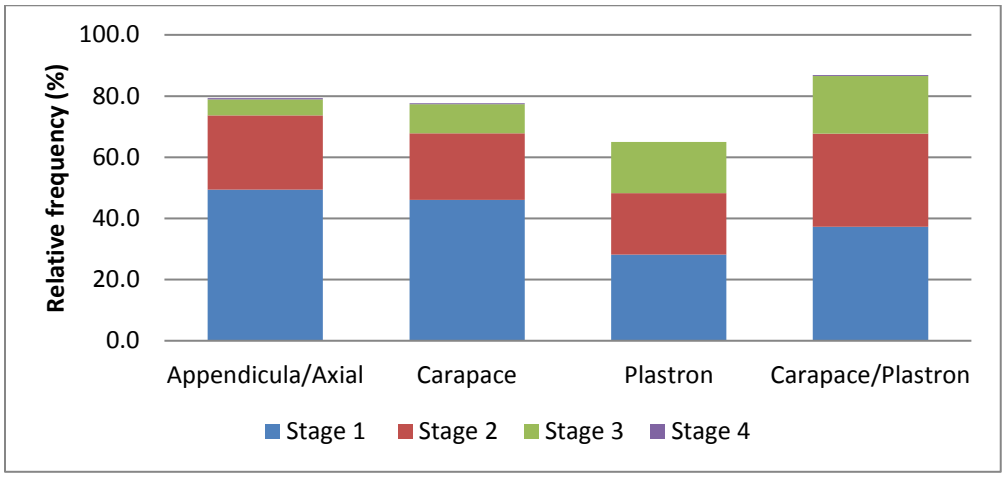


Figure 8.150. Intensity of abrasion in chelonia parts from Profile One

Table 8.88. Abrasion intensity with body size class in chelonia shell remains from Profile One

	Size Class 1		Size Class 2		Size Class 3		Size Class 4		Total	
	N	%	N	%	N	%	N	%	N	%
Stage 1	77	47.5	79	40.5	112	36.6	67	33.2	**335**	**38.7**
Stage 2	22	13.6	59	30.3	92	30.1	44	21.8	**217**	**25.1**
Stage 3	17	10.5	37	19	45	14.7	30	14.9	**129**	**14.9**
Stage 4	1	0.6	-	-	1	0.3	-	-	**2**	**0.2**
Total	**117**	**72.2**	**175**	**89.7**	**250**	**81.7**	**141**	**69.8**	**683**	**79**

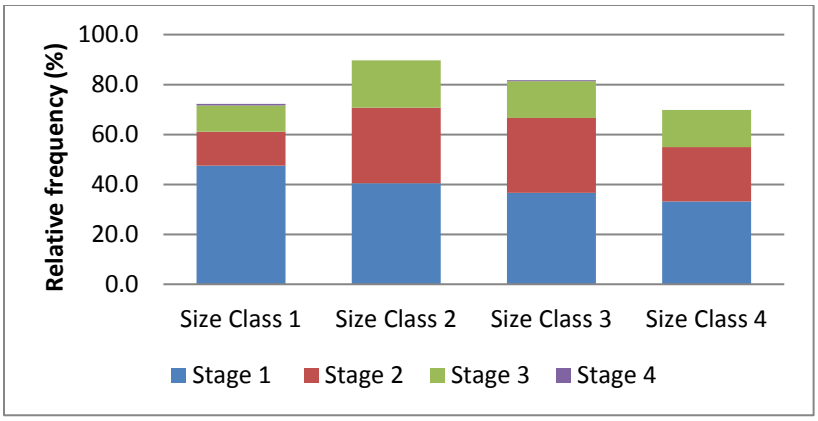


Figure 8.151. Intensity of abrasion with body size class in chelonia shell remains from Profile One

Table 8.89. Sheen intensity in chelonia remains from Profile One

	Appendicular/Axial		Carapace		Plastron		Carapace/Plastron		Total	
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Stage 1	55	22.3	97	29.8	65	37.4	113	31	**330**	**29.7**
Stage 2	46	18.6	29	8.9	15	8.6	39	10.7	**129**	**11.6**
Stage 3	37	15	7	2.1	1	0.6	11	3	**56**	**5**
Stage 4	2	0.8	-	-	-	-	-	-	**2**	**0.2**
Total	**140**	**56.7**	**133**	**40.8**	**81**	**46.6**	**163**	**44.7**	**517**	**46.5**

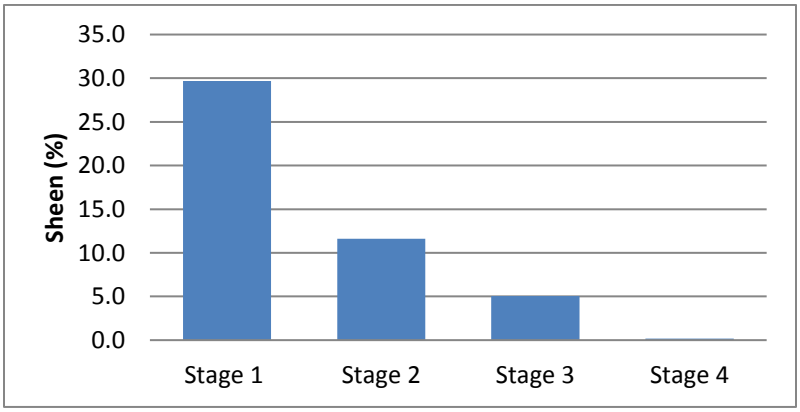


Figure 8.152. Sheen intensity in chelonia remains from Profile One

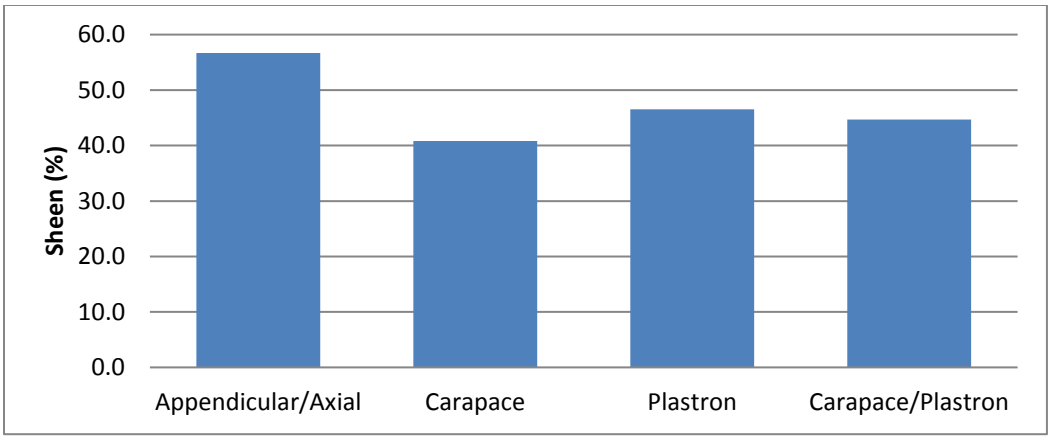


Figure 8.153. Relative frequency of sheen in chelonia parts from Profile One

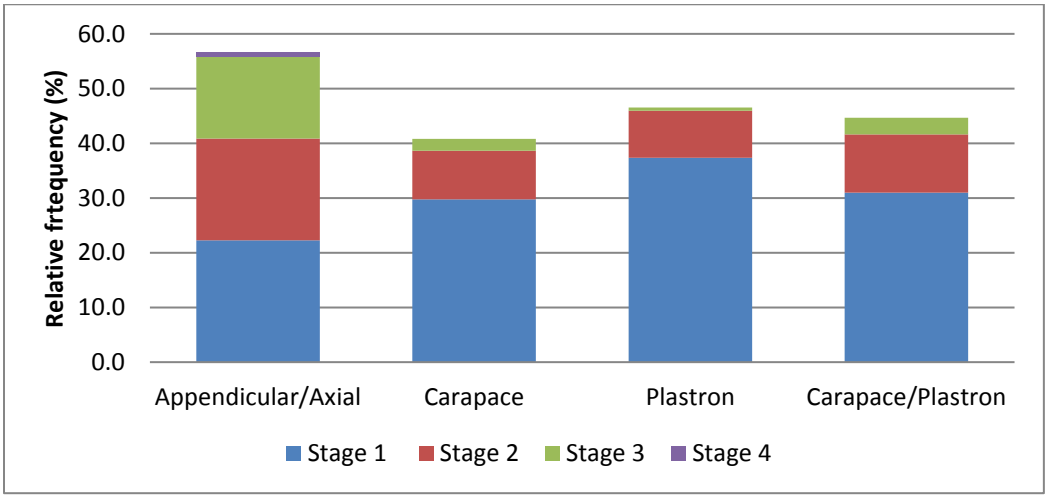


Figure 8.154. Intensity of sheen in chelonia parts from Profile One

Table 8.90. Sheen intensity with body size class in chelonia shell remains from Profile One

	Size Class 1		Size Class 2		Size Class 3		Size Class 4		Total	
	N	%	N	%	N	%	N	%	N	%
Stage 1	47	29	55	28.2	98	32	75	37.1	**275**	**31.8**
Stage 2	21	13	20	10.3	28	9.2	14	6.9	**83**	**9.6**
Stage 3	11	6.8	3	1.5	3	1	2	1	**19**	**2.2**
Total	**79**	**48.8**	**78**	**40**	**129**	**42.2**	**91**	**45**	**377**	**43.6**

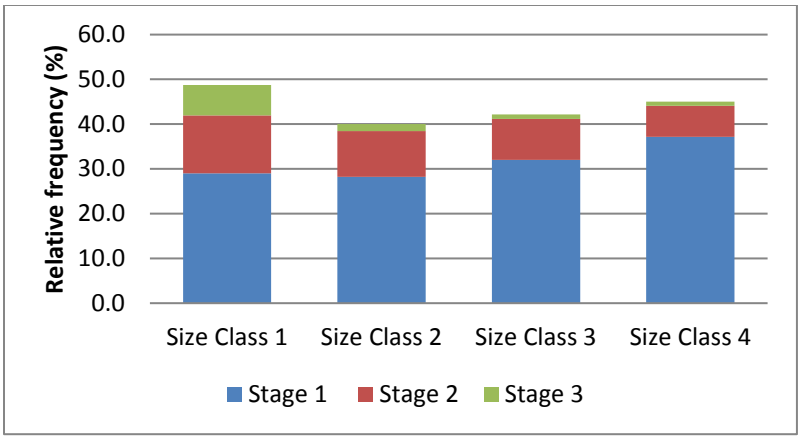


Figure 8.155. Intensity of sheen with body size class in chelonia shell from Profile One

Table 8.91. Trampling in chelonia parts from Profile One

	Appendicular/Axial		Carapace		Plastron		Carapace/Plastron		Total	
	N	%	**N**	%	**N**	%	**N**	%	**N**	**%**
Stage 1	69	27.9	82	25.2	53	30.5	125	34.2	**329**	**38**
Stage 2	11	4.5	18	5.5	12	6.9	37	10.1	**78**	**9**
Total	**80**	**32.4**	**100**	**30.7**	**65**	**37.4**	**162**	**44.4**	**407**	**47.1**

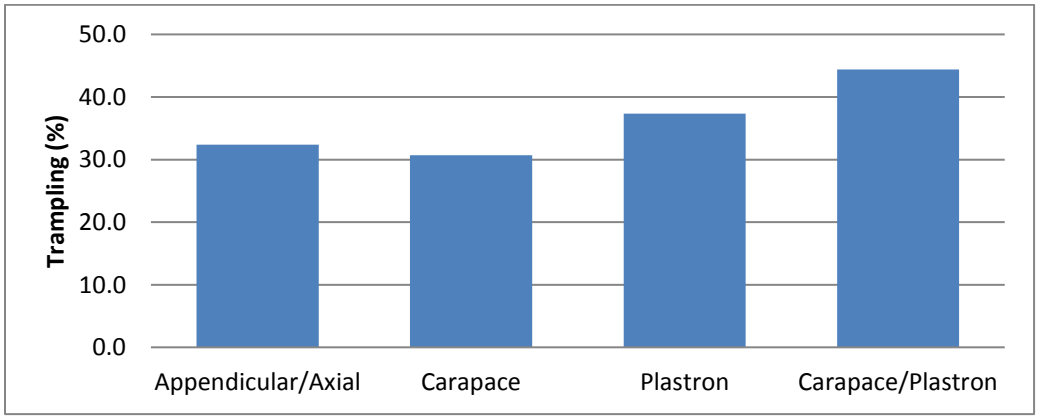


Figure 8.156. Relative frequency of trampling in chelonia parts from Profile One

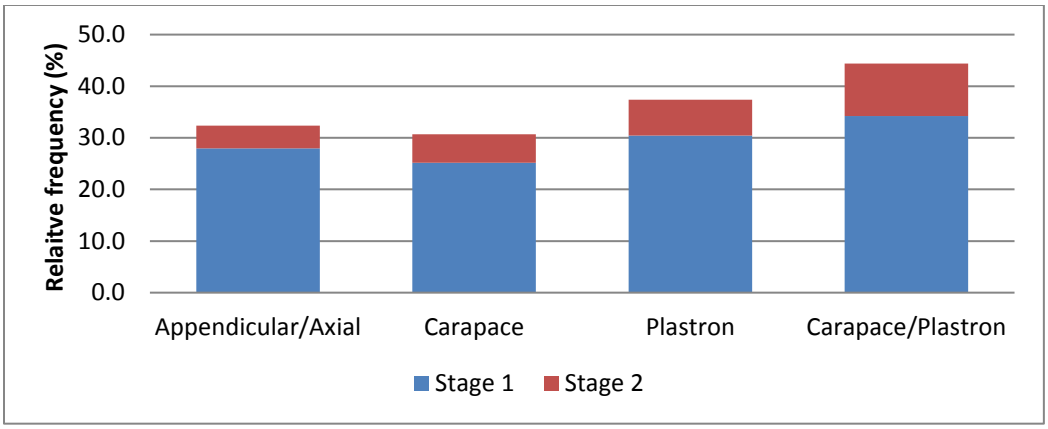


Figure 8.157. Intensity of trampling in chelonia parts from Profile One

Table 8.92. Trampling intensity with body size class in chelonia shell remains from Profile One

	Size Class 1		Size Class 2		Size Class 3		Size Class 4		Total	
	N	%	N	%	N	%	N	%	N	%
Stage 1	29	17.9	56	28.7	105	34.3	70	34.7	**260**	**30.1**
Stage 2	2	1.2	12	6.2	36	11.8	17	8.4	**67**	**7.7**
Total	**31**	**19.1**	**68**	**34.9**	**141**	**46.1**	**87**	**43.1**	**327**	**37.8**

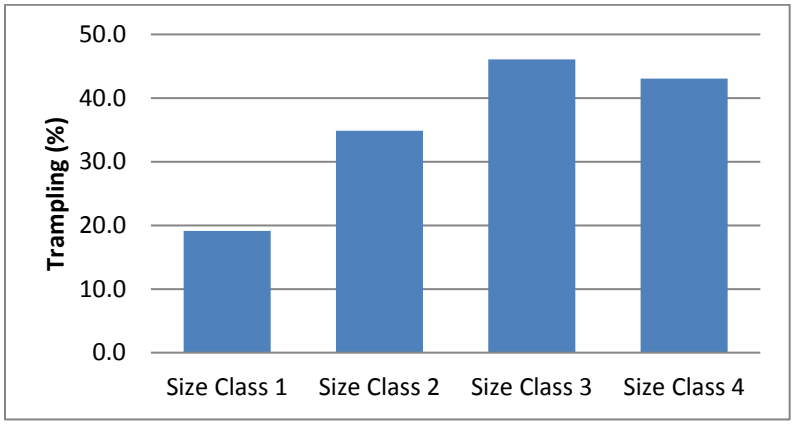


Figure 8.158. Trampling intensity in chelonia shell remains from Profile One

Table 8.93. Carnivore tooth marked bones in chelonia remains from Profile One

	Appendicular/Axial		Carapace		Plastron		Carapace/Plastron		Total	
	N	%	N	%	N	%	N	%	N	%
Stage 1	10	4.	12	3.7	5	2.9	13	3.6	**40**	**3.6**
Stage 2	1	0.4	4	1.2	-	-	4	1.1	**9**	**0.8**
Total	**11**	**4.5**	**16**	**4.9**	**5**	**2.9**	**17**	**4.7**	**49**	**4.4**

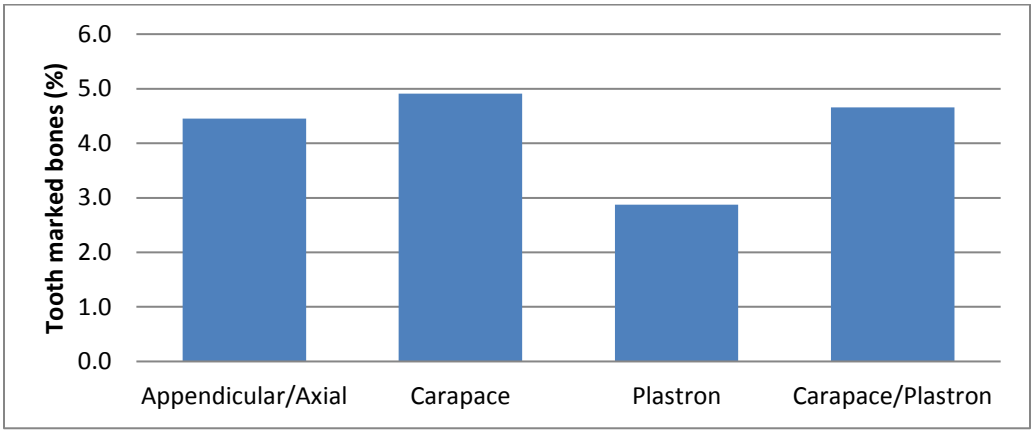


Figure 8.159. Relative frequency of carnivore tooth marked bones in chelonia parts from Profile One

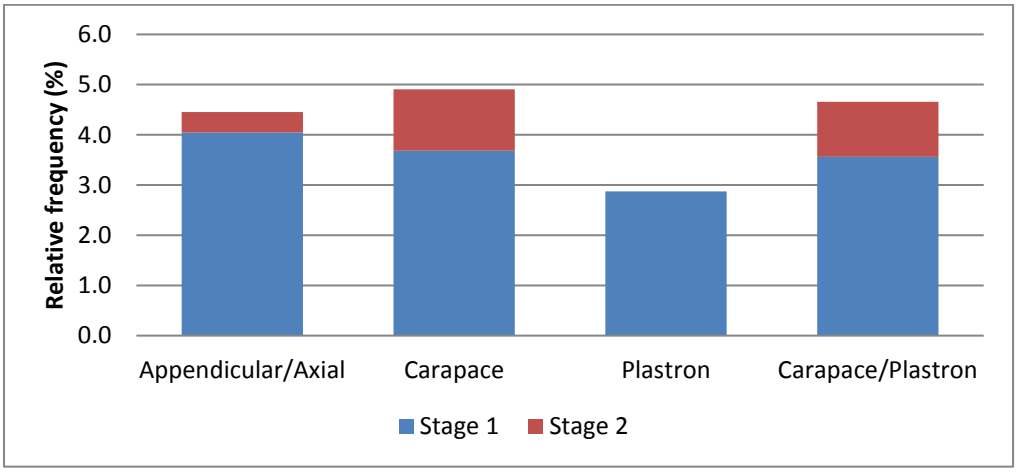


Figure 8.160. Intensity of tooth marked chelonian bones from Profile One

Table 8.94. Carnivore tooth marks in chelonia appendicular remains from Profile One

	Stage 1		Stage 2		Total	
	N	**%**	**N**	**%**	**N**	**%**
Humerus	2	100	-	-	**2**	**25**
Femur	2	100	-	-	**2**	**8**
Tibia	1	50	1	50	**2**	**13.3**
Fibula	2	100	-	-	**2**	**40**
Ilium	2	100	-	-	**2**	**6.9**
Ischium	1	100	-	-	**1**	**12.5**
Total	**10**	**90.9**	**1**	**9.09**	**11**	**4.5**

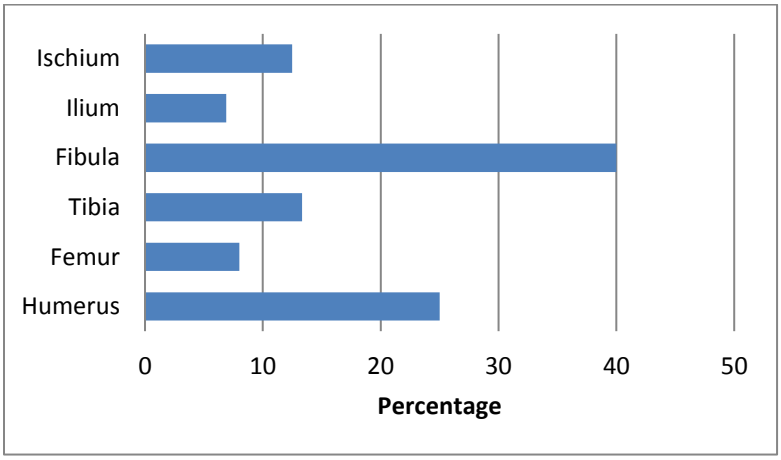


Figure 8.161. Relative frequency of carnivore tooth marks in tortoise appendicular remains from Profile One

Table 8.95. Carnivore tooth marks with body size class in chelonia shell remains from Profile One

	Size Class 1		Size Class 2		Size Class 3		Size Class 4		Total	
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Stage 1	2	1.2	8	4.1	12	3.9	8	4	**30**	**3.5**
Stage 2	-	-	2	1	4	1.3	2	1	**8**	**0.9**
Total	**2**	**1.2**	**10**	**5.1**	**16**	**5.2**	**10**	**5**	**38**	**4.4**

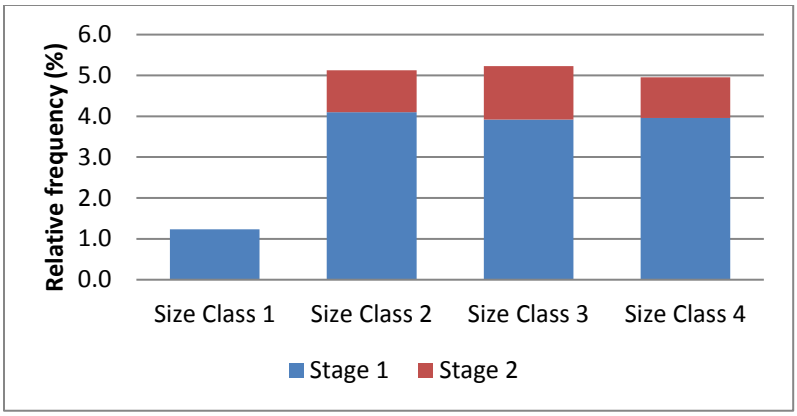


Figure 8.162. Intensity of carnivore tooth marks with body size class in chelonia shell remains from Profile One

Table 8.96. Digestive corrosion in chelonia remains from Profile One

	Appendicular/Axial		Carapace		Carapace/Plastron		Total	
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Stage 1	12	4.9	3	0.9	2	0.5	**17**	**1.5**
Stage 2	2	0.8					**2**	**0.2**
Total	**14**	**5.7**	**3**	**0.9**	**2**	**0.5**	**19**	**1.7**

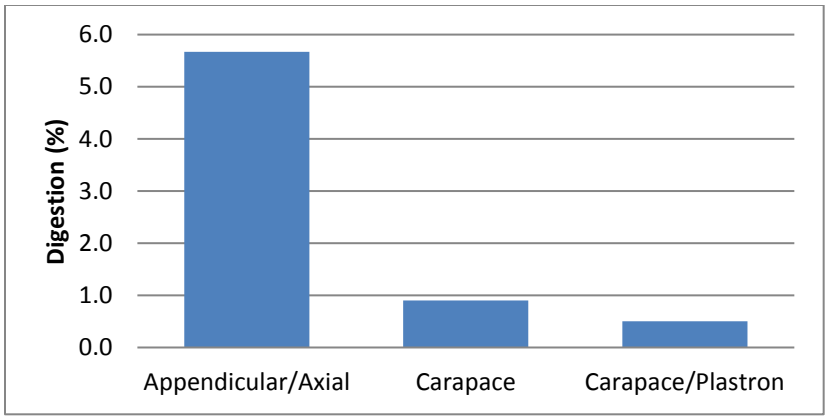


Figure 8.163. Relative frequency of digestive corrosion in chelonia remains from Profile One

Table 8.97. Digestive corrosion in chelonia appendicular remains from Profile One

	Stage 1		Stage 2		Total	
	N	**%**	**N**	**%**	**N**	**%**
Ulna	2	100	-	-	**2**	**18.2**
Ilium	1	100	-	-	**1**	**3.4**
Publis	1	100	-	-	**1**	**14.3**
Femur	1	100	-	-	**1**	**4**
Tibia	1	100	-	-	**1**	**6.7**
Proximal phalange	1	100	-	-	**1**	**50**
Middle phalange	2	100	-	-	**2**	**100**
Distal phalange	1	100	-	-	**1**	**4.3**
Phalange	2	50	2	50	**4**	**40**
Total	**12**	**85.7**	**2**	**14.3**	**14**	**5.7**

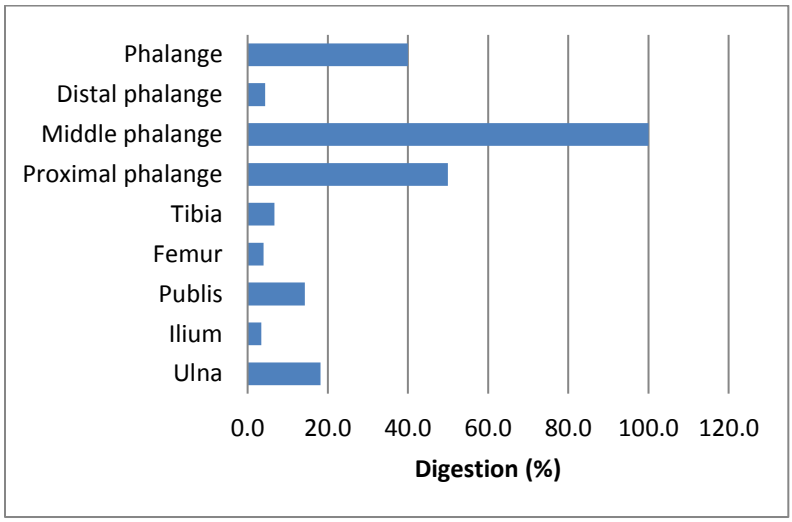


Figure 8.164. Digestive corrosion in chelonia appendicular remains from Profile One

Table 8.98. Root etching in chelonia parts from Profile One

	Appendicular/Axial		Carapace		Plastron		Carapace/Plastron		Total	
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Stage 1	25	10.1	44	13.5	28	16.1	85	23.3	**182**	**16.4**
Stage 2	11	4.5	22	6.7	8	4.6	37	10.1	**78**	**7**
Stage 3	1	0.4	-	-	-	-	4	1.1	**5**	**0.4**
Total	**37**	**15**	**66**	**20.2**	**36**	**20.7**	**126**	**34.5**	**265**	**23.8**

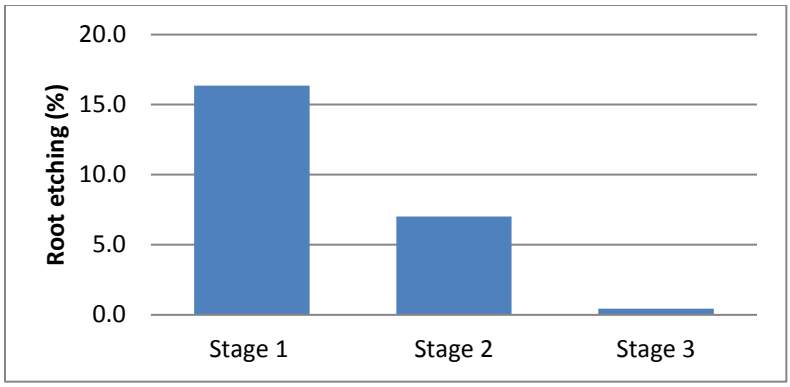


Figure 8.165. Root etching intensity in chelonia remains from Profile One

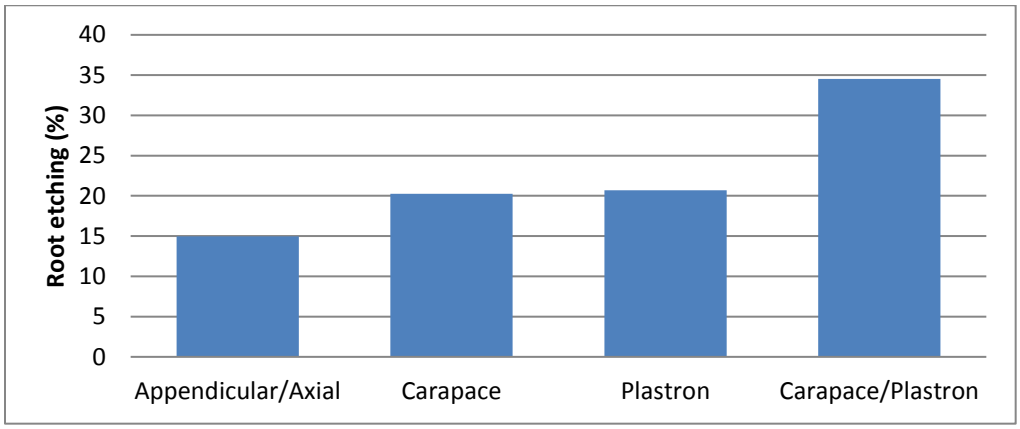


Figure 8.166. Relative frequency of root etching in chelonia parts from Profile One

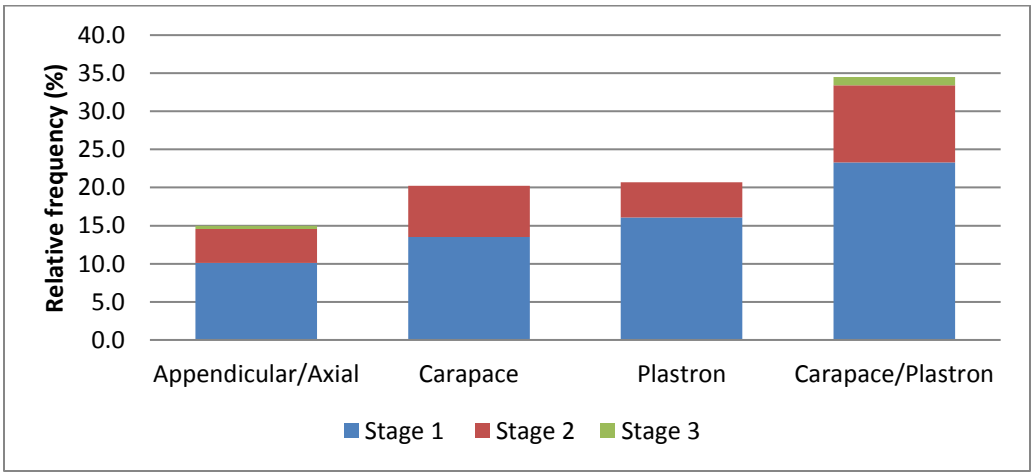


Figure 8.167. Intensity of root etching in chelonia parts from Profile One

Table 8.99. Root etching in appendicular and axial chelonians remains from Profile One

	Stage 1		Stage 2		Stage 3		Total	
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Scapula	-	-	3	100	-	-	**3**	**14.3**
Coracoid	2	50	1	25	1	25	**4**	**28.6**
Humerus	7	77.8	2	22.2	-	-	**9**	**34.6**
Radius	2	100	-	-	-	-	**2**	**25**
Ulna	-	-	1	100	-	-	**1**	**9.1**
Ilium	5	83.3	1	16.7	-	-	**6**	**20.7**
Publis	1	100	-	-	-	-	**1**	**14.3**
Femur	3	75	1	-	-	-	**4**	**16**
Tibia	1	100	-	-	-	-	**1**	**6.7**
Fibula	-	-	1	100	-	-	**1**	**20**
Distal phalange	1	100	-	-	-	-	**1**	**4.3**
Vertebra	2	66.6	1	33.3	-	-	**3**	**13**
Long bone fragment	1	100	-	-	-	-	**1**	**12.5**
Total	**25**	**15.4**	**11**	**5.6**	**1**	**0.3**	**37**	**15**

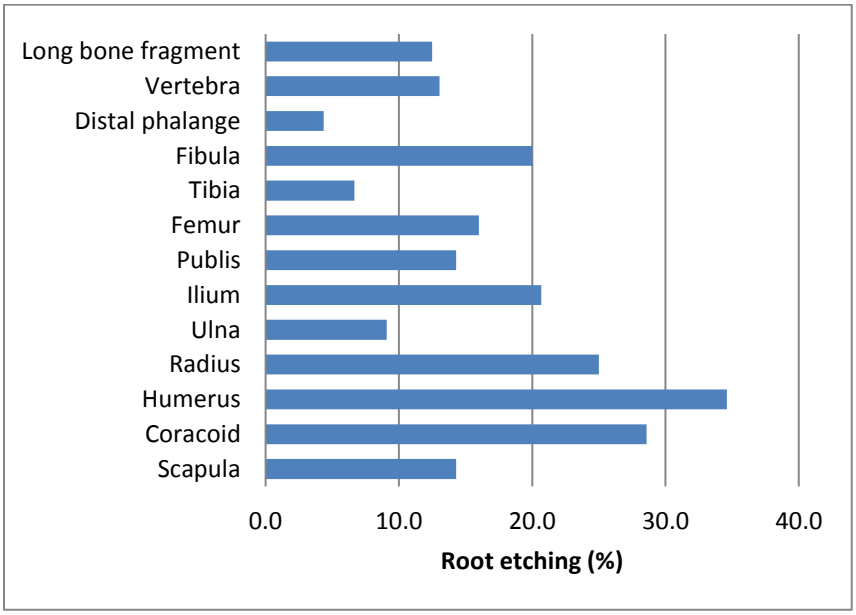


Figure 8.168. Root etching in appendicular and axial chelonia remains from Profile One

Table 8.100. Root etching with body size class in chelonia shell remains from Profile One

	Size Class 1		Size Class 2		Size Class 3		Size Class 4		Total	
	N	%	**N**	%	**N**	%	**N**	%	**N**	%
Stage 1	17	10.5	35	17.9	68	22.2	37	18.3	**157**	**18.2**
Stage 2	7	4.3	16	8.2	29	9.5	15	7.4	**67**	**7.7**
Stage 3	-	-	2	1	2	0.7	-	-	**4**	**0.5**
Total	**24**	**14.8**	**53**	**27.2**	**99**	**32.4**	**52**	**25.7**	**228**	**26.4**

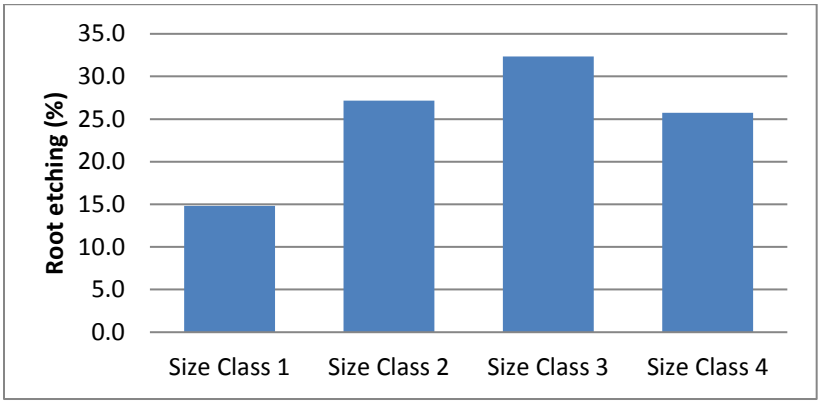


Figure 8.169. Relative frequency of root etching with body size class in chelonia shell remains from Profile One

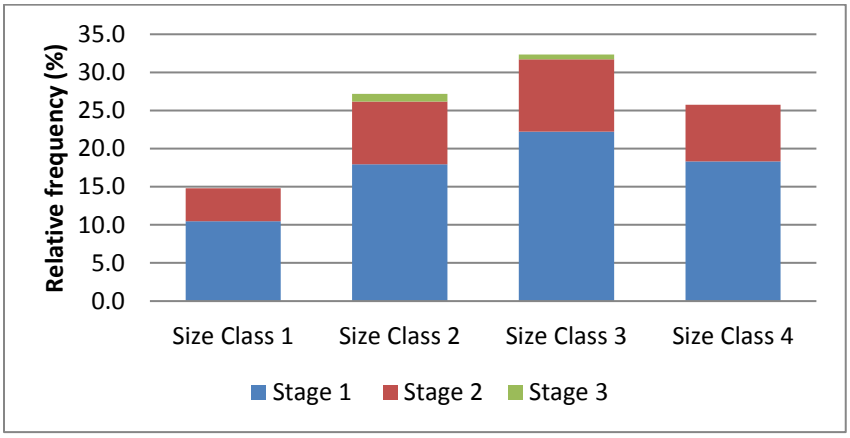


Figure 8.170. Intensity of root etching with body size class in chelonian shell remains from Profile One

Table 8.101. Avian species representation and body size class in Profile One

	Size Class 1		Size Class 2		Size Class 3		Size Class 4		Total	
	N	%	N	%	N	%	N	%	N	%
Phasianidae	-	-	-	-	2	100	-	-	**2**	**3**
aff. Ciconiiforme	-	-	-	-	-	-	1	100	**1**	**1.5**
Passerine	1	100	-	-	-	-	-	-	**1**	**1.5**
Unid. aves	5	7.8	25	39.1	28	43.8	5	7.8	**63**	**94**
Total	**6**	**9**	**25**	**37.3**	**30**	**44.8**	**6**	**9**	**67**	

Table 8.102. Avian remains by spit from Profile One

	Spit1		Spit2		Spit3		Spit4		Total	
	N	%	N	%	N	%	N	%	N	%
Phasianidae	2	100	-	-	-	-	-	-	**2**	**3**
aff. Ciconiiforme	-	-	1	100	-	-	-	-	**1**	**1.5**
Passerine	-	-	1	100	-	-	-	-	**1**	**1.5**
Unid. aves	15	23.4	35	54.7	12	18.8	1	1.6	**63**	**94**
Total	**17**	**4**	**37**	**5.4**	**12**	**5.7**	**1**	**10**	**67**	

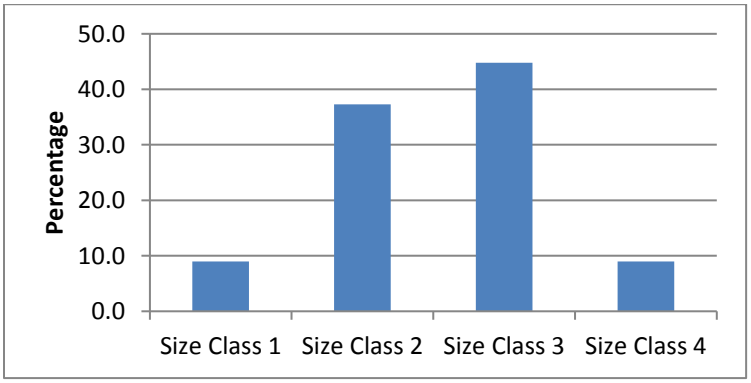


Figure 9.171. Body size class in aves from Profile One

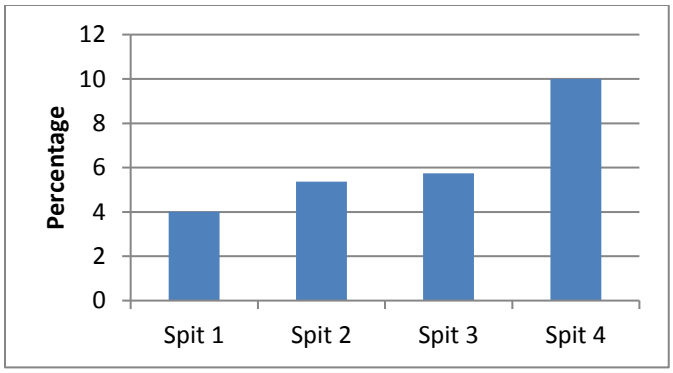


Figure 8.172. Relative frequency of avian remains by spit in Profile One

Table 8.103. Anatomical composition and body size in avian remains from Profile One

	Size Class 1		Size Class 2		Size Class 3		Size Class 4		Total	
Element	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Sternum	-	-	-	-	1	100	-	-	**1**	**1.5**
Scapula	1	25	-	-	3	75	-	-	**4**	**6**
Coracoid	2	18.2	3	27.3	6	54.5	-	-	**11**	**16.4**
Humerus	-	-	-	-	1	50	1	50	**2**	**3**
Radius	-	-	1	50	-	-	1	50	**2**	**3**
Ulna	-	-	1	20	3	60	1	20	**5**	**7.5**
Carpometacarpus	-	-	-	-	2	100	-	-	**2**	**3**
Second wing phalange	1	33.6	1	33.3	1	33.3	-	-	**3**	**4.5**
Innominate	-	-	-	-	1	100	-	-	**1**	**1.5**
Femur	-	-	4	75	1	25	-	-	**5**	**7.5**
Tibiotarsus	1	10	7	70	2	20	-	-	**10**	**14.9**
Tarsometatarsus	-	-	3	42.9	3	42.9	1	14.3	**7**	**10.4**
Tarsal/carpal	-	-	-	-	-	-	1	100	**1**	**1.5**
Cervical vertebra	-	-	-	-	2	100	-	-	**2**	**3**
Vertebra	1	20	3	60	1	20	-	-	**5**	**7.5**
Ribs	-	-	-	-	2	100	-	-	**2**	**3**
Long bone fragment	-	-	2	50	2	50	-	-	**4**	**6**
Total	**6**	**9**	**25**	**37.3**	**31**	**46.3**	**5**	**7.5**	**67**	**5**

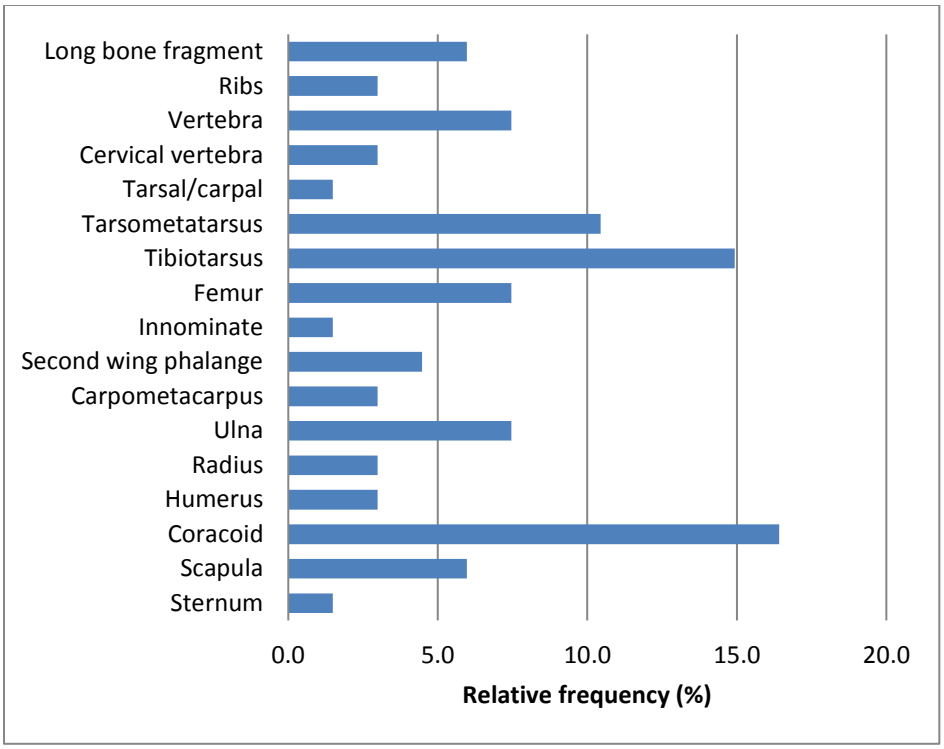


Figure 8.173. Relative frequency of skeletal elements in aves from Profile One



Figure 8.174. Body size class and skeletal element representation in aves from Profile One

Table 8.104. Anatomical composition by spit in avian remains from Profile One

	Spit1		Spit2		Spit3		Spit 4		Total	
Element	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Sternum	-	-	-	-	1	100	-	-	**1**	**1.5**
Scapula	1	25	3	75	-	-	-	-	**4**	**6**
Coracoid	1	9.1	9	81.8	1	9.1	-	-	**11**	**16.4**
Humerus	1	50	1	50	-	-	-	-	**2**	**3**
Radius	1	50	1	50	-	-	-	-	**2**	**3**
Ulna	2	40	2	40	1	20	-	-	**5**	**7.5**
Carpometacarpus	1	50	1	50	-	-	-	-	**2**	**3**
Second wing phalange	-	-	-	-	2	66.6	1	33.3	**3**	**4.5**
Innominate	-	-	1	100	-	-	-	-	**1**	**1.5**
Femur	2	40	3	60	-	-	-	-	**5**	**7.5**
Tibiotarsus	4	40	4	40	2	20	-	-	**10**	**14.9**
Tarsometatarsus	2	28.6	4	57.1	1	14.3	-	-	**7**	**10.4**
Tarsal/carpal	-	-	-	-	1	100	-	-	**1**	**1.5**
Cervical vertebra	-	-	2	100	-	-	-	-	**2**	**3**
Vertebra	-	-	5	100	-	-	-	-	**5**	**7.5**
Ribs	-	-	-	-	2	100	-	-	**2**	**3**
Long bone fragment	2	50	1	25	1	25	-	-	**4**	**6**
Total	**17**	**4**	**37**	**5.4**	**12**	**5.9**	**1**	**10**	**67**	

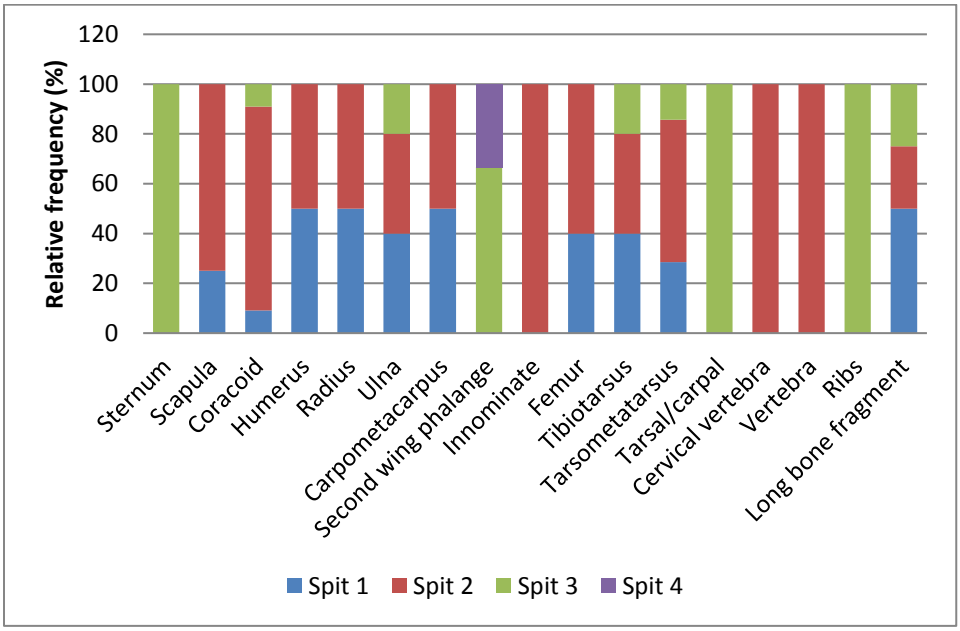


Figure 8.175. Skeletal element representation by spit in aves from Profile One

Table 8.105. Skeletal frequencies in avian remains from Profile One

Element	NISP	MNE	MAU	%MAU	MNI
Sternum	1	1	1	20	1
Scapula	4	2	2	40	2
Coracoid	11	5	5	100	5
Humerus	2	2	2	40	2
Radius	2	2	2	40	2
Ulna	5	4	3	60	3
Carpometacarpus	2	2	2	40	2
Second wing phalange	3	3	3	60	3
Innominate	1	1	1	20	1
Femur	5	4	3	60	3
Tibiotarsus	10	4	4	80	4
Tarsometatarsus	7	3	2	40	2
Tarsal/carpal	1	1	1	20	1
Cervical vertebra	2	2	2	40	2
Vertebra	5	4	4	80	4
Ribs	2	1	1	20	1
Long bone fragment	4	2	2	40	2
Total	**67**				**5**

Table 8.106. Descriptive statistics of maximum length in avian remains from Profile One

	Combined	Size Class 1	Size Class 2	Size Class 3	Size Class 4
N	67	6	25	31	5
Minimum	7	9	7	8	11
Maximum	32	14	31	32	27
Mean	16.6	11.7	16	17.5	20.7
Standard Deviation	6.2	1.86	6.32	6.21	6.07

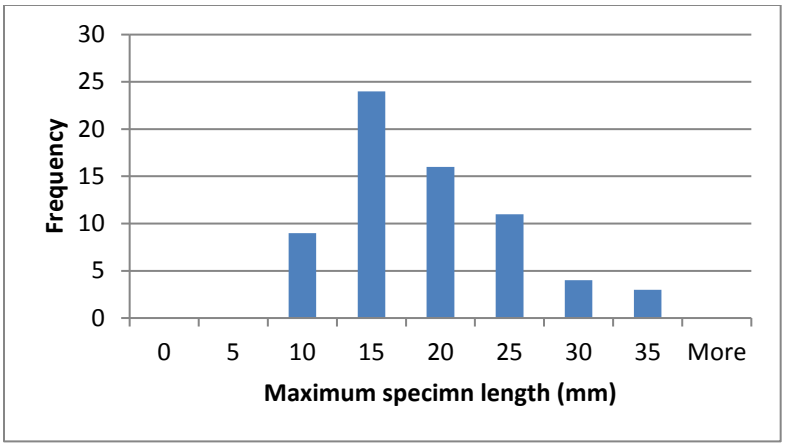


Figure 8.176. Histogram of maximum length of combined avian remains from Profile One

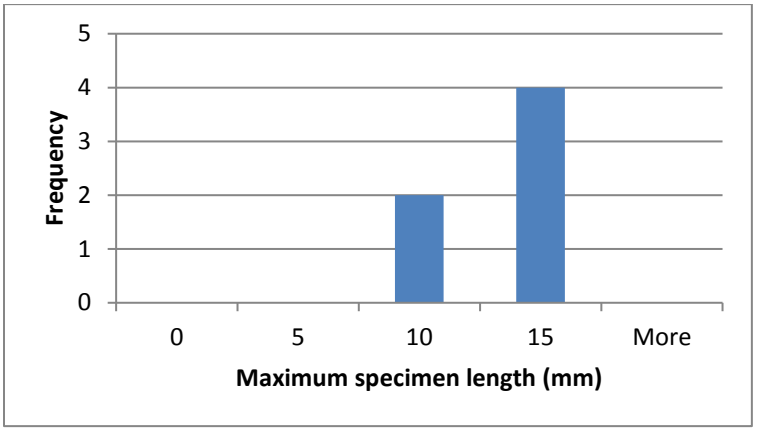


Figure 8.177. Histogram of maximum length of size class one avian remains from Profile One

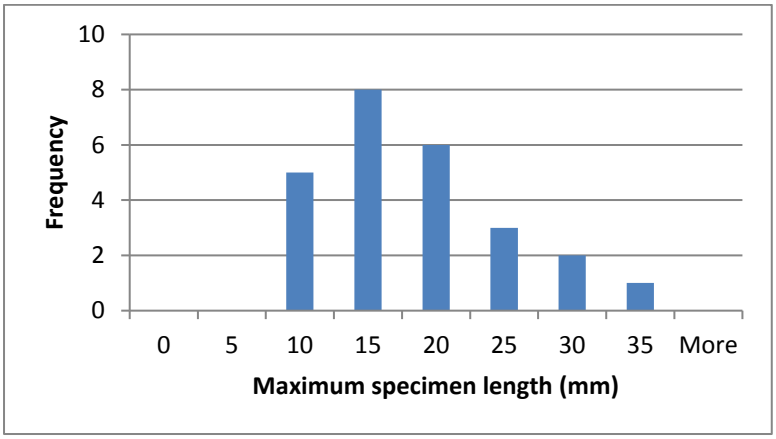


Figure 8.178. Histogram of maximum length of size class two avian remains from Profile One

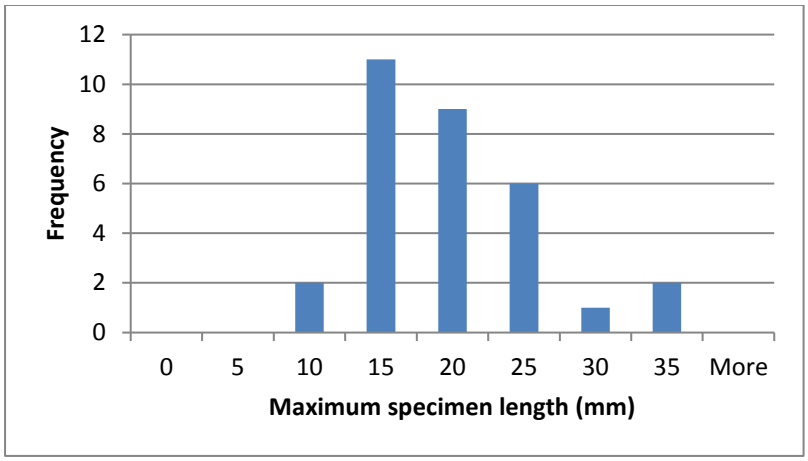


Figure 8.179. Histogram of maximum length of size class three avian remains from Profile One

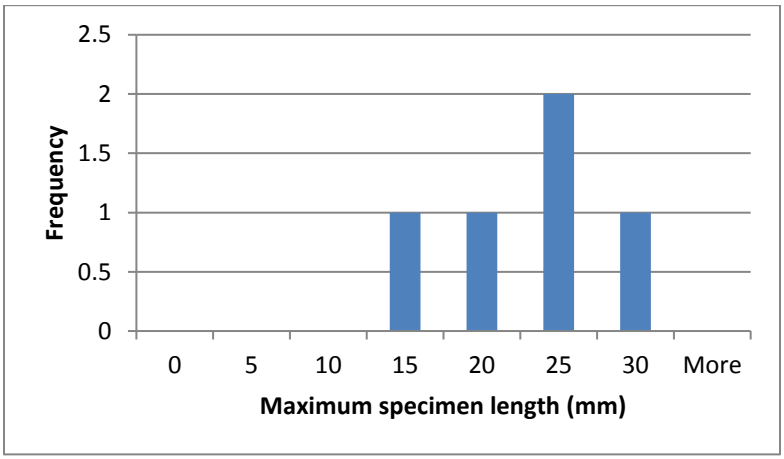


Figure 8.180. Histogram of maximum length of size class four avian remains from Profile One

Table 8.107. Epiphyseal fusion in aves from Profile One

	Size class 1		Size class 2		Size class 3		Size class 4		Total	
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Adult	4	8.9	19	42.2	18	40	4	8.9	**45**	**97.8**
Juvenile	-	-	-	-	1	100	-	-	**1**	**2.2**
Total	**4**	**8.7**	**19**	**41.3**	**19**	**41.3**	**4**	**8.7**	**46**	**68.7**

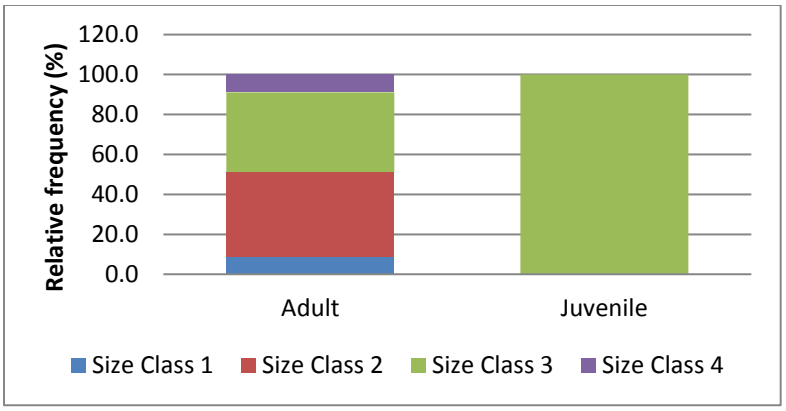


Figure 8.181. Epiphyseal fusion in aves from Profile One

Table 8.108. Completeness by body size class in avian remains from Profile One

	Size Class 1		Size Class 2		Size Class 3		Total	
Element	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Coracoid	2	66.6	1	33.3	-	-	**3**	**42.9**
Second wing phalange	-	-	1	100	-	-	**1**	**14.3**
Cervical vertebra	-	-	-	-	2	100	**2**	**28.6**
Vertebra	-	-	1	100	-	-	**1**	**14.3**
Total	**2**	**28.6**	**3**	**42.9**	**2**	**28.6**	**7**	**10.4**

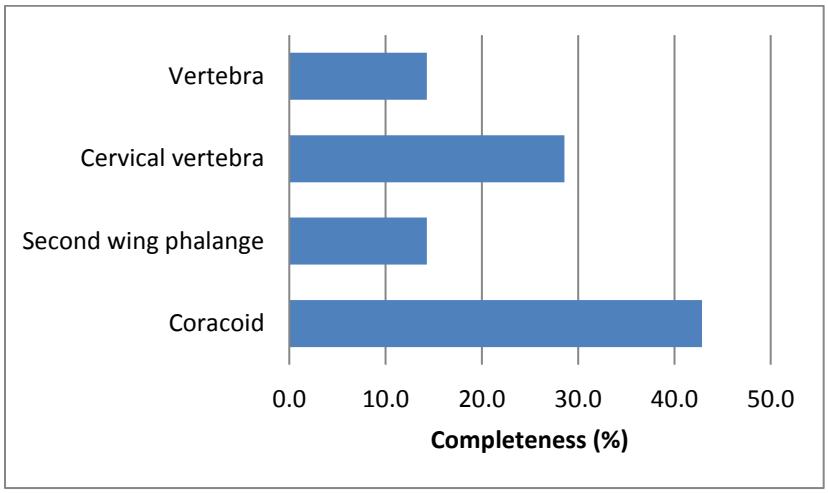


Figure 8.182. Relative frequency of completeness in avian elements from Profile One

Table 8.109. Completeness by spit in avian remains from Profile One

	Spit2		Spit4		Total	
Element	**N**	**%**	**N**	**%**	**N**	**%**
Coracoid	3	100	-	-	**3**	**42.9**
Second wing phalange	-	-	1	100	**1**	**14.3**
Cervical vertebra	2	100	-	-	**2**	**28.6**
Vertebra	1	100	-	-	**1**	**14.3**
Total	**6**	**85.7**	**1**	**14.3**	**7**	**10.4**

Table 8.110. Breakage categories in avian remains from Profile One

	Complete		Proximal		Shaft		Distal	
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Humerus	-	-	-	-	-	-	2	100
Radius	-	-	-	-	1	50	1	50
Ulna	-	-	4	80	1	20	-	-
Carpometacarpus	-	-	1	50	1	50	-	-
Second wing phalange	1	33.3	1	33.3	1	33.3	-	-
Femur	-	-	1	20	-	-	4	80
Tibiotarsus	-	-	5	50	3	30	2	20
Tarsometatarsus	-	-	3	50	1	**16.7**	2	**33.3**
Total	**1**	**2.9**	**15**	**42.9**	**8**	**22.9**	**11**	**31.4**

	Complete		Proximal		Shaft	
	N	**%**	**N**	**%**	**N**	**%**
Coracoid	3	27.3	7	63.6	1	9.1

	Glenoid		Blade	
	N	**%**	**N**	**%**
Scapua	1	33.3	2	66.6

	Complete		Centrum	
	N	**%**	**N**	**%**
Vertebra	3	42.9	4	57.1

	Complete		Fragment	
	N	**%**	**N**	**%**
Sternum	-	-	1	100
Innominate	-	-	1	100
Tarsal/carpal	-	-	1	100
Ribs	-	-	2	100
Long bone fragment	-	-	1	100

Table 8.111. Fracture outline in avian long bones with body size class from Profile One

	Spiral (fresh)		Transverse (dry)		Total	
	N	**%**	**N**	**%**	**N**	**%**
Size Class 1	2	25	3	38	**5**	**62.5**
Size Class 2	19	43.2	2	4.5	**21**	**47.7**
Size Class 3	20	47.6	4	9.5	**24**	**57.1**
Size Class 4	3	37.5	1	12.5	**4**	**50**
Total	**44**	**43.1**	**10**	**9.8**	**54**	**52.9**

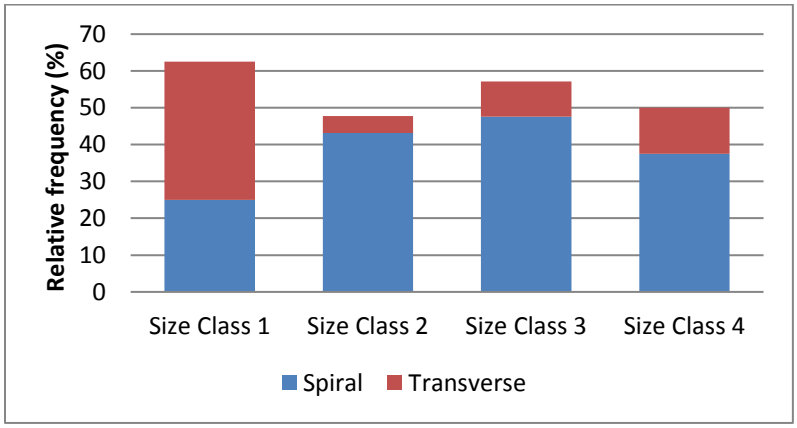


Figure 8.183. Fracture outline in avian remains with body size class from Profile One

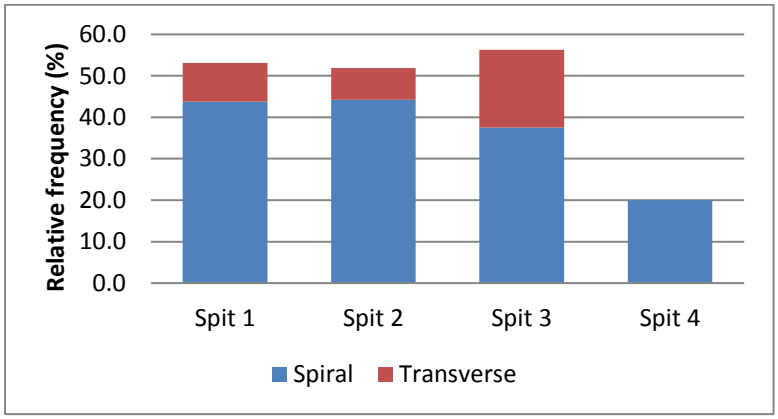


Figure 8.184. Fracture outline in avian remains by spit from Profile One

Table 8.112. Fracture outline in avian remains by spit from Profile One

	Spiral (fresh)		Transverse (dry)		Total	
	N	**%**	**N**	**%**	**N**	**%**
Spit 1	14	43.8	3	9.4	**17**	**53.1**
Spit 2	23	44.2	4	7.7	**27**	**51.9**
Spit 3	6	37.5	3	18.8	**9**	**56.3**
Spit 4	1	20	-	-	**1**	**50**
Total	**44**	**43.1**	**10**	**9.8**	**54**	**52.9**

Table 8.113. Fracture angle in avian remains with body size class from Profile One

	Oblique		Right		Mixed		Total	
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Size Class 1	2	25	1	12.5	2	25	**5**	**62.5**
Size Class 2	6	13.6	7	15.9	10	22.7	**23**	**52.3**
Size Class 3	12	28.6	6	14.3	7	16.7	**25**	**59.5**
Size Class 4	1	12.5	2	25	1	12.5	**4**	**50**
Total	**21**	**36.8**	**16**	**28.1**	**20**	**35.1**	**57**	**55.9**

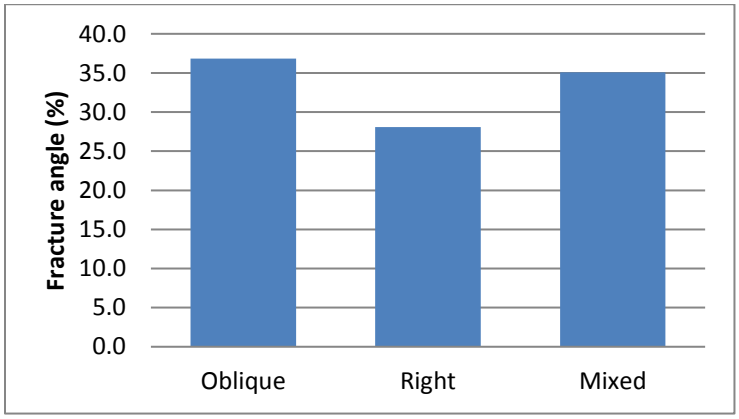


Figure 8.185. Relative frequency of fracture angle in avian remains from Profile One



Figure 8.186. Fracture angle and body size class in avian remains from Profile One

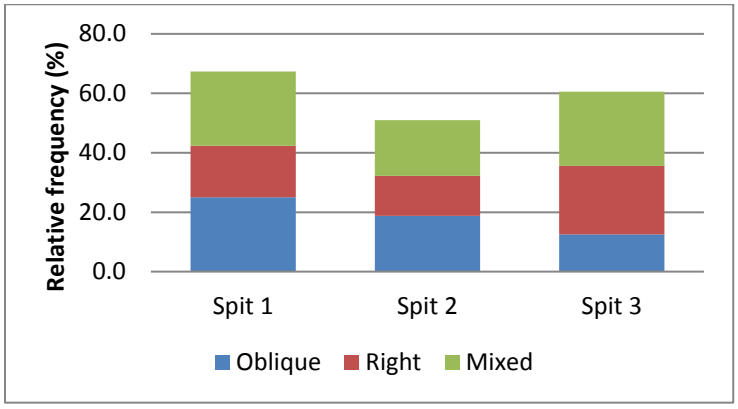


Figure 8.187. Fracture angle by spit in avian remains from Profile One

Table 8.114. Fracture angle by spit in avian remains from Profile One

	Oblique		Right		Mixed		Total	
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Spit 1	8	25	6	18.8	4	12.5	**18**	**56.3**
Spit 2	9	17	7	13	12	23.1	**28**	**53.8**
Spit 3	4	25	3	18.8	4	25	**11**	**68.8**
Total	**21**	**2.4**	**16**	**1.8**	**20**	**2.3**	**57**	**55.9**

Table8.115. Weathering in avian remains from Profile One

	N	%
Coracoid	1	9.1
Humerus	1	50
Ulna	1	20
Innominate	1	100
Femur	1	20
Tarsometatarsus	1	14.3
Cervical vertebra	1	50
Long bone fragment	2	50
Total	**9**	**13.4**

Table 8.116. Burning in avian remains from Profile One

	Stage 2		Stage 3		Total	
	N	%	N	%	N	%
Coracoid	-	-	1	100	**1**	**9.1**
Humerus	-	-	1	100	**1**	**50**
Tibia	2	100	-	-	**2**	**20**
Long bone fragment	-	-	1	100	**1**	**25**
Total	**2**	**40**	**3**	**60**	**5**	**7.5**

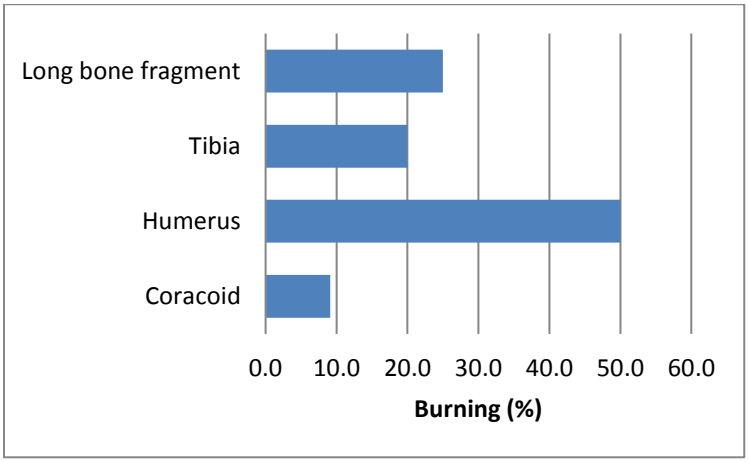


Figure 8.188. Relative frequency of burning in avian elements from Profile One

Table 8.117. Staining intensity with body size class in avian remains from Profile One

	Size Class 1		Size Class 2		Size Class 3		Size Class 4		Total	
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	%
Stage 1	3	50	15	60	13	41.9	1	20	**32**	**47.8**
Stage 2	2	33.3	6	24	8	25.8	3	60	**19**	**28.4**
Stage 3	-	-	2	8	5	16.1	-	-	**7**	**10.4**
Total	**5**	**83.3**	**23**	**92**	**26**	**83.9**	**4**	**80**	**58**	**86.6**

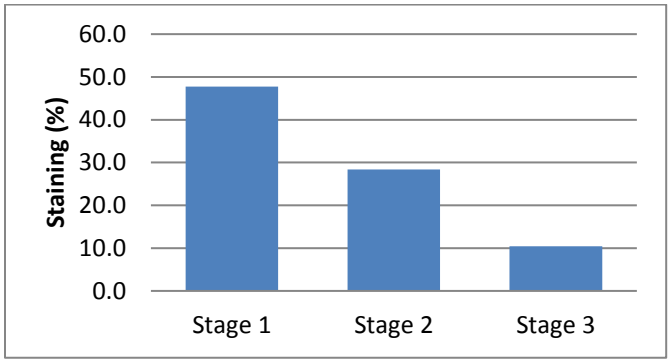


Figure 8.189. Staining intensity in avian remains from Profile One

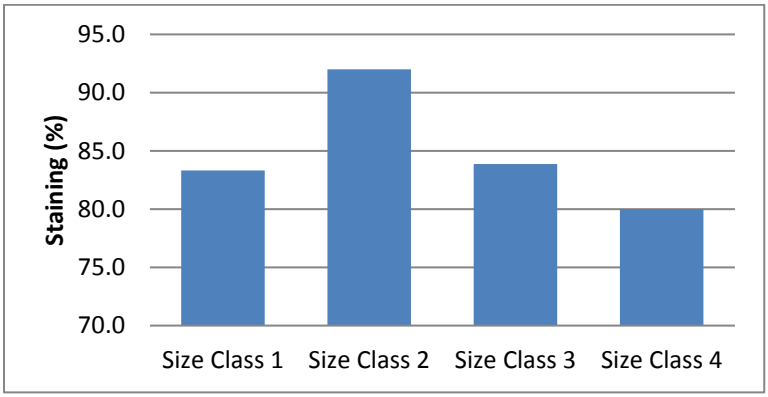


Figure 8.190. Relative frequency of staining in aves body size classes from Profile One

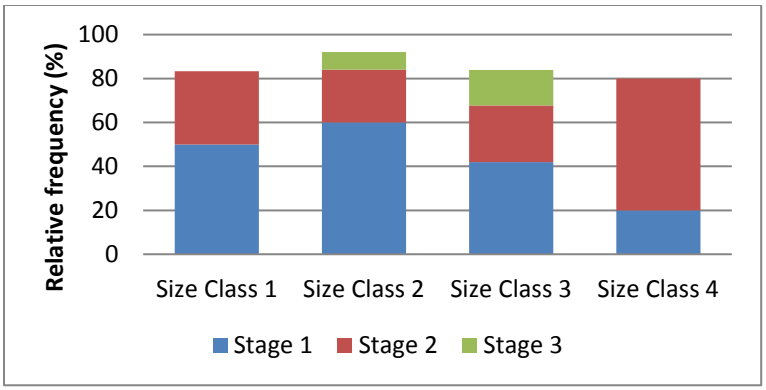


Figure 8.191. Intensity of staining in aves body size class from Profile One

Table 8.118. Abrasion intensity wth body size class in aves remains from Profile One

	Size Class 1		Size Class 2		Size Class 3		Size Class 4		Total	
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Stage 1	3	50	12	48	18	58.1	3	60	**36**	**53.7**
Stage 2	-	-	1	4	-	-	1	20	**2**	**3**
Stage 3	1	16.7	-	-	-	-	-	-	**1**	**1.5**
Total	**4**	**66.7**	**13**	**52**	**18**	**58.1**	**4**	**80**	**39**	**58.2**



Figure 8.192. Relative frequency of abrasion with body size class in aves remains from Profile One

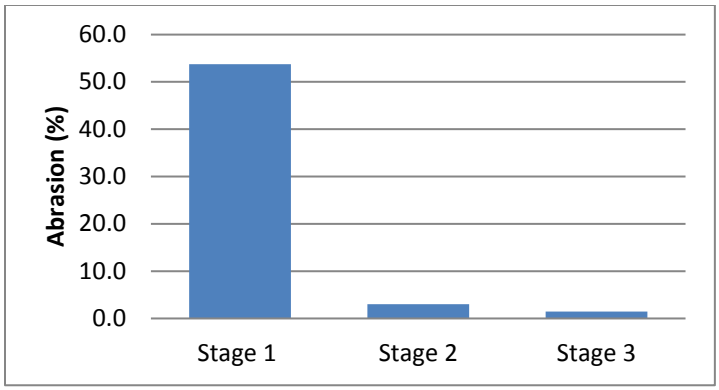


Figure 8.193. Abrasion intensity in aves remains from Profile One

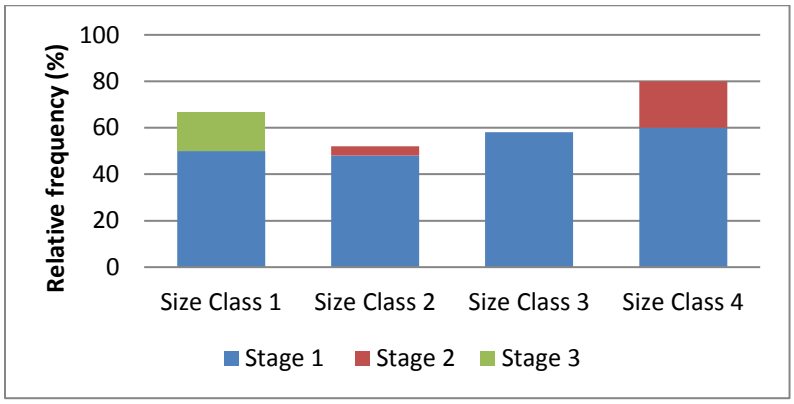


Figure8.194. Intensity of abrasion with body size class in aves remains from Profile One

Table 8.119. Sheen intensity in aves remains from Profile One

	Size Class 1		Size Class 2		Size Class 3		Size Class 4		Total	
	N	%	N	%	N	%	N	%	N	%
Stage 1	2	33.3	3	12	12	38.7	-	-	**17**	**25.4**
Stage 2	2	33.3	3	12	5	16.1	-	-	**10**	**14.9**
Stage 3	-	-	9	36	11	35.5	3	60	**23**	**34.3**
Stage 4	-	-	1	4	-	-	-	-	**1**	**1.5**
Total	**4**	**66.7**	**16**	**64**	**28**	**90.3**	**3**	**60**	**51**	**76.1**

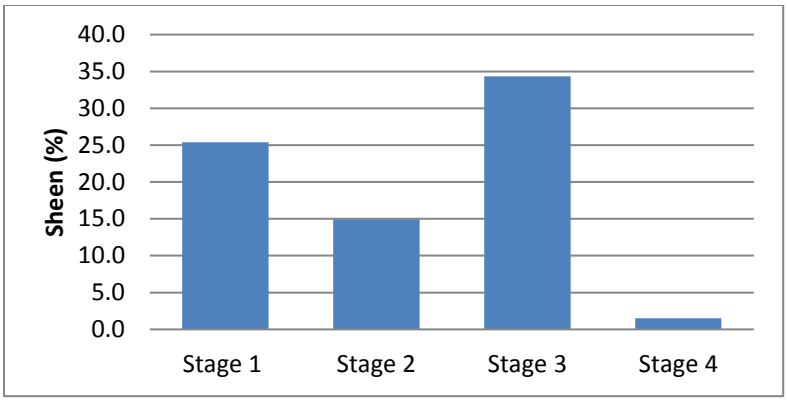


Figure 8.195. Sheen intensity with body size class in avian remains from Profile One

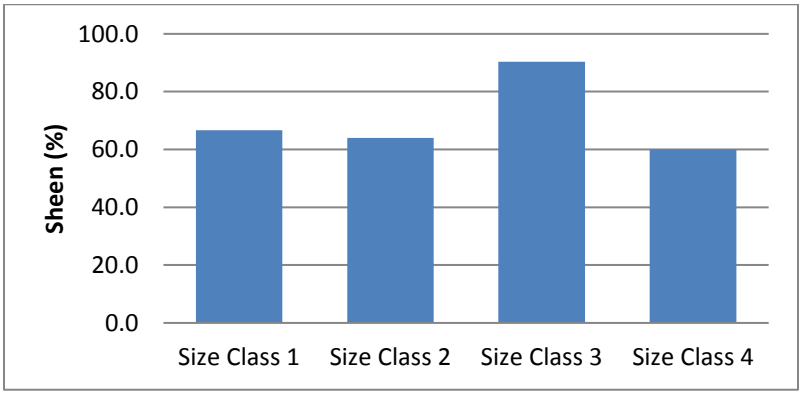


Figure 8.196. Relative frequency of sheen with body size class in avian remains from Profile One

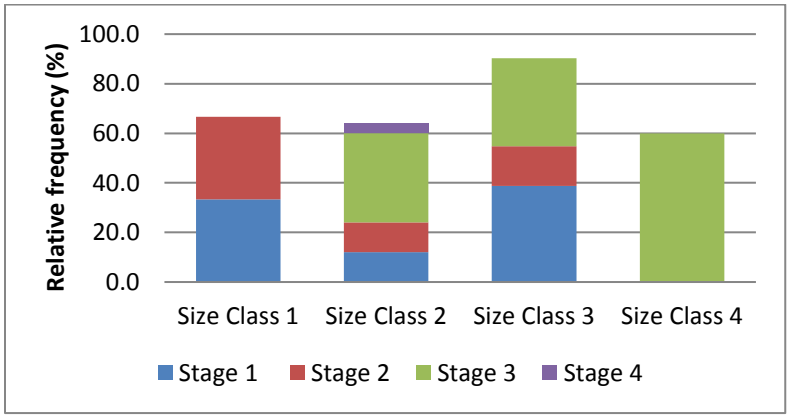


Figure 8.197. Intensity of sheen by body size class in aves remains from Profile One

Table 8.120. Trampling in avian remains from Profile One

	Size Class 2		Size Class 3		Size Class 4		Total	
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Stage 1	7	28	9	29	-	-	**16**	**23.9**
Stage 2	1	4	-	-	2	40	**3**	**4.5**
Total	**8**	**32**	**9**	**29**	**2**	**40**	**19**	**28.4**



Figure 8.198. Relative frequency of trampling with body size class in avian remains from Profile One

Table 8.121. Carnivore tooth marks in avian remains from Profile One

	N	**%**
Coracoid	1	9.1
Ulna	1	20
Carpometacarpal	2	100
Total	**4**	**6**

Table 8.122. Digestive corrosion in avian remains from Profile One

	Size Class 1		Size Class 2		Size Class 3		Total	
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Stage 1	1	16.7	1	4	1	3.2	**3**	**24.5**
Stage 2	-	-	1	4	1	3.2	**2**	**3**
Total	**1**	**16.7**	**2**	**8**	**2**	**6.5**	**5**	**7.5**



Figure 8.199. Digestive corrosion with body size class in avian remains from Profile One

Table 8.123. Root etching in avian remains from Profile One

	Size Class 1		Size Class 2		Size Class 3		Size Class 4		Total	
	N	**%**	**N**	**%**	**N**	**%**	**N**	%	**N**	%
Stage 1	2	33.3	1	4	4	12.9	1	20	**8**	**11.9**
Stage 2	-	-	1	4	1	3.2	-	-	**2**	**3**
Total	**2**	**33.3**	**2**	**8**	**5**	**16.1**	**1**	**20**	**10**	**14.9**

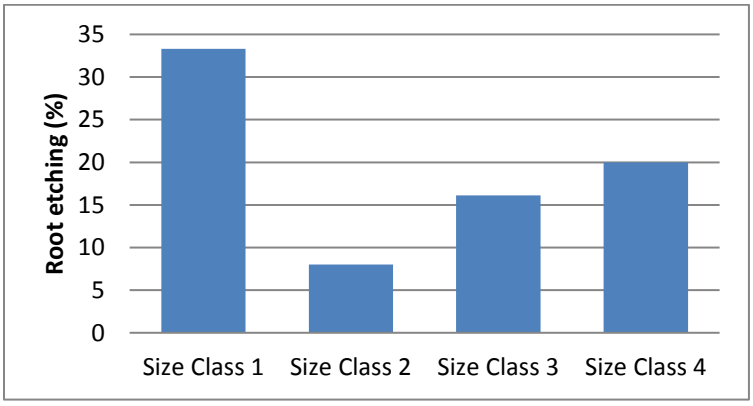


Figure 8.200. Root etching with body size class in avian remains from Profile One

Table 8.124. Body size class in pisces remains from Profile One

	N	%
Size Class 1	11	73.3
Size Class 2	3	20
Size Class 3	1	6.7
Total	**15**	**1.1**

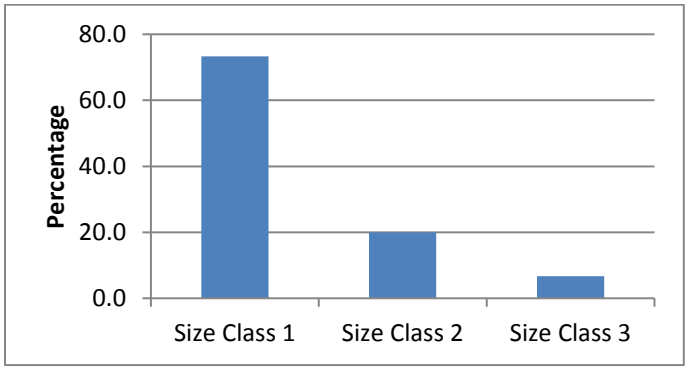


Figure 8.201. Relative frequency of body size class in pisces remains from Profile One

Table 8.125. Pisces remains by spit in Profile One

	N	%
Spit 1	1	0.2
Spit 2	10	1.5
Spit 3	3	1.4
Spit 4	1	10
Total	**15**	

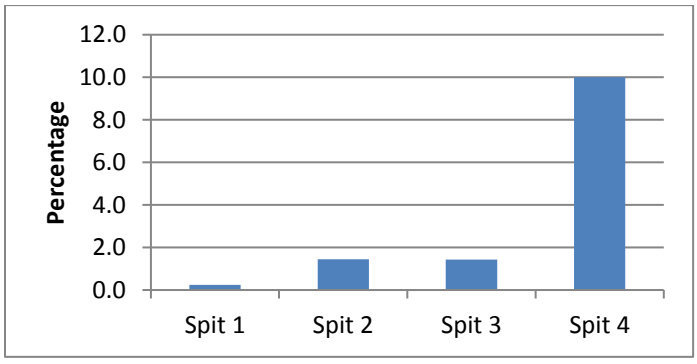


Figure 8.202. Relative frequency of pisces by spit in Profile One

Table 8.126. Anatomical composition and body size in pisces remains from Profile One

	Size Class 1		Size Class 2		Size Class 3		Total	
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Mandible	3	100	-	-	-	-	**3**	**20**
Vertebra	8	66.7	3	25	1	8.3	**12**	**80**
Total	**11**	**73.3**	**3**	**20**	**1**	**6.7**	**15**	

Table 8.127. Anatomical composition by spit in pisces remains from Profile One

	Spit1		Spit2		Spit3		Spit 4		Total	
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Mandible	-	-	3	100	-	-			**3**	**20**
Vertebra	1	8.3	7	58.3	3	25	1	8.3	**12**	**80**
Total	**1**	**6.7**	**10**	**66.7**	**3**	**20**	**1**	**6.7**	**15**	

Table 8.128. Descriptive statistics of maximum length in pisces remains from Profile One

	Pisces
N	15
Minimum	6
Maximum	21
Mean	8.7
Standard Deviation	3.94

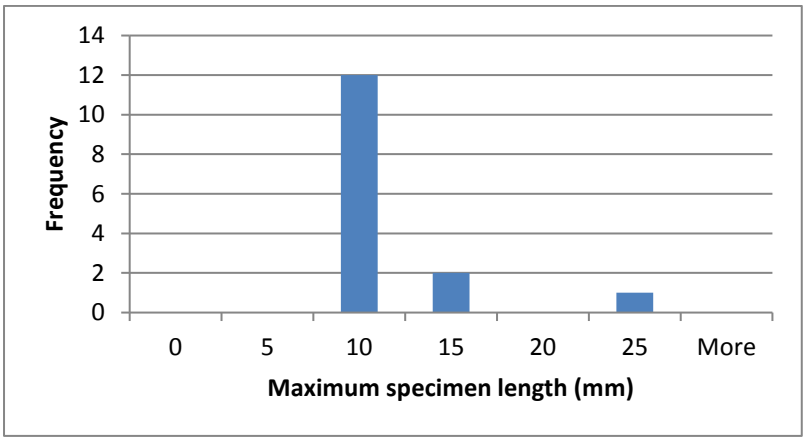


Figure 8.203. Histogram of maximum length in pisces remains from Profile One

Table 8.129. Completeness and body size class in pisces from Profile One

	N	%
Size Class 1	6	66.67
Size Class 2	3	33.3
Total	**9**	**60**

Table 8.130. Completeness by spit in pisces from Profile One

	N	%
Spit 1	1	0.2
Spit 2	6	0.9
Spit 3	1	0.5
Spit 4	1	10
Total	**9**	**90**

Table 8.131. Staining in pisces remains from Profile One

	Size Class 1		Size Class 2		Total	
	N	%	N	%	N	%
Stage 1	7	63.6	1	33	**8**	**53.3**
Stage 2	1	9.1	1	33	**2**	**13.3**
Stage 3	2	18.2	1	33	**3**	**20**
Total	**10**	**90.9**	**3**	**100**	**13**	**86.7**

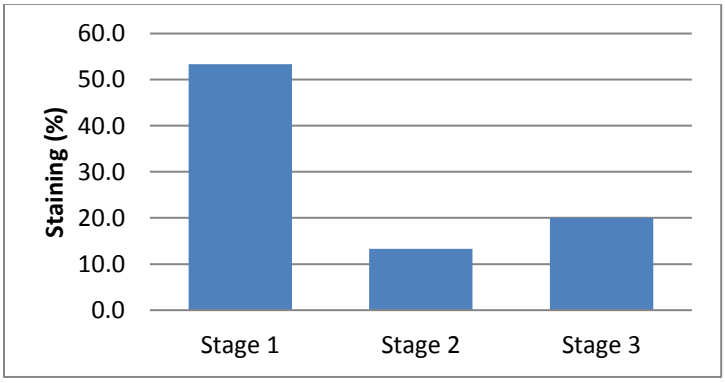


Figure 8.204. Staining intensity in pisces from Profile One

Table 8.132. Abrasion in pisces remains from Profile One

	Size Class 1		Size Class 2		Total	
	N	**%**	**N**	**%**	**N**	%
Stage 1	6	85.7	3	100	**9**	**60**
Stage 3	1	14.3	-	-	**1**	**6.7**
Total	**7**	**70**	**3**	**30**	**10**	**66.7**

Table 8.133. Sheen in pisces remains from Profile One

	Size Class 1		Size Class 2		Total	
	N	**%**	**N**	**%**	**N**	**%**
Stage 2	-	-	1	33.3	**1**	**6.7**
Stage 3	4	36.4	-	-	**4**	**26.7**
Stage 4	1	9.1	-	-	**1**	**6.7**
Total	**5**	**45.5**	**1**	**33.3**	**6**	**40**

Table 8.134. Taphonomic characteristics of taxonomic groups in Profile One

	Mammal	Chelonia	Aves	Amphibian	Pisces
n	137	1112	67	1	15
%assemblage	10.3	83.5	5	0.1	1.1
Body Size Class	2	3	3	1	1
Depth	3	1	-	2	2
Avg length (mm)	21.7	21.8	16.6	15	8.7
Adult (%)	75.8	75.4	-	-	-
Completeness (%)	19	18.2	10.4	-	60
Fracture outline	Spiral	Spiral	Spiral	-	-
Fracture angle	Mixed/Oblique	Mixed/Oblique Right (shell)	Mixed/Oblique Right (shell)	-	-
Weathering	15.3	19.6	13.4	-	-
Burning	6.6	11.3	7.5	-	-
Staining	82.5	73.9	86.6	100	86.7
Stain colour	Brown	Brown	Brown	-	Brown
Abrasion	76.6	79	58.2	-	66.7
Sheen	47.4	46.5	76.1	-	40
Trampling	19	47.1	28.4	-	-
Tooth marks	1.5	4.4	6	-	6.7
Digestion	5.8	1.7	7.5	-	6.7
Root etching	12.4	23.8	66.7	-	-

Table 8.135. Taphonomic characteristics of the MPPM and LQSM in Profile One

	MPPM	Contact	LQSM
n	424	689	219
%assemblage	31.8	51.7	16.4
Mammal	7.5	9	19.6
Chelonia	81.8	84	72.6
Aves	4	5.4	5.9
Amphibia	-	0.1	-
Pisces	0.2	1.5	1.8
Avg length	23	21	21
Completeness (%)	4.1	7.4	8.7
Spiral fractures (%)	54.5	49.2	59.4
Right angle fractures (%)	36.8	33.1	34.3
Weathering	17.5	19	18.7
Burning	16.7	8.4	5.3
Staining	77.8	76.2	69.4
Abrasion	77.1	79	75.3
Sheen	51.2	46.4	46.6
Trampling	41.7	30.6	29.2
Tooth marks	4.2	3.8	5.7
Digestion	1.4	2.8	3.8
Root etching	37.7	15.8	10.5

CHAPTER NINE

DISCUSSION

The aim of this study was to explore the relationship between the Langeberg Quartzose Sand Member (LQSM) and the Muishond Fontein Pelletal Phosphorite Member (MPPM) of the Varswater Formation exposed in E-Quarry at Langebaanweg. Specifically, it sought to investigate the depositional conditions under which the LQSM and MPPM were deposited, as well as any temporal differences between them. This study, additionally, investigated some long held taphonomic questions regarding the influence of fire and carnivory on bone accumulation and explored factors like sub-aerial exposure time and transport distances that reflect environmental conditions at Langebaanweg at the time of deposition.

I studied three test pits located in (1) the high-density river channel (1976/2), (2) the sivathere bonebed, and (3) a locality external to the riverine complex, in the southern part of the quarry. The bonebed and 1976/2 are key fossil localities which have produced many important discoveries; however, the depositional conditions that lead to these deposits are contentious. This is the first large scale taphonomic analysis that has been conducted at Langebaanweg E-Quarry; where modern techniques were applied across multiple taxonomic groups and contrasted with lithological evidence. It has allowed me to address a number of taphonomic questions regarding bone or species accumulation methods at Langebaanweg, and has elucidated various taphonomic pathways at the site.

9.1 THE LITHOLOGY OF LANGEBAANWEG

The sediments collected from the three test pits excavated in this analysis, consisted of fine to medium grained sands (80 – 100%) with a small contribution of coarse material (>2 mm) and an almost complete absence of silt and mud. This pattern was repeatedly observed in the MPPM ansd LQSM between all three sampled areas (Profiles One, Two and Four); with the exception of the MPPM of Profile One, which seemed to contain high amounts of mud and silt. The sedimentology of the LQSM samples and of the Profile Two and Four MPPM compare favourably with previous lithological analyses of Langebaanweg E-Quarry (Roberts 2006c; Roberts *et al.* 2011; Brumfitt *et al.* 2013).

The fine texture and dark colour of the Profile One MPPM material could be indicative of a tidal flat or marshy environment. The possible organic content of the deposit, along with abundant faunal material suggests a marsh is the more likely environment. Hendey (1981) and Dingle *et al*. (1979) recorded the presence of tidal flats, peat beds and marshes at Langebaanweg but these areas have either been mined out or their locations have been lost. There have been no opportunities to explore the palaeoecological information that might have been preserved in such sites. For example, the sandy sediments of Langebaanweg (MPPM, LQSM) are not conducive to the preservation of pollens (Scott 1995). The fine sediments of the marsh bed may have greater botanical preservation potential. Microfauna and invertebrates from this unit, may also be more common or display substantial differences in taxonomic composition from the remainder of the assemblage. Substantial numbers of microfaunal remains were recovered from the excavations of the Profile One MPPM. Previously, invertebrate assemblages from Langebaanweg were recovered from tidal flat deposits (Kensley 1977). Additionally, the avifauna of Langebaanweg preserves many species whose modern relatives prefer marshy habitats and this deposit may provide a clearer picture of the taxonomic composition or habitat preferences for these birds. This is supported by the relatively large bird assemblage recovered from Profile One. The identification of a possible marsh deposit in Langebaanweg E-Quarry, is very exciting as it will allow researchers an unique opportunity to investigate the palaeoenvironmental characteristics of a habitat type that has not been previously available. These characters will inform our understanding of palaeoecological conditions in a wider spectrum of Langebaanweg.

A particularly remarkable aspect of the lithology of the MPPM and the LQSM samples excavated in this analysis is the almost identical grain texture (grain size, morphology, sorting etc.) displayed by both. This would suggest that the MPPM and LQSM were deposited via the same process and/or were derived from the same source material. The sandy nature of the sediments displayed a distinct similarity to beach sands. The predominance of fine sand particles, with a lack of muds and silts, generally poor sorting and moderate to high sphericity could indicate deposition in a tidally dominated estuary. Estuaries of this nature can build up large sand bodies where fine (mud / silt) particles are winnowed out of the system or deposited on the fringes of the estuary in marshes or tidal flats (Boggs 2011). The most significant feature that distinguishes the MPPM from the LQSM is that the latter was non-phosphatic (Hendey 1981b). The phosphates of the MPPM developed authigenically in a shallow marine setting (Tankard 1975); and may be a secondary process to the original deposition of the LQSM and MPPM.

The sediments of Profile Four were massive and structureless. There was no evidence for peak flood flows (in fluvial settings) such as trough cross bedding, climbing ripple cross laminations or gravel bedload in Profile Four or the bonebed. Evidence for standing water suspension settling, like fine laminations, was inconclusive and thus, Profile Four was likely deposited in low flow or standing water conditions. Profile Two basal MPPM displayede erosional features and possible intermixing of the MPPM with the LQSM. The two horizons interfingered, and the LQSM formed thin, channel-like structures in the MPPM. Taphonomic characteristics of bones from Profile Two (abrasion, fragmentation) indicate deposition in a higher energy environment than experienced by bones from Profiles One or Four. These characteristics provide some support for Hendey's (1980) hypothesis of a river channel in the 1976/2 excavation.

9.2 TAXONOMIC COMPOSITION

Large numbers of bone remains were recovered from the test pit excavations at Langebaanweg. Profile Four produced over 20 000 remains, while Profile One produced half that number, but was excavated to half the depth, suggesting that these deposits had similar specimen density (Table 9.1). Profile Two, on the other hand, produced less than 5 000 bones. Profile One (MPPM) is the first area discovered outside of the bed 3aN/S river channel or bonebed, to display such high specimen density. This, together with the likely marshy environment in the Profile One area, suggests there is high palaeontological potential for this deposit, a potential that has been previously untested. Given the many large bones and partial skeletons recovered from the LQSM (Hendey 1981b) in previous excavations, and the high numbers of bones recovered from the LQSM in Profiles One and Two, this horizon still appears to have a great deal of palaeontological potential. The relative percentage of identifiable bones as highest in Profile One, which, supported by the fragmentation patterns (see below), indicates low bone destruction and deposition in a low energy environment, consistent with a marsh. On the other hand, Profile Two displayed low specimen density, low frequency of identifiable bones, and high fragmentation suggesting deposition in a higher energy environment.

Mammals, chelonia and aves were recovered in all three test pits and represent the most commonly occurring taxonomic groups at Langebaanweg. In all cases, chelonia were the most frequently occurring animal. Mammals were also highly common and were best represented (almost 40% of the assemblage) in the bonebed (Profile Four). The high abundance and diversity of mammal remains in Profile Four

indicates the action of some kind of concentrating mechanism for mammals in the bonebed. Avian bones made up 5% or less of all assemblages and were particularly common in Profile One, this could be a factor of low energy deposition of fragile bones, or could reflect high avian prevalence in the local environment prior to deposition of Profile One. Piscine remains were recovered from Profiles One and Four and were relatively frequent in the latter test pit. The recovery of fish bones could indicate an aquatic environment for these test pits. This would support marshy conditions in Profile One. However sub-aerial weathering and burning modification on piscine bones from Profile Four, indicates either periodic drying out of the deposit, which was not supported by the lithology, or transportation of the fish remains from a sub-aerial surface by biotic or abiotic processes unknown. Profile Four was the only test pit to produce bones from reptiles that were large enough to be separated from the microfaunal assemblage. Reptile remains are highly likely to be found in the microfaunal samples of the other test pits in low frequencies, and the group has never been properly studied at Langebaanweg. A large amphibian was recovered from Profile One, although more of this material will be preserved in the microfaunal sample from both this test pit and from Profile Four. Profile Two produced almost no microfaunal remains, this could reflect winnowing away of this material in a high energy setting or could indicate a relative lack on microfauna in the surrounding environment. Further analysis and additional excavations with improved protocols for the preservation of microfauna will be necessary in order to address this issue.

Chelonia

In all three test pits, chelonia were the most frequently occurring taxonomic group, making up as much as 80% of the Profile One assemblage. Tortoise bones, historically, have been commonly recovered at Langebaanweg (Hendey 1981b), and the reasons for their high density are not well understood. Chelonia bones are common components of many Western Cape archaeological assemblages (Sampson 2000; Thompson 2010; Steele & Klein 2013; Thompson & Henshilwood 2014), but in most of these cases, humans are considered the concentrating mechanism (Sampson 2000; Avery *et al*. 2004; Orton 2012; Thompson & Henshilwood 2014). Chelonia have also been recovered in archaeological or palaeontological deposits in other sites across southern Africa, but are usually rare outside of the southwest cape (Plug 2004; de Ruiter *et al.* 2008). Extant tortoises, particularly the angulate tortoise (*Chersina angulata*), are common in the south-western Cape coastal region today (Boycott & Bourquinn 2000). Thus, the high prevalence of chelonia at Langebaanweg could reflect natural background

densities of tortoises on the landscape. The other alternative is that there is some kind of concentrating mechanism at work on the chelonian remains at Langebaanweg. There are various possibilities, namely that tortoises are predated upon by raptorial birds (Boshoff *et al*. 1991; Sampson 1998, 2000) and/or by carnivores like brown hyena (Avery *et al*. 2004), badgers, and jackals (Hewitt 1937).

Sampson (2000) finds similar patterns, of a dominance of chelonia shell elements over appendicular elements and high degrees of fragmentation in skeletal elements, from raptor kill sites to those observed from Langebaanweg. In the case of Profile Four and the bonebed deposit, the phosphate rock outcrop could have provided an ideal 'killing rock' on which to drop tortoises. Although my results do differ from Sampson's in some key features; tortoise limb extremities were scarce in tortoise kill sites and hindlimbs were better represented than forelimbs (Sampson 2000). Chelonia were collected from kill site localities as complete or partial carcasses and while shell bones were fragmented, they were complete enough for easy identification. Finally, small species and juveniles abounded in kill sites. At Langebaanweg, distal limb elements were common and there was no preservation preference between forelimbs and hindlimbs. Chelonia skeletons were in almost all cases completely disarticulated and highly fragmented. In the two associated partial skeletons excavated in the bonebed, bones did not display fragmentation consistent with Sampson's findings. Similarly, chelonia remains from roost samples (Sampson 2000) are inconsistent with the tortoise bones from Langebaanweg, and in any event there are few appropriate roost localities (cave, rock ledges or cliffs) in the Langebaanweg region. Additionally, there is a relative paucity of raptorial birds at Langebaanweg (Manegold *et al.* 2013). Fracture shape in both shell and appendicular bones does indicate the majority of fragmentation occurred while fresh and a small percentage (<4.5%), of tortoise bones display carnivore tooth marks and digestive etching. I thus conclude that carnivores and raptorial birds may have contributed some of the chelonia material, but they were not the primary accumulating agent of chelonian at Langebaanweg.

Chelonia are known to perish in veld fires, as they cannot escape quickly enough (Avery *et al*. 2004); and some authors have hypothesised that burning may be the primary accumulating mechanism for chelonia at the site. Burning affected less than 12% of chelonia remains, only a slightly greater percentage than all taxonbomic groups combined (10.5%). Burning damage was frequently observed on both inner and outer surfaces of tortoise shell bones, which would suggest that bones were disarticulated prior to burning. Avery and colleagues (2004) found, during an investigation of fire-killed tortoises, that in the case of a fast moving fire, chelonia killed by the blaze displayed little evidence of burning (having died of asphyxia). Bones exhibiting charring or calcination were dried bones from previously deceased

individuals; which was probably the case at Langebaanweg. Whethere those previously deceased tortoises died from asphyxia in seasonal veld fires cannot be ruled out at this stage.

Thus, chelonian remains from my excavations suggest predators and burning played a limited role in the accumulation of these bones. However no meaningful interpretations regarding chelonia palaeoecology can be made until the species composition and number of tortoise individuals has been more accurately quantified. A typical chelonian skeleton can produce as many as 47 carapace and plastron bones and tortoise skeletons will naturally start to dissociate after relatively short periods (12 – 30 months) of sub-aerial exposure (Dodd 1995). A single tortoise skeleton can thus contribute a large number of bones to an assemblage, particularly as in the case of Langebaanweg, if the individual shell bones become fragmented. I estimated the minimum number of tortoises (MNI) based on humeri and size class for each test pit. MNI in chelonia varied from two individuals (Profile Two) to six individuals (Profile Four). In all cases, this is lower than the estimated MNI for mammals, despite the numerical dominance (NISP) of chelonian bones. Extant population density in tortoises, as measured in live populations or as post-fire mortalities, appears to measure between 1 and 6 individuals per hectare (Avery *et al*. 2004; Branch 1984). It is challenging to make inferences between density in hectares and a fossil site where factors like transportation and time averaging may have played a role. At Langebaanweg, a 1 m^2 test pit produced the same number of chelonian individuals as might be encountered in a hectare of open land, and this pattern of high tortoise density was observed in multiple test pits, sampling different micro-environments (like Profiles One and Four). This might suggest that chelonia density at Langebaanweg is higher than typically observed in the Western Cape today. This seems likely given the low energy depositional conditions indicated for Profiles One and Four, which suggests bones in these test pits did not travel far.

Mammals

Langebaanweg has historically produced a highly diverse and abundant mammal assemblage (Hendey 1981b). In this investigation of the site, mammals were found to make up between 10% (Profile One) and 40% (Profile Four) of the assemblage in each test pit. The higher frequency of mammals in the river channel and bonebed test pits could reflect habitat preferences of the mammals and an attraction to freshwater, but there are myriad factors that affect mammal movement and fossil preservation. The vast majority of mammal remains in all test pits were not identifiable even to family level, as the

excavated samples lacked any diagnostic characteristics (like long bone fragments). In Profiles One and Four, bovids were the most commonly occurring mammal family, closely followed by carnivores; while in Profile Two this pattern is reversed, and carnivores are dominant. This as not entirely unexpected given Langebaanweg's large carnivore assemblage. Carnivores rarely outnumber herbivores in either modern environments or fossil assemblages. High ratios of carnivore to herbivore bones have been observed in carnivore den assemblages, but these often contain juvenile carnivore bones (Kuhn *et al*. 2010). Lithology and other characters are inconsistent with the presence of a carnivore den in Profile One. It is more likely that the naturally patchy distribution of bones in the fossil assemblage and poor sample size has resulted in this one square containing more carnivore remains than others.

Profile Two displays the highest relative frequency of small mammals (size class one and size class two). Remarkably though, micromammals were all but absent from this test pit. Such a pattern could be a reflection of prey choice by a predator; for example, leopards are known to preferentially take prey smaller than themselves, including small mammals (Brain 1981). However, previous studies in this area (1976/2) indicate that this is part of a river channel. Hydrodynamic sorting may have had some effect on animal size preservation indicating a moderate flow that deposited small but not micro-sized remains. The rarity of megamammals (size class five) in Profile Four is noteworthy considering the preponderance of large bodied sivatheres in the bonebed deposit. While the sivathere bones, many of which are from associated partial skeletons, appear to dominate the bonebed assemblage, their large size probably overemphasises their importance. Expanded sampling would be needed to address the question of mammal accumulation with greater confidence.

Mammal remains were common in Profile Four, which produced a particularly high diversity of families most of which were not observed in the other test pits. These include two extinct species of bovid, equid, giraffid, canid, phocid, herpestid, and bathyergid. The relatively high frequency of mammal remains in Profiles Two and Four supports the hypothesis that these deposits were part of an aquatic system, providing fresh drinking water. Mammal remains can concentrate around a water source during times of drought, and large numbers of dead and dying animals can attract carnivores and lead to their eventual demise (Behrensmeyer 2007). There is some evidence that might indicate drying up of the Profile Four deposit (sub-aerial weathering and burning of piscine bones), but lithology is inconsistent with periodic or seasonal drying or later flooding as is common with this scenario. Hendey (1980) believed that bed 3aN, (1976/2 excavation), was laid down as part of a wet season (flooding) channel of a river. The bonebed (and Profile Four) should also sample bed 3aN (see Chapter Four). Researchers

have suggested that carcasses of large animals like Sivathere or Ursidae may have been washed into the river channel or bonebed from further upstream (Hendey 1980; Roberts *et al*. 2011). However taphonomy and lithology of Profile Four points to low energy deposition, suggesting that many animals incorporated in the bonebed arrived under their own steam and perished for reasons as yet unknown.

Aves

Avian bones were recovered in all test pits but were always a relatively rare (>5%) component of the faunal assemblage. At least 1690 bird bones have been recovered from Langebaanweg since the deposit was first discovered. This value has been estimated from NISP values given by Manegold *et al.* (2013), Rich (1980) and Pavia *et al.* (2014) in various reviews or descriptions of the Langebaanweg avifauna. A number of avian groups from Langebaanweg are poorly studied and NISP values are unavailable for those remains, thus the total number of bird bones from Langebaanweg is likely to increase in the future. Similarly, the NISP of many other species or taxonomic groups (mammals, chelonia, anura) have never been published and any values given in older papers may have been expanded by more recent excavations. It is thus not possible to accurately estimate of the relative frequency of avian remains in the total faunal assemblage; however researchers have estimated that as many as one million specimens have been collected from the site. If this value is utilised, then birds would represent less than 1% (0.169%) of the Langebaanweg assemblage. In this analysis, Profiles One, Two and Four produced 67, 3 and 49 bird specimens respectively, for a total of 119 bird specimens; representing between 1.5% and 5% of the faunal assemblage of each test pit. Bird specimens from Profile One and Profile Four display higher relative frequencies of burning damage and carnivore modification than other taxonomic groups from these test pits. The prevalence of these characteristics in avian remains could suggest possible concentrating mechanisms, particularly in the case of carnivore damage. Burning in bird remains is much more likely to occur on bones that have been exposed on the surface than in freshly killed individuals, as has been shown with roasting carcasses (Gifford-Gonzales 1989; Asmussen 2009). Aves, like chelonia, were likely predeceased before burning occurred. The possibility that the birds were killed by asphyxiation in a fire from a previous season cannot be ruled out, but there are a number of possible means of death including carnivory. Birds were infrequent in Profile Two and did not display burning or carnivore marks.

There is little comparative information on fossil bird numbers from other Miocene or late Pliocene sites in Africa and abundance and taxonomic diversity appears greater in Langebaanweg than other similarly aged sites (Harrison 1980; Worthy *et al.* 2011). For example, a study of fossil birds from four localities in northern Namibia, in the Sperrgebiet region, identified a total (between the sites) of only 31 specimens from a number of genera and families (Mourer-Chauviré 2008). The relative frequency of aves compared to other taxa in the Sperrgebiet is unknown. Avian abundance and diversity at Langebaanweg resembles some younger deposits. For example, the Middle Stone Age (MSA) coastal deposit of Sibudu has produced a large avian assemblage with 1835 identified specimens (Val 2014). Birds at Sibudu make up a similar relative percentage (3%) of the faunal assemblage as observed in Profiles One and Four. Other coastal MSA sites (ex. Diepkloof rock shelter, Pinnacle Point 13B) in the western Cape have produced bird assemblages that, while abundant, make up less than 1% of the total faunal samples for those localities (Thompson 2010; Steele & Klein 2013). The large time gap and anthropogenic origin of birds in the MSA means that birds from these sites can't be meaningfully compared to the Langebaanweg avifauna, however it does show the unusually high diversity and abundance of birds in this locality.

Profiles One and Four both produced remains attributed to Phasianidae and Ciconiidae, indicative of an open environment and freshwater source in the vicinity of the deposits. The latter, is also supported by the presence of piscine remains in these test pits. Manegold and colleagues (2013) have shown that fossil birds are valuable palaeoecological indicators. The avifauna of Langebaanweg indicate a mosaic environment, with open grassland, woodland, marshy and marine habitats. Some habitat types, like woodland, were previously considered sparse in palaeoenvironmental reconstructions based on mammalian data. The avifauna of Langebaanweg has expanded previous reconstructions greatly. Langebaanweg, additionally, has provided a great deal of new information regarding the evolution of many important avian families.

9.3 TAPHONOMY

9.3.1 Bone size frequency distribution and fragmentation

Fragmentation was high in the three test pits sampled in this analysis. All produced vast numbers of unidentifiable remains,with the identifiable portion of the assemblage representing less than 13% of bone remains recovered. Complete specimens were rare, never greater than 20% of the assemblage. Profile One displayed higher frequencies of complete bones (all small or compact elements) compared

to the other test pits. Maximum specimen length was very similar in all three test pits, with specimens averaging between 21 mm and 26 mm in maximum length and the maximum recorded specimen in Profile Two (65 mm) and Profile One (69 mm) was less than 70 mm. Larger specimens (up to 117 mm) were only recovered from the bonebed layer of Profile Four. The bonebed, with its many very large specimens, is thus exceptional. Fracture shape in all test pits indicated that fragmentation occurred while bones were fresh and unweathered, and taphonomic criteria all indicate short periods of sub-aerial exposure and little transport. The high degree of fragmentation at Langebaanweg is likely to be the result of processes like trampling. Mortality profiles of the remains sampled in this analysis suggest catastrophic patterns with high numbers of adult specimens. The high degree of fragmentation has however resulted in only a small sample of remains preserving epiphyseal fusion, which could suggest that more fragile bones from juveniles or subadults were destroyed. The question of mortality profiles will require greater sampling before it can be addressed effectively.

9.3.2 Bone Surface Modifications

Weathering

The relative frequency of sub-aerial bone weathering was similar in Profiles One, Two and Four. Weathering was uncommon, occurring on less than 20% of the faunal assemblage in each test pit. Weathering damage was always low in intensity. Taken together, these factors indicate that bones in all three test pits suffered only short periods of sub-aerial exposure, in the region of 1-2 years or less (Behrensmeyer 1978). This pattern in weathering signal is consistent across the different areas studied in this analysis. This could be used to argue that all the bone remains in Langebaanweg E-Quarry were laid down in a single event, but this is likely not the case; not in an area where river channels, flood plains and peaty patches occur in close proximity. It may, on the other hand, indicate a certain amount of seasonality. Animals perish on the landscape due to environmental stress or in some cases an event deposits bones (for example flooding after heavy rains), the bones are exposed for a short time and then another event results in swift internment.

In all three test pits, mammal bones were more frequently modified than those of other taxonomic groups, although chelonia come a close second. Weathering occurs substantially less frequently on avian remains. This pattern of differential weathering on taxonomic groups is commonly observed in modern environments (Cruz 2008; Behrensmeyer *et al.* 2003). Behrensmeyer *et al.* (2003) have observed that

weathering destruction accelerates after stage two, resulting in bones with more intense destruction becoming increasingly rare. From this, they concluded that the dominance of low intensity weathering on bird remains was a result of their tendency to weather more rapidly (than mammals). In addition the small size of avian carcasses and bones will result in more rapid burial, particularly in sandy substrates such as those found at Langebaanweg (Cruz 2008).

Burning

The appearance of burning damage on bones from Langebaanweg has been noted in the past (Hendey 1981b), but no previous attempts have been made to quantify or describe the intensity of damage. Burning at Langebaanweg is of particular interest to archaeologists as these fires would be able to give a view on how naturally occurring veld fires affect local animals and their deposition. Grassland and fynbos environments both experience seasonal fires and the prevalence of burnt remains at Langebaanweg could be an indication of both seasonality and grass and/or fynbos vegetation. Unfortunately, palynological and phytolith evidence cannot indicate the relative prevalence of these vegetation types. Charcoals are unknown from Langebaanweg, but micro-charcoals have have been preserved and an analysis of this material may help elucidate the prevalence of fynbos, woody and grassy elements. Burning was, overall, found to be relatively uncommon in the test pits studied with the highest relative frequency of 10.5% of the assemblage occurring in Profile One. Chelonia remains do show higher burning prevalance, relative to this value, but most of the burning observed in this analysis appears to have occurred on bones that were already exposed on the surface. To put this in perspective, burning has been shown to affect 65% to 95% of bone remains in African MSA archaeological deposits (Cain 2005; Thompson & Henshilwood 2014; Reynard *et al.* 2015). These high percentages have been shown to be the result of anthropogenic modifications from cooking and disposal of bones in the hearth.

Profile Four displays a particularly low prevalence of burning throughout most of the deposit, but burning does increase (slightly) in the bonebed layer. In addition, burnt mammal bones in this test pit were particularly rare. It is possible, given previous reconstructions of the Profile Four area as a river or pond, that water and green vegetation in the proximity of the site may have protected bones from burning. In many African localities were water is scarce, vegetation (especially grass) growing in close proximity to a water source is heavily over-utilised, resulting in little biomass to burn. Burning was always light to occasionally moderate in bone remains recovered in this analysis, suggesting swift

moving and low temperature fires (Brain 1993), as is common in grassland environments. As expected, burning was more common on chelonian bones than mammals in Profiles One and Two, although in both cases, the relative frequency was still low. Burning in avian remains was generally rare (6% – 8%) but birds were more frequently burned than mammals or chelonia in Profiles One and Four.

Colour mottling and staining

One of the most commonly observed modifications on the fossil bones analysed in this study, was staining. Staining affected over half the remains in all three test pits and was particularly prevalent (75.6%) in Profile One. In all cases, mammals were the most strongly affected taxonomic group. Other taxonomic groups like birds varied widely (44% - 100%) in the relative frequency with which they were affected. Staining was predominantly light, and brown was the most common colour observed, although purple, black and orange staining were also encountered in all test pits. Staining was the result of post-depositional diagenetic processes. Bones that display higher frequency or most intense marking may have been interred for longer periods than bones that were less modified, however chemical precipitation and diagenesis are complex processes and there are many factors that can influence intensity and timing of staining.

Brumfitt*et al.* (2013), during a histological investigation of bone remains from the bonebed, found evidence of apatite cements and late stage manganese oxide staining. Apatite cement and staining can occur as black or as a brown/orange or purple colour. Manganese staining was black and often appeared as spotting on bone surfaces (Brumfitt *et al*. 2013). Manganese could have been mobilised in a reducing environment by ground waters leaching the mineral from surrounding sediments. The same ground water moving through the phosphate rich sediments of Langebaanweg would have become apatite-saturated. Ground waters must then have become oxidising to result in precipitation of apatite and manganese oxide cements(Brumfitt *et al*. 2013). Orange staining is likely the result of iron precipitation. The greater prevalence of staining in Profile One suggests that this area of the quarry experienced greater levels of diagenesis than did the bonebed or the area around it (1976/2 excavation).

Bone Abrasion

Abrasion was highly prevalent on bones excavated for this study, occurring on over 80% of specimens. Abrasion was predominantly light and all taxonomic groups including fish were affected. Bone remains from Profile Two display greater relative frequency of abrasion and were modified to a greater intensity than in the other test pits. This suggests a higher energy environment or that greater transport distances were experienced by bones in this test pit. This would concur with previous reconstructions of this area (1976/2) as part of a river channel. It should however, be noted that while the remains from Profile Two display greater abrasion than other bones excavated at Langebaanweg, the damage is not severe, consistent with deposition (in most cases) in a low energy environment. In both Profiles One and Two, abrasion is greater in the LQSM layers; and the bonebed layers (Profile Four) display less abrasion than the overlying bones. In Profiles One and Four, avian bones display lower frequencies of abrasion. This, like weathering, could reflect rapid destruction from abrasion in avian remains (Cruz 2008).

Sheen and Polish

Polishing was most frequently observed on remains from Profile One and was infrequent in Profile Four. There were few patterns with regards to polishing on bones from the test pit excavations. No taxonomic group was consistently well or poorly polished, and there was little pattern in polishing frequency between sedimentary units. In addition, polishing modification often conflicts with abrasion data. Water action is generally believed to result in polished surfaces on bones, but the subject has received little work (Denys 2002). Fernández-Jalvo and Andrews (2016) have recorded polishing from tumbling experiments with water and sand and from wind abrasion, but have been unable to differentate what causes polishing or what kinds of bones are most likely to be affected. Reynard (2014) found in a trampling experiment that polishing in trampled bones was a common occurrence. Polishing prevalence on bones from the test pit excavations is more similar to trampling than abrasion, and it is possible that the polishing observed in these excavations may be the result of trampling, rather than fluvial abrasion. At this time it is impossible to state the cause of polishing at Langebaanweg with certainty and the subject requires much greater investigation and experimentation before the processes inherent in this modification are understood.

Trampling

Trampling damage was observed on approximately 30% of remains from all three test pits, and was in all cases predominantly light in intensity. All of the areas excavated in this analysis must have been affected by animal trampling and this may be one of the reasons for the high degree of fragmentation in otherwise low energy depositional environments. Profile One displayed the greatest prevalence of trampling. None of the bone remains excavated in this analysis display the type of clear, 'green-stick' fractures characteristic of large animal trampling evident in the sivathere bonebed. This dichomomy between parts the sivathere bonebed and Profile Four suggests that some areas of the bonebed suffered greater levels of trampling than others. The high prevalence of trampling damage indicates that animals were highly active at Langebaanweg during the period of deposition. Palaeoecological reconstructions have found evidence for a number of habitats and vegetation types that suggest that Langebaanweg was probably highly productive.

Root Etching

Root etching affected between 20% (Profile One) and 40% (Profile Two) of bones excavated from the three test pits. The relative paucity of root marks on bones from Profile One is interesting given that these bones were excavated from an area that is today vegetated and biologically (plant material) active. The high prevalence of root marks on bones from Profile Two may well be the result of ancient root activity. On the other hand the Profile Two test pit, located in the 1976/2 excavation area, has been exposed for many years. There is no vegetation growing on the surface of the deposit but there is a lot of vegetation in close proximity. At this stage, I know of no reliable manner in which to separate ancient root etching from modern etching of fossil remains. Modern roots were observed in the fossil assemblage, apparently drawn to the mineral content of fossil bones (Figure 9.1). I also do not know of any manner by which the type of plant that caused etching might be identified. The relative frequency of root etching indicates bones were exposed on the surface for a (short) period before internment, a finding supported by weathering and burning. Bones can also become modified while resident in a soil before final burial.

Carnivore Modifications

Tooth marked and digested bones were rare in the excavated bone assemblage. Carnivore modifications were observed on less than 5% of remains in any of the test pits excavated in this analysis. Carnivore modifications were particularly rare in Profile Two where 1.4% of bones were tooth marked and less than 1% digested. All carnivore modified bones from Profile Two belonged to chelonians. Carnivore modifications were especially common on avian remains in the other test pits. This could indicate that avian remains were accumulated in Profile One and Profile Four by carnivore activity, but more indepth analysis of Langebaanweg aves is required. A number of taxonomic groups display greater prevalence of digestion than tooth marks. This pattern has been observed in experimental analyses of small carnivores and small mammals, where digestion is common and tooth marked bones very rare (Lloveras *et al.* 2008; Cohen & Kibii 2015; Lloveras *et al.* 2012). Chelonian remains from Profile Four show a greater relative frequency of carnivore modifications. Carnivore tooth marks have been observed on remains from the bonebed excavation previously (Smith & Haarhoff 2006), which supports these findings. Tooth marking was more common on chelonian carapace and shell remains, while digestion appeared more frequently on appendicular remains. Sampson (2000) observed the same pattern on tortoise remains derived from raptor roosts. Chelonian limbs can be swallowed whole by both raptors and carnivores and are thus protected from tooth marking, while shells have to be broken open and become damaged or modified. I have already shown that element preservation and breakage in the Langebaanweg chelonia do not support accumulation by predators.

This data would suggest that carnivores did not contribute substantially to the fossil deposits excavated in this analysis. Carnivores feeding on birds often consume or destroy the skeleton in its entirety, and those bones that are not destroyed typically display few tooth marks (Cruz 2008). Acid etched bones, from digestion, usually represent only a small proportion of the total consumed skeleton. Remarkably the only taxonomic group with high prevalence of tooth marks is aves. Langebaanweg has a diverse carnivore assemblage with a broad range of predator sizes. Tooth marks observed in this analysis were all small (hard to see with the naked eye), consistent with small sized carnivores (Selvaggio *et al.* 2001). There are no patterns consistent with a carnivore den (Kuhn *et al*. 2010), but bones can accumulate in areas where carnivores regularly feed. Future, quantification of carnivore tooth mark size may help elucidate the predators responsible for bone accumulation at Langebaanweg, especially in the chelonian and avian assemblages. Digestion was consistently found to be light in intensity, but the sample sizes of

digested bones recovered in this analysis was too small to make efforts at interpretaing the carnivore responsible ineffective.

Carnivore activity may provide an alternative explanation for the appearance of marine remains in otherwise terrestrial deposits. Previously, intermittent connection between the bonebed area and the sea has been proposed as a likely mechanism for transport of marine specimens into that deposit (Brumfitt *et al.* 2013; Smith & Haarhoff 2006). This may apply in some parts of the quarry, like distal parts of the river channel or on the flood plains. I would like to offer an alternative scenario, whereby carnivores contribute marine bones, scavenged from the beach and environs. There are already records of carnivores feeding on seal and marine birds scavenged or killed on or near the beach (Klein *et al.* 1999; Cruz 2008). The primary argument against carnivore contribution of the marine component at Langebaanweg, is the presence of bones from large bodied marine mammals like whale vertebra (Figure 9.2). Govender *et al.*(2016) in an analysis of the balaenopterids from bed 3aN/S found that at least some of the specimens were derived from juvenile individuals. Large carnivores have been observed carrying remains from prey animals much larger than themselves (Figure 9.3). Once defleshed these elements are much lighter and easier to carry. Such bones will not necessarily display tooth marks depending on how much those remains were processed by the carnivore before internment. Tooth marks from probable sharks have been described on cetacean bones at Langebaanweg (Govender 2015), but these do not preclude terrestrial carnivore scavenging. It is tempting to expand the taphonomic modifications observed in the three test pits from this analysis to the whole of Langebaanweg E-Quarry. But this is a very small sample from a large deposit and these test pits sample (in the case of Profiles Two and Four) specific habitats. The consistency of some patterns like light weathering could indicate a larger pattern of bone modification, but these patterns should be taken as preliminary when applied to the quarry as a whole.

9.4 DEPOSITIONAL ENVIRONMENT OF THE MPPM AND LQSM

9.4.1 Depositional processes

It has long been hypothesised that the Langebaanweg fossils accumulated during the Early Pliocene, in an estuary which formed at the mouth of the palaeo-Berg River as it discharged into the sea in the region of E-Quarry (Hendey 1981b; Roberts *et al*. 2011). Further, it was thought that sediments now making up the LQSM and MPPM were deposited as part of a marine transgression that occurred at the

same time (Hendey 1981; Pether 1986; 1994a, b). During his initial inquiries into Langebaanweg, Hendey (1976) suggested that the MPPM and LQSM were separate chronostratigraphic units, differing in age by at least half a million years. With extended excavations and improved samples however, Hendey (1981) later came to believe that the MPPM and LQSM were deposited, at least in part, contemporaneously. Currently, all indications are for a minimal age difference between the MPPM and LQSM (Roberts *et al*. 2011). Differences in taxonomic composition between the MPPM and LQSM are minimal, and probably reflect differences in local environment or taphonomic processes in these deposits.

The relationship between the MPPM and the LQSM in this system has never been well understood. Hendey (1981) believed that the LQSM represented the flood plain of a river discharging into the estuary. He suggested a scenario whereby the river channel entered E-Quarry and flowed towards the south and southeast (Figure 9.4), with inundation by slow-moving backwaters, which overflowed from the river channel and deposited the LQSM. River flood plains deposited by slow-moving overflow are generally fine-grained, with large amounts of silts and muds (Boggs 2011). Typical examples are the Mississippi and Nile delta flood plains. This analysis has shown that sediments of the LQSM are sandy and do not resemble typical delta flood plain deposits. Sea level rise from marine transgression later resulted in the LQSM becoming buried by deposition of the MPPM. Flood plains typically occur on the flanks of the river and shifting river courses can excavate into flood plain deposits. At Langebaanweg E-Quarry the LQSM consistently underlies the MPPM. The only locality where the MPPM might have excavated into the LQSM was in the 1976/2 area and this process appears to have only affected the upper-most parts of the deposit. Hendey (1981), does not provide a clear indication of the depositional origins of the MPPM. He consistently focuses on the bed 3aN/S river channel in his discussions. Hendey appears to indicate that the MPPM sediments were deposited by the bed 3a N/S river. That is not possible given the relatively small size of the river channels and the vast lateral and vertical extent of the MPPM. It should also be noted that the bed 3aN/S river channels are located near the base of the MPPM and that there is as much as 20 m of MPPM sediment overlying the channels. Roberts *et al.* (2011) described the MPPM as recording estuarine, marine and *localised* fluvial sedimentation. The confusion regarding the origins of the MPPM continues to this day. There are two possible scenarios for the depositional environment of the MPPM. The first is a fluvial origin, where the MPPM was laid down as part of a large estuary with anatomising or braided river channels and all associated features including sand bars, vegetated islands and flood plains. In this interpretation, the LQSM would represent the flood plain facies of the system and beds 3aN/S would represent minor, abandoned channels. The second scenario is a marine origin for the MPPM and LQSM in a tidally dominated estuary.

In the current analysis, neither the LQSM nor the MPPM displayed any bedding characters consistent with fluvial deposition, with the exception of Profile Two. The lithology and sedimentary bedding of Profile Two, support previous reconstructions of a river channel in the 1976/2 excavation. The river channel appears to have been restricted to this area and the remainder of the MPPM is massive and structureless, except for discontinuous lenses of phosphate rock (Roberts *et al*. 2011). Fluvial systems, particularly where they form part of estuaries and deltas are often characterised, at least in some parts, by large amounts of silts and muds, and the lack of fine sedimentary material in much of the Langebaanweg deposit requires explanation. Muds and silts do occur, for example in the Profile One MPPM sample, but it is localised to this one area and one sedimentary unit, which is a small sample in an otherwise large deposit with good preservation (Hendey 1981; Roberts *et al.* 2011). It is possible that there were more examples of localised silty areas in the MPPM that have been mined out, although few authors working during the mining period record such features in the MPPM. But muds and silts appear less common at Langebaanweg than would be expected in a purely fluvial setting. It is difficult to make assertions regarding the character of the Langebaanweg river system when its origins are unknown. It is often referred to in the literature as a 'proto-Berg River' (Roberts *et al.* 2011). Hendey (1980) offered the Berg River as a facsimile to the fossil river channel as it is the only major drainage in the area today, and there is, as yet, no evidence connecting the bed 3aN/S river channel to the modern Berg River. If bed 3aN/S was part of a palaeo-Berg River, then fine terrugenous sedimentary material derived from upstream erosion of Malmesbury Group shales would be expected in the estuary or river channel deposits (Brumfitt *et al.* 2013). The lack of shales and mud and the generally massive character of the MPPM do not support a fluvial origin for this horizon.

Langebaanweg was characterised in both the MPPM and the LQSM by a dominance of fine to very fine (sized) sand grains that are generally poorly sorted and well rounded. The sediments bear a strong resemblance to beach sands (Boggs 2011; Brumfitt *et al.* 2013), and I believe, are likely of marine origin. The occurrence of minor amounts of shell fragments in the MPPM (Brumfitt *et al.* 2013) supports this. Tankard (1975), who was one of the first authors to investigate the lithology of the Varswater Formation, identified a beach bar formation along the south western edge of the E-Quarry terrace. The position of the beach bar relative to E-Quarry is shown in Figure 9.5. The hypothesised Langebaanweg estuary would have developed behind this sand bar or barrier-island. Barrier-island estuaries are best developed on wave-dominated coasts with small tidal ranges (Boggs 2011). Sediments in these estuaries are composed predominantly of fine to medium grained sands that originated from the beach (Boggs 2011). The primary control mechanisms of sedimentary movement in barrier-island estuaries are

marine, and they can lay down sand bodies tens to hundreds of meters thick (Boggs 2011). Due to marine action, fine sedimentary particles are winnowed out and tidal-flats, lagoons and marshes can accumulate along the margins and grade laterally into sandier deposits (Boggs 2011). The lithology at E-Quarry is consistent with deposition of sediments in an estuary situated behind a barrier island. Under this scenario, thick fine-grained sand bodies would have built up on the landward side of a sand bar. Estuaries are highly biologically productive systems with high habitat variability, but they are almost by definition, saline. While, the fossil deposits at Langebaanweg E-Quarry preserve many species that were freshwater dependent, indicating the existence of a substantial freshwater source like the palaeo-Berg River.

Marine transgressions over a barrier-island estuary can create a reversed vertical profile, where offshore sediments are stacked on top of nearshore sediments (Boggs 2011). Sand bodies will thus become stacked with increasing depth.Transgressions will also result in the river and its tributaries changing course (Hendey 1981). The most significant feature that distinguishes the MPPM from the LQSM is that the latter are non-phosphatic (Hendey 1981b), a finding supported by grain analysis in this investigation. The phosphates of the MPPM were formed authigenically in a marine littoral setting (Dingle *et al*. 1979). Full details of the process and the characteristics of the MPPM phosphates is given in Chapter Two, section 2.5. Phosphogenesis can occur where there is a sudden mortality of phytoplankton which results in the release of high concentrations of phosphorous (phosphate ions) (Birch 1979). These micro-organisms occur in large numbers on the south west coast due to the nutrient rich waters of the Benguella Upwelling System (BUS). The BUS is currently believed to have initiated during the Middle Miocene and various lines of evidence indicate it was already established and cool at the time the LQSM and MPPM were deposited. In an enclosed system like a barrier-island estuary, waters can quickly become super-saturated, especially if the estuary mouth has become temporarily closed off from the sea. Increased water temperature (from solar radiation on the estuary) can then result in precipitation of the phosphate as a pore-filling cement in the sandstone (Middleton 2003). Phosphogenesis, was thus a secondary process that occured after the sediments have been deposited in a shallow water setting.

Thus the MPPM and LQSM were laid down in a barrier-island estuary during a marine transgression. A river was discharging into the sea where E-Quarry is now located during the Early Pliocene. A beach bar formed near the river mouth, probably due to wave action, leading to the creation of an estuary behind it. Sands from the beach and even from beach dunes were transported into the estuary by tidal action. Muds and silts and associated environments (tidal-flats and marshes) accumulated around the edges of

the estuary. The MPPM and LQSM deposits could represent a stacked sequence of sandbodies, with the LQSM laid first and continued marine transgression resulting in sands of the MPPM overlying it. However the consistency of sedimentary characters in the MPPM and LQSM suggests that these members likely represent a single sand body. This single sand body later became inundated by rising sea levels, until shallow marine conditions in the estuary lead to phosphogenesis. Phophogenesis affected the upper parts of the deposit, but the sediments known today as the LQSM were too deeply buried to be affected. This is supported by the fine intermingling of the LQSM and MPPM sediments, and the generally similar taxonomic composition and taphonomic characteristics of the deposits. The occurrence of phosphate rock in the bonebed which has been smoothed, eroded and partly undercut by unidirectional water flow (Smith & Haarhoff 2006) suggests phosphogenesis occurred in multiple events or stages (Roberts *et al.* 2011). Roberts *et al.* (2011) concur with Smith and Haarhoff (2006) that cementation of the phosphate rock preceded deposition of the river channel fossils, which may have been laid down during a slight regression in the Pliocene transgressive sequence. It is not possible to know the exact period of time in which these developments occurred but it implies that there has been some level of time averaging in the MPPM deposit at E-Quarry.

9.4.2 Bed 3aN/S and the Bonebed

A typical characteristic of estuaries is that they form at the distal part of a river where it discharges into the sea. The river can take the form of a single large channel or break down into many small distributary channels. It can alter course leaving behind abandoned channels or it can display some combination of these characters depending on a wide array of environmental conditions like discharge rate, sedimentation rate, tides, vegetation cover, and storm surges (Boggs 2011). The river channel with its associated environments like ponds and marshes provides essential habitat and resources for many species occurring in the estuary. In the case of Langebaanweg, the river channel probably acted as a nucleus, where animals gathered to drink freshwater and feed on riverine vegetation.

The estuarine depositional conditions of the MPPM and LQSM would be expected to preserve estuarine and shallow marine fauna and the invertebrates, piscine and chondrichthyan remains support this, but Langebaanweg E-Quarry additionally preserved terrestrial and freshwater fauna. The bed 3aN/S river channel was incised into the base of the MPPM and upper LQSM suggesting temporary exposure (possibly during a slight regression in sea levels) of the MPPM after a previous phase of phophogenesis.

Animals from various habitats across the estuary may have been attracted to the freshwater and may have died in the vicinity of the river for numerous reasons. Their remains later become interred when sedimentary deposition restarted and the river channels were buried. Additional phases of phosphogenesis later occurred. Well preserved fossils (of terrestrial animals) in the form of partial skeletons have been recovered scattered throughout the LQSM, and do not appear to be concentrated in any localised environment. It is unfortunate that little has been published about the distribution of bones and carcasses in modern estuaries, as it may provide a wealth of information regarding bone preservation potential in these habitats. For example, Cruz (2008) found in a survey of a Patagonian coast that the majority (60%) of remains were recovered in coastal habitats, compared to wetlands (31%) and steppe (9%) habitats.

Excavation 1976/2 (Profile Two)

There has been some debate over the origins of the faunal remains from the river channels. Bed 3aN has previously been described as a fossil lag deposit in the river, with many species having been washed downstream to this point (Hendey 1981b; Roberts *et al.* 2011). Hendey (1981b) believed this channel was deposited during flood conditions when the river had sufficient force to flow over the top and travel around the phosphate rock. It has additionally been suggested that the river had excavated fossil material from the LQSM and redeposited it in the channel bed. There are some lithological characteristics observed in the test pit from this deposit (Profile Two) that may indicate fluvial deposition. For example, channel scours in the LQSM and many small abraded and unidentifiable bones.

Taphonomic featurese indicate deposition in a higher energy environment. The relative proportion of unidentifiable bones was high in Profile Two and these bones do resemble a lag-like bone gravel. Large sized animals were rare in Profile Two and microfauna were almost absent, also suggesting destructive forces and possibly winnowing. Abrasive damage was most prevalent in Profile Two, but in all test pits excavated abrasion damage was slight. Staining and root etching was likewise common in Profile Two, although both of these factors appear to be post-depositional. Thus, lithological and taphonomic characters indicate fluvial activity and deposition in a higher energy environment. It is impossible to test (taphonomically) whether some bones in the river channel were derived the LQSM, as they have not travelled far enough to become modified. Even if such a process had occurred the MPPM and LQSM are likely sampling bones from the same environment with little time difference.

The Langebaanweg Bonebed

The bonebed was located in an area considered by Hendey (1981) to form part of the bed 3aN deposits (see Chapter Three.). The depositional origins of this bed have proved contentious. Roberts *et al*. (2011) follow Hendey (1981) in describing this deposit as an ill-sorted lag of the bed 3aN river channel. Hendey does not address the bonebed directly, which was excavated much later, but described all fossil remains related to the phosphate rock in this manner. Smith and Haarhoff (2006) described the bonebed as an elongate channel lag, which is continuous with the 1976/2 excavation. They suggested that the bones were concentrated in a scour pool on the downstream side of the phosphate rock, which acted as an obstruction to flow.

The association of the bonebed with the riverine complex is beyond question. But the density of bones and the preservation of such large bones in the bonebed, suggests a very different set of depositional conditions from the other river channels (1976/2) that were excavated. Fossil remains from the Profile Four test pit, excavated immediately north of the exposed portions of the bonebed, do not display any characteristics of a lag deposit. There are no upward fining sequences or scour fills with gravel. There is no gravel in the MPPM of Profile Four. There is a gravel-like portion of the deposit, but this material has been disturbed and redeposited by flowing water during mining activity. It is possible that the position of Profile Four in the upstream part of the bonebed might not intersect typical lag features, but a visual inspection of the open bonebed excavation cannot identify lag gravels or features in the bonebed deposit. The excellent bone preservation, with complete elements of very large individuals that show point compression and ‘greenstick’ fractures, where the broken parts are still associated, are all indications for a low energy depositional environment. Slight and infrequent weathering on bone remains from Profile Four indicates quick internment. Abrasion damage was light and trampling relatively (40%) frequent. Smith and Haarhoff (2006) also describe light weathering on the sivathere remains. Given the location of the bonebed within the riverine complex, I would suggest that the contouring of the phosphate rock and erosion of the scour pool are likely separate events to the low energy deposition of the fossils of the bonebed. In other words the phosphate rock and the scour pool were excavated by running water from a temporary river channel. Later water flow slowed or stopped and the pool was filled with freshwater. This water source could have provided habitat for freshwater taxa like anurans and pisces and additionally provided drinking water for large mammals and other taxa.

An alternative depositional scenario for the bonebed, that accounts for the low energy conditions, is a near-coastal aquifer-fed waterhole (Brumfitt *et al*. 2013). Brumfitt *et al*. (2013) argument was based

primarily on the low energy conditions and the lack of terrugenous muds. Although the current study has now suggested that the lack of mud was a characteristic of a wider area of the Langebaanweg estuary than the bonebed, and more likely is the result of processes occurring at the level of the estuary. There is little literature pertaining to how aquifer-fed water holes or artesian springs can be recognised in ancient settings. What literature is available suggests that aquifer-fed waterholes are characterised by evaporates (Le Tenser *et al.* 2007; Braun *et al.* 2013). Wellsprings are found in the Sandveld area around Langebaanweg today and are known from as far back as the Middle Pleistocene. For example, at Elandsfontein, wellsprings have been identified from preserved calcareous well-spring eyes (Braun *et al.* 2013). No evaporates or evaporite structures have been recorded from Langebaanweg however, which argues against the bonebed as an aquifer.

The bonebed was characterised by the presence of a large number of sivathere bones, belonging to at least eight sub-adult individuals (Smith & Haarhoff 2006). The sivathere remains could have accumulated at the bonebed locality as floating carcasses transported by the river (Smith & Haarhoff 2006). Alternatively, the sivatheres were attracted to the pool looking for freshwater and perished due to reasons unknown (Brumfitt *et al*. 2013). There is little evidence for the former proposal. A strong flow rate would be needed to move just one carcass of this size, even if bloated with gass and the bonebed deposits lack evidence for fluvial activity. In addition, all eight individuals would have had to have been washed in during the same event as there is no indication for repeated fluvial activity. All taphonomic signatures suggest low energy deposition, where the faunal accumulation was, for most species, biological.

A number of factors indicate that the area around Langebaanweg was experiencing increased seasonality in the Early Pliocene. Botanical proxies indicate an increased presence of grasslands and sclerophyllous vegetation (Sciscio et al. 2013; Roberts et al. 2017); the latter vegetation type is intrinsically linked with seasonal (winter) rainfall. Additionally, the development of the BUS in the Middle Miocene is known to have resulted in increased aridification on the west coast of souther Africa (Heinrich et al. 2011). Increasing aridity and seasonality could have resulted in the death of the sivatheres along with many other animals (Brumfitt *et al*. 2013). The attritional mortality profile (majority are subadult) of the sivatheres supports this (Smith and Haarhoff 2006), although as noted the sample sizes used in this analysis are insufficient. It seems more likely that animals were either resident in the pool before preservation (anurans, piscines), or came to the pool to drink, or were brought to the deposit by predators as meals (isolated bones) or as regurgitates (owl pellets). It should also be noted

that the presence of a carcass of a large mammal like the sivathere is likely to attract carnivores and scavengers, some of which, particularly in times of drought, may also then have perished in the vicinity of the pool. Carnivores have additionally, been suggested as potential taphonomic accumulators of marine taxa in the bonebed and surrounds. The evidence does not support the transport of large marine mammals into the bonebed by drifting up the river. The taphonomic analysis of Profile Four also provides evidence for infrequent and low intensity burning in the vicinity of the bonebed. Weathering data from Profile Four suggests bones were quickly interred but suffered extensive trampling. This could happen if bones became submerged in water or soft mud for a period before final internment. Fernández-Jalvo and Andrews (2016) described cracking, flaking and exfoliation in bones from the bonebed which they attribute to submersion in water before final burial. The bonebed can thus be considered a low energy, freshwater depositional environment associated with a riverine complex. Hendey (1980, 1981) suggested bed 3aN and 3aS represented low water and flood seasonal channels. Other authors believed bed 3aN was a short-headed ephemeral stream (Roberts *et al*. 2011). It is difficult to say at this point whether these channels represent seasonal beds or abandoned channels, and it is impossible to return to bed 3aS as it has been mined out. I find no evidence for washing in of bones or carcasses from upstream areas and conclude that the fossils that came to be preserved in the bonebed and 1976/2 excavation were resident in the vicinity of the pool and either travelled to the bed in search of water or were brought there by predators.

9.5 LIMITATIONS AND FUTURE WORK

This study is the first to investigate taphonomy at a broad scale, across multiple areas and taxonomic groups, at Langebaanweg. Previous studies have focussed on a single taxonomic group (Matthews 2006) or have only provided brief descriptions. The study has identified the effects of a number of taphonomic processes like carnivory, trampling and burning, and has identified possible taphonomic pathways for the accumulation of bones at Langebaanweg E-Quarry. This is the first time the relative frequency or intensity of these modifications has been quantified in the deposit. Additionally, this study expands our knowledge of lithology in key areas of the site. Little lithological work has been undertaken at Langebaanweg since the 1970's and this one of the few studies to utilise new exposures. This study has reinvestigated the depositional environments of a number of key fossiliferous areas of the Langebaanweg deposit. By undertaking test pit analyses in these areas, I was able to investigate both lithology and taphonomy of all bones (not just large or readily identifiable remains) from areas that have

not been investigated in many years and whose origins are contentious. Overall the study has proved informative, however its limitations should be acknowledged.

The use of test pits, while providing a highly controlled sample, only provides limited insight into the deposits of Langebaanweg E-Quarry. Some lithological characteristics like sedimentary bedding could not be effectively analysed in such small excavations. Future research, expanding the excavations over a wider area, particularly in the Profile One location, will greatly improve our understanding of the lithology of these deposits. Langebaanweg is a large site with a broad lateral and temporal range. It is difficult to make generalisations about the whole site from the excavation of three small areas. Expanding excavations at Langebaanweg by opening new fossil localities could greatly ameliorate our understanding of E-Quarry as a whole and has the potential to discover new fossil localities like the river channel. The review of the literature and field notes from earlier excavations, provided in this thesis should assist future researchers in identifying localities of interest.

Many important faunal groups at Langebaanweg have not been well studied and require the attention of experts. These include a number of bird families, piscines and reptilia. Tortoises, which make up a large percentage of the Langebaanweg faunal assemblage, are virtually unstudied and even their taxonomic classification is insufficiently known. Clarification of the taxonomic classification of these animals will improve taphonomic and palaeoecological interpretations. Additionally the test pits sampled in this study collected a large assemblage of microfauna, included within which will be mammals, anurans, and small reptiles. Microfauna remains are known to be highly habitat specific and these assemblages have great potential for palaeoenvironmental interpretations.

The 1976/2 excavation has been shown to still contain large amounts of bone and is an excellent locality in which to investigate the LQSM deposits which have received very little attention in recent years. Additionally, many taphonomic questions regarding the bonebed remain. For example, a fabric analysis of orientation and inclination of bones in the bonebed can indicate the presence of flowing water in the past, and will provide further insight to the deposition of this bed. Little has been published on this exceptional locality and there is still a great deal that can be learned about the deposit.

Taphonomy is a complex science and we are constantly learning new things about the environment and how it can affect bones. For example, in this study it has been shown that more experimental research is needed into the processes and affects of root etching on bones and fossils.

Table 9.1. Taphonomic characteristics of Profile Four, Profile Two and Profile One

	Profile Four	Profile Two	Profile One
Total specimens	20487	4094	10246
Identifiable specimens (n)	1589	202	1332
Identifiable specimens (%)	7.8	5.2	13
Unidentifiable specimens	16855	3874	7267
Microfauna (%)	2043	<1	16
Mammal (%)	39.6	25.2	10.3
Chelonia (%)	55.8	73.3	83.5
Aves (%)	3.1	1.5	5
Pisces (%)	2	-	-
Reptilia (%)	0.5	-	-
Amphibian (%)	-	-	0.1
Bone Weathering (%)	17.5	19.3	18.6
Burning (%)	5.3	8.4	10.5
Colour Mottling and Staining (%)	56.8	58.9	75.6
Abrasion (%)	83.5	93.6	77.8
Sheen & Polish (%)	23.1	33.7	48
Trampling (%)	28.8	25.7	33.9
Carnivore Tooth Marks (%)	4	1.4	4.2
Digestive Erosion (%)	3	0.7	2.5
Root Etching (%)	26.1	39.6	21.9
Insect (%)	4.2	-	-

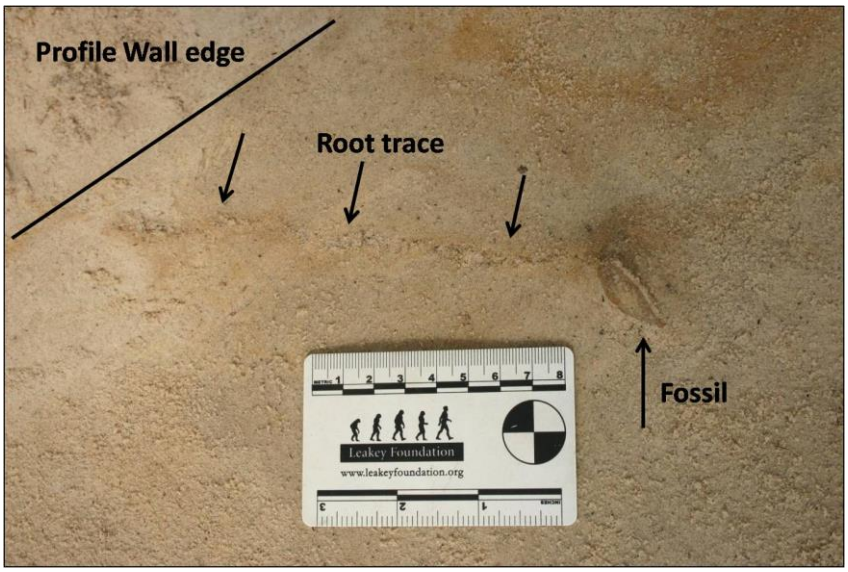


Figure 9.1. Root trace tracking through profile wall towards fossil. Observed in 1976/2 excavation.

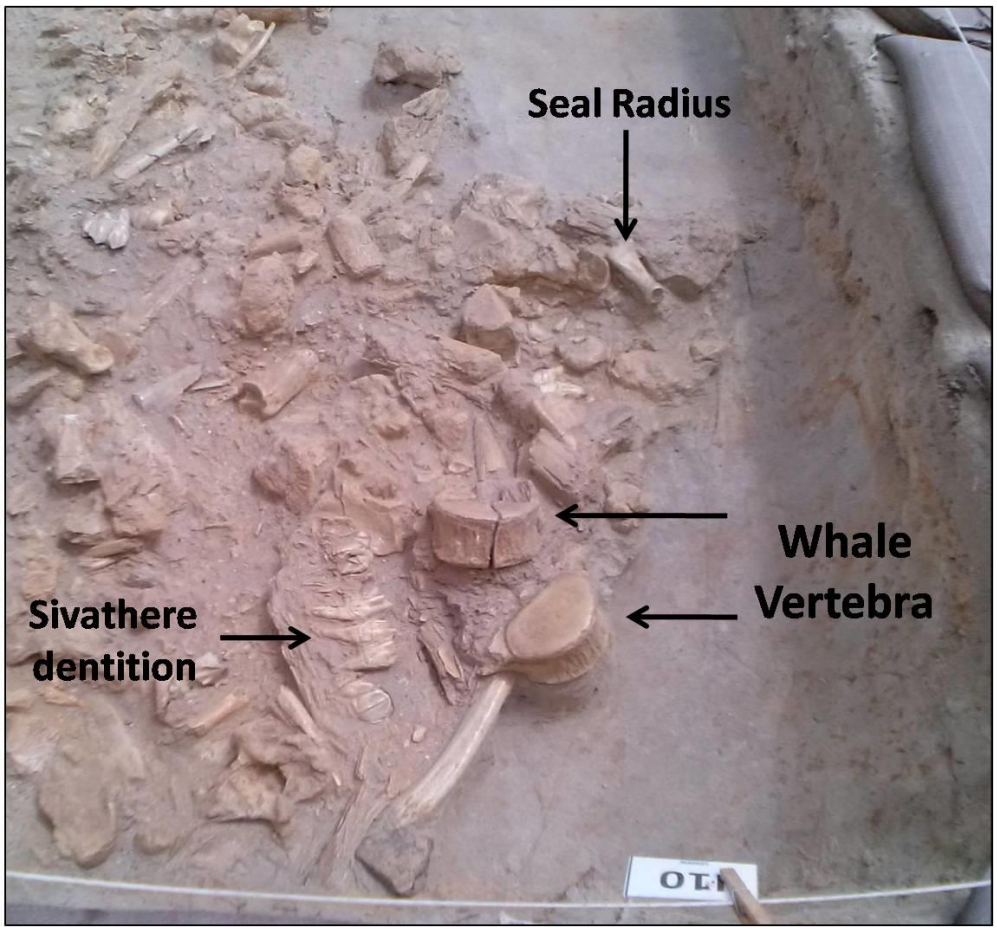


Figure 9.2. Whale vertebra in close association with terrestrial and marine mammal bones in the bonebed deposit

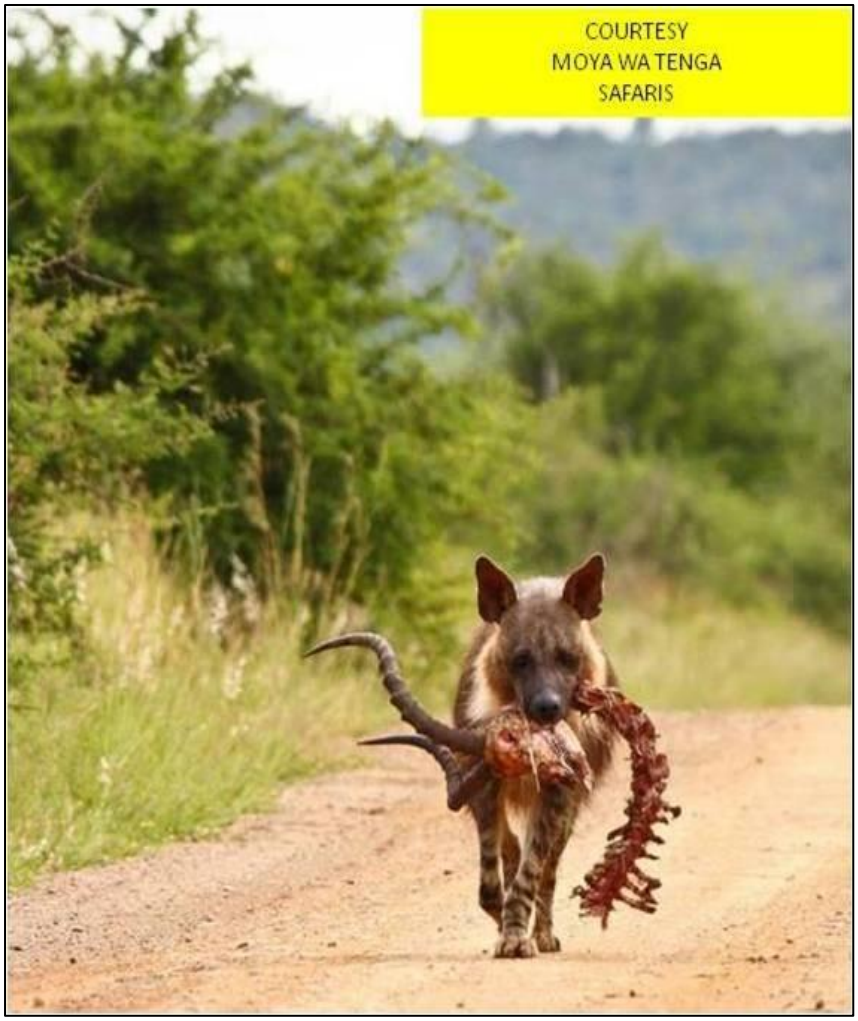


Figure 9.3. Brown hyena carrying bones of large prey back to den. Photograph courtesy of Moya wa Tenga Safaris and Dr Job Kibii.

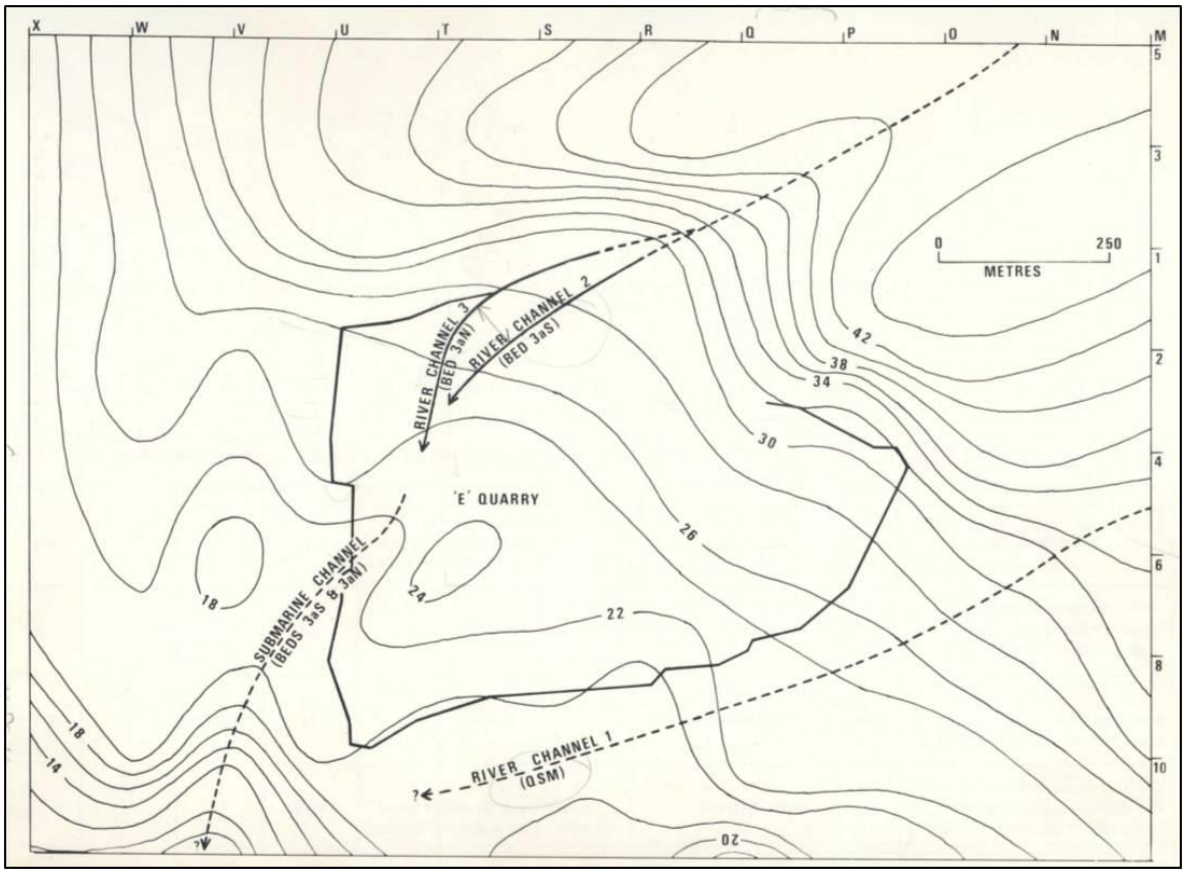


Figure 9.4. Sketch of E-Quarry from 1981 overlain onto a structure contour map of the base of the MPPM. Note the location of the purported river channels, the numbers indicate succeeding positions. Reprinted from Hendey (1980), Annals of the South African Museum, 84 (1), 55.

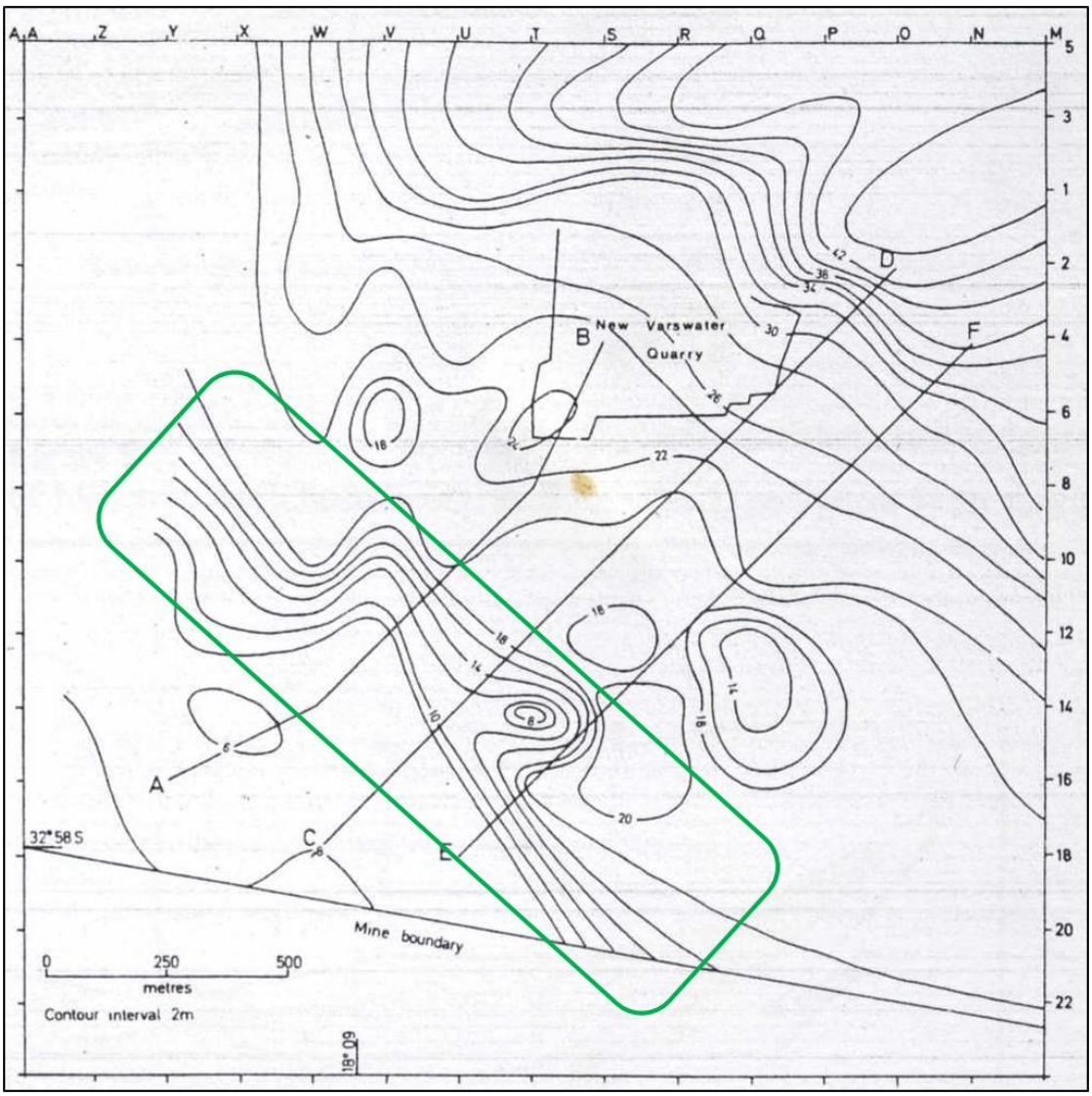


Figure 9.5. Structure contour map of the base of the MPPM. Note the position of E-Quarry (New Varswater Quarry). The area demarcated in the green rectangle is the likely position for the sand bar. Reprinted and adapted from Tankard (1975), Transactions of the Geological Society of southern Africa, 77, pp. 270.

CHAPTER TEN

CONCLUSIONS

10.1 CONCLUDING REMARKS

Langebaanweg is a tremendously important fossil locality. It preserves a vast array of faunal remains including taxonomic groups that are otherwise poorly represented in the fossil record of southern Africa. It is the only Mio-Pliocene site in South Africa. Langebaanweg records a time period that globally saw major climatic shifts leading to massive faunal and floral species turnover. There are however, many unanswered questions regarding Langebaanweg, its depositional environment and palaeoenvironment. This study has addressed some of these questions and the results of this analysis have augmented our understanding of Langebaanweg E-Quarry in the following ways:

1) Sedimentary texture and grain size were found to be almost identical in the MPPM and LQSM in the test pits excavated in this analysis. This has lead me to conclude that the MPPM and LQSM were deposited by the same depositional process. I provide evidence that the MPPM and LQSM were likely deposited together as a single unit and are distinguished only by secondary phosphatisation of the upper parts. They thus differ only very slightly in age and there is no unconformity between these deposits.

2) The depositional environment of the MPPM and LQSM was reconstructed as a barrier-island estuary on a tidally dominated coast. The sediments that make up the MPPM and LQSM were derived from the beach and all silts and muds were winnowed out by wave action. This differs from previous depositional reconstructions of the MPPM as part of a complex of anastomsing river channels. Similarly, the LQSM has previously been reconstructed as the floodplain facies of the (Palaeo-Berg) river.

3) The MPPM sediments of Profile One, located 200 m to the south of the tunnels, were dominated by silt and mud grains, with a possible high organic content. This deposit was interpreted as a marsh habitat and this is the first identification of a fine-grained deposit at

Langebaanweg since the 1980's. It provides researchers with a unique opportunity to sample a habitat that has not been available to researchers in decades and that has the potential to provide novel information.

4) This study investigated and tested various theories put forward to describe the depositional origins of the bonebed. Taphonomic and sedimentological characteristics unequivocally indicate low energy deposition and are inconsistent with Hendey (1980), Roberts *et al*. (2011) or Smith and Haarhoff's (2006) reconstructions of the bonebed as a lag deposit of the river. Nor, are there any evaporate features that could indicate the presence of an aquifer-fed spring. The bonebed was deposited in a low energy freshwater pool, fed (at least intermittently) by the bed 3aN river channel.

5) Sedimentological and taphonomic results in the 1976/2 excavation (Profile Two) support Hendey's (1981b) interpretations for a river channel deposit in bed 3aN. I found no evidence to indicate that bones preserved in Profile Two were derived from upstream areas and transported into the site.

6) A number of conclusions regarding the depositional origins and environment of the three test pits can be made based on the taphonomic data from this analysis. Bones in all three spits were quickly interred and relatively little of the assemblage was burnt. Burning damage was consistent with low intensity, quick moving fires and the appearance of similar levels of burning in all three pits may be an indication for regular (or seasonal) burning. Bone remains from Profiles One and Four were deposited in low energy environments and display little abrasion, but Profile Two displays higher abrasion levels, consistent with deposition in a river channel. Carnivore modifications were very rare in all test pits and tooth marks were small sized, suggesting the work of small carnivores. Trampling marks were extensive in all locals and this may be the cause of some of the intense fragmentation observed. Post-depositional modifications like root etching and staining were among the most frequent surface modifications observed on bones in this analysis.

7) The test pits were found to contain very high predominance of chelonian remains but fragmentation was high in these bones, and mammals were more common by number of individuals. The test pits displayed high density of tortoises compared to estimates of modern tortoise density on the landscape. Carnivory and burning were found to affect a relatively small

percentages of tortoise bones and were concluded to have made little contribution to the assemblage.

8) I utilised field notes (see appendix), mine documents and aerial photographs to track and infer Hendey's collecting strategies and some key fossil locations. This information has resulted in the identification of the location of a number of localities or fossil collecting areas at Langebaanweg E-Quarry including beds 3aN/S and the East Stream. These maps and notes will prove highly beneficial to any researchers hoping to return to old localities or looking to identify new deposits.

9) Palaeontological information based on the three test pits conforms to previous reconstructions of a mosaic environment with many habitats. The three test pits produced freshwater, terrestrial and marine remains. There were taxa indicative of open grasslands, wooded environments and even arid habitats.

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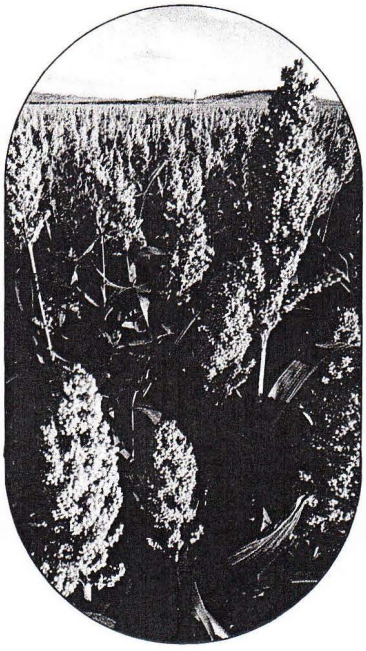
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Langebaanweg - 1966 Excavations
('E' Quarry 1966/1)






CHEMFOS

1966/1

APPENDIX A

EXCAVATIONS AT LANGEBAANWEG

From 2nd - 13th May, 1966, an investigation was made on behalf of the University of Chicago and the South African Museum of Natural History of the deposits exposed in the new 'E' quarry for phosphatic sand at Langebaanweg. Permission for this work was kindly given by AMCOR, who also gave access to the borehole records, geological and geomorphological reports and other relevant papers in their possession. Mr. Robin Warren, chemist at the site, added many of his observations.

Fossil mammalian bones have been recovered from phosphatic sand quarries in this district since 1958. The new 'E' quarry was opened in 1964 and numerous fossil bones have been found by the quarrymen since then and placed in the South African Museum of Natural History. The great interest of the site is the presence of both archaic forms of mammals generally considered to have lived during the Lower Pleistocene period (Hipparion, Stegolophodon, etc.) and of mammals considered to belong to the Middle Pleistocene period (Archidiskidon, Homoioceras, etc.).

A cutting was made on the west side of the quarry so that the deposits could be studied in detail and photographically recorded. The cutting was 10 feet wide from the surface in convenient steps to a depth of 56 ft, covering a horizontal distance of 245 ft. The top was at 150 ft. above present mean sea level.

The deposits divide broadly into three divisions:

1. 150 - 132 ft. a.m.s.l.	Aeolian sands with dune bedding and humified horizons in the upper 4 ft.
2. 132 - 95 ft. a.m.s.l.	Phosphatic sands and sandstones with distinct traces of current-bedding in the lower 5 ft.
3. 95 ft - ?	Clay, probably marine, separated from phosphatic sands by a layer of beach gravel.

a) Beach gravel: although not well represented in the cutting, this feature is constant in the borehole records at about 95-100 ft. a.m.s.l. and relates to the 100 ft. shoreline known round much of the coast of the Cape. The 100 ft. or Tyrrenhian sea level is a world-wide feature dated to the Middle Pleistocene period and there are no abnormalities such as tectonic movements in this part of South Africa to make this dating suspect. All deposits above this level will thus have formed during or after the Middle Pleistocene. The marine nature of the gravel is attested by rounded pebbles and also sharks' teeth collected by Mr. Warren.

b) Phosphatic sands and sandstones: these sands were deposited in slow-moving water and subsequent chemical changes have altered them into sandstones or concretions. The phosphatic content is thought to have been derived from a concentration of bird excrement (guano) as found on several offshore islands at the present time. This sand

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flowed...../

flowed about 100 ft. higher than it does now and made a southward turn straight towards Langebaan and not, as nowadays, westward to St. Helena Bay.

Further evidence for a high sea level after the 100 ft. sea is that the top of these sands were planed smooth by its retreat to a lower level at a later date. This is shown by plotting the top of the phosphatic sands across the area, north-south and east-west. In both cases a smooth curve indicates the action of water.

c) Aeolian sands: these rest on a weathered surface and probably accumulated during the Upper Pleistocene.

FOSSIL BONES: A few were found at various levels throughout the phosphatic sands, but are very numerous in the lower part, particularly in the current-bedded sands and within clay inclusions also containing plant remains. In this lower part were many hundreds of small bones, mainly fragments but also of micro-fauna and birds. A few large bones also occurred and it is clear that only these have hitherto been spotted by the quarrymen.

Interpretation: The rise in sea level which followed the 100 ft. sea level ponded back the early Berg River which then joined the sea in this area and its load was deposited in the form of sandbanks and spits. On some of these sea-birds massed and produced thick deposits of guano. As the sea level rose so this guano was mixed with aggrading sand. Some form of lagoon must have existed as the open sea would have dispersed the guano. Animal carcases, floating down the Berg River in flood time, would come to rest on the sandy obstructions and gradually be covered by sand. When the sand was saturated it was relatively plastic, hence the current-bedding is now contorted and it is thought that the clay inclusions with plant remains are traces of former swampy surfaces which sunk into the sand.

The fossil bones appear, therefore, to belong to one period of time in the Middle Pleistocene and it does not seem possible that any of them could be derived from earlier deposits so it must be concluded that these archaic forms of mammals persisted in this part of South Africa until such relatively recent date as the Middle Pleistocene, possibly 300,000 years ago.

J.J. Wymer, F.S.A.

1766/1

APPENDIX A

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J.J. Wymer, F.S.A.

J Wagner Excavation S(1966/1)

EXCAVATIONS AT LANGEBAANWEG

APPENDIX A

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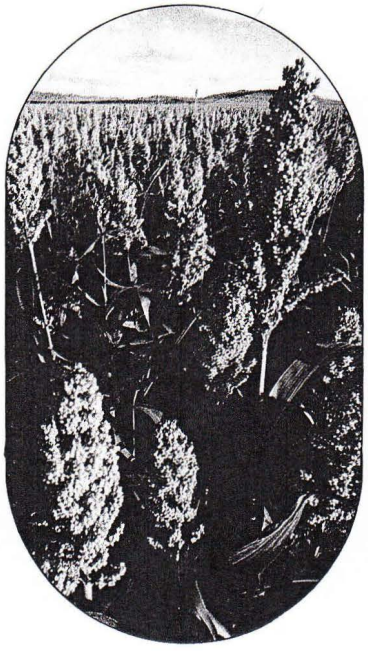
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J.J. Wymer, F.S.A.

Langebaanweg – 1966 Excavations (E Quarry 1966/2)









CHEMFOS

1966/2

APPENDIX B

LANGEBAAN EXCAVATION

During the period from the 29th August, 1966 to 27th October, 1966, the "Langebaan excavation" was carried out in the "E Quarry" of the A.M.C.O.R. phosphate quarries. The site of the excavation was chosen adjacent to an earlier excavation carried out by Mr. J. Wymer. This was done to enable it to be treated as an extension of Mr. Wymer's. The people present were myself, Mr. P. Saunders and two labourers, R. Jones and J. Louw.

The height above sea level of the surface of the cutting is ± 111.5', while the base which is level with the floor of the quarry is ± 95.6'.

The methods of excavation used varied according to circumstance. In the upper 7' - 9' the amount of fossils did not justify trowelling, consequently it was dug and sieved ($\frac{1}{2}$"), except in cases of important or fragile specimens. The whole cutting was dug in 1' steps; in the upper 7' - 9' a trial trench was always dug (the length of the cutting x 2' x 1' deep) to ensure that it was safe to continue at that level. Below the distinct "yellow layer", which separated the two main sand bodies, the fossils were so prolific and in most cases their condition so poor that everything had to be done by hand, i.e. trowelling, and in a number of cases sieving ($\frac{1}{4}$"). In cases of important or fragile specimens the methods used were the same throughout the whole cutting. The specimen was exposed, cleaned, photographed, hardened with Industrial Adhesive (complete with a block of soil), and finally restored in the Museum.

As can be seen in the sectional drawings, buttresses were left on all three faces to ensure both safety from collapsing walls and to provide easy access to the bottom of the cutting.

The amount of catalogued specimens obtained from this excavation is 1395. They are numbered from L10,000 to L11,395.

The...../

APPENDIX B

The following is a list of the most important specimens:-

L.10055 Skull, Hyaenid

L.10056 Left Mandible, Hyaenid

L.10057 Right Mandible, Hyaenid
Associated with the above skull and mandible were a number of carnivore post cranial bones, including a humerus, tibia gratment, metatarsals, metacarpals, phalanges and others. All of which can with near certainty be said to have come from the same animal (i.e. Hyaena).

L.10,100 Left Maxilla fragment (Felid?)

L.10343 - L10352 Complete upper dentition (minus incisors) Giraffid (Gracilis?)

L.10723 Right Mandible, Canidae

L.10724 Left Mandible, Canidae

L.10802 - L.10808 Associated teeth, Hyaenid Hyaenid

L.10810 - L10823 Teeth and skull fragments, ~~Felid (Lion?)~~

L.11125 - L.11131 Elephantidae teeth, (Anancus?)

L.11192 Tusk, Elephantidae (associated with L.11125 - L.11131)

L.11193 Tusk fragments, Elephantidae (associated with L.11125 - L.11131)

Fish vertebrae were found at all levels.

Numerous "pockets" of Bovine teeth were found, each "pocket" presumably coming from a separate animal.

A number of Rhinocerotidae teeth were excavated all coming from a very consistent level at approximately 15' from the surface, but as these are quite common from this site, I have not included them in the above list.

The following list gives the numbers and description of the slides taken on the excavation:

No. 1 Position of intended cutting prior to beginning work.

2 Northern view of the cutting at a level of 5'.

3 & 4 Cutting at 5', taken from the East side of "E Quarry"

5 & 6 The "yellow layer" taken from the N.E. corner, showing the slope downwards towards the West.

7 West face of cutting with incompleted steps.

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8	South face of the cutting, showing the river bedding.

APPENDIX B

No. 9 North face of the cutting, showing the "jumbled-up" river bedding

10 Close up view of whole cutting, approximately 4' from the base

11 As No. 10, taken from the East side of "E Quarry"

12 & 13 Close up view of completed original cutting

14 "Langebaan Excavation 2"

15 View of entire cutting

16 & 17 Elephantidae tusk, (from Dr. Strauss)

18 (Felid?) maxilla fragment L.10100

19 Close up of 18.

20 Group of bones (juv. Giraffid?)

21, 22 and 23 Hyaenid skull and mandible

24 Position of a cluster of teeth and bones

25 & 26 Close ups of 24.

27 Close up of Elephantidae tooth from above cluster

28 Elephantidae tusk, L.11392

29 Close up of 28

30 Entire tusk after exposing the portion buried in the South wall

31 Position of the tusk in relation to the two large ribs

32 & 33 Strip of film on which the slides overlapped owing to jamming in the camera, the left hand one shows an antelope skull + Metatarsal in highly fragmentary state, the other shows a typical cluster of bones.

The faunal assemblage obtained from this excavation might, with further research, lead to some conclusions, which in turn could add to the knowledge of this particular site.

The following facts might help in the formation of some conclusions.

The excavation can be divided into three sections:

(a) The upper uniform brown sand, containing a few fossils, and many clay inclusions. 0' - $\pm$ 7' - 9'.

(b) Directly under the upper layer, showing the yellow band and subsequent contortions denoting river bedding, containing very many fossils. 7' - 9' -- $\pm$ 12'.

(c) Below the above layer to the base, ranging from blue-

The following facts might help in the formation of some conclusions.

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(a) The upper uniform brown sand, containing a few fossils, and many clay inclusions. 0' - ± 7' - 9'.

(b) Directly under the upper layer, showing the yellow band and subsequent contortions denoting river bedding, containing very many fossils. 7' - 9' -- ± 12'.

(c) Below the above layer to the base, ranging from blue-grey at the top to white-grey to white, containing some large fossils and very many Chelonia carapace fragments. ± 12' -- 15.75'

The faunal assemblage from the "(a)" level is poor, on account of the small amount of fossils obtained from this section of the cutting. However, it can be noted that although the condition of the fossils was very poor they could not have been subjected to much movement subsequent to their being "deposited" at Langebaan. This is made obvious by the Hyaenid skull L.10055 which, although being highly fragmentary, was still intact. Furthermore, the p.c. carnivore material found next to the skull can with near certanty be assumed to have come from the same Hyaena. This suggests that the entire skeleton was "deposited" and covered up very soon afterwards, otherwise with prolonged exposure it would show signs of weathering or gnawing, neither of which I have found any trace of.

In this upper layer there is a predominance of Chelonia carapace fragments.

The "(b)" level is a mass of fossils, which, with a few exceptions, are in a very poor condition. Many teeth (chiefly Bovid), were found in this level. They appeared in "pockets" surrounded in some cases by highly fragmentary bone (slide 32). It can be assumed that these teeth are from the same skull or mandible, the bone of which has subsequently disintegrated in the process of fossilization. To be noted is the presence of quite a large proportion of juvenile Bovid cranial remains. Also present are marine mammal fossils, chiefly seal, and unfortunately no cranial material. From this level the Giraffid and Hipparion material came. The amount of Chellonia carapace fragments increases with depth, but is not in such profusion as the other two layers. There is a great deal of Microfauna from this layer, predominantly bird and mammal, this is particularly so in the yellow band itself, this appears to decrease with depth (numerically). Also found in this layer were some (Felid?) cranial remains, and a Canid mandible.

Except for a few Chelonia carapace fragments, the upper ± 1' of the "(c)" level is nearly sterile. At approximately 14' 6" there were patches of darker sand which contained very many fossils, there are chiefly very small Chelonia carapace fragments, but also some microfauna, teeth (mammal), fish vertebrae and bone fragments.

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At a..../

At a consistent level of ± 15' below the surface there were a few Elephantidae and Rhinocerotidae teeth and some large bone fragments. These, however, were not found in the same dark sand, in some cases they were half in the dark sand giving the appearance of being independent from them.

Below this almost on the base of the cutting the two large ribs were found (slide 31).

The fossils found in this level were, on account of their proximity to the water level, more mineralised than those which came from a higher level.

Fish vertebrae were found at all levels throughout the cutting, but were most common in the "(c)" level, where about 10 were found.




5

1966/2

LANGEBAAN EXCAVATION

APPENDIX B

During the period from the 29/8/66 to the 27/10/66 the "Langebaan excavation " was carried out in the "E Quarry" of the A.M.C.O.R. phosphate quarries. The site of the excavation was chosen adjacent to an earlier excavation carried out by Mr. J.Wymer. This was done to enable it to be treated as an extention of Mr.Wymer's.The people present were myself , Mr.P.Saunders & two labourers R.Jones & J.Louw.

The height above sealevel of the surface of the cutting is ± 114.5 ' while the base which is level with the floor of the quarry is ± 95.5'.

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The amount of catalogued specimans attained from this excavation is 1395. They are numbered from L10,000 to L11,395.

The following is a list of the most important specimans:-

L10,055	Skull, Hyaenid,
L10,056	Left Mandible , Hyaenid
L10,057	Right " "

Associated with the above skull & mandible were a number of carnivore post cranial bones, inc. a humerus , tibia frag. , Mt,s. , Mc,s., phalanges, & others.All of which can with near certainty be said to have come from the same animal.(ie Hyaena)

L10100	Left Maxilla frag. (Felid?)
L10343 - L10352	Complete upper dentition (minus incisors) Giraffid (Gracilis?)
L10723	Right Mandible, Canidae.
L10724	Left " "
L10802 -L10808	Associated teeth ,Hyaenid.
L10810 -L10823	Teeth & skull frags. , Felid (Lion ?)
L11125 -L11131	Elephantidae teeth , (Anancus?)
L11192	Tusk, Elephantidae,(associated with L11125 - L11131)
L11193	Tusk frags, " " " " "

Fish vertebrae were found at all levels,

Numerous"pockets"of Bovine teeth were found , each "pocket" presumeably coming from a separate animal.

A number of Rhinocerotidae teeth were excavated all coming from a very consistant level at approx. 15' from the surface, but as these are quite commen from this site I have not included them in the above list

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~~Very consistantly(at about 15' below the surface)~~ there were a few Elephantidae teeth , & Rhinocerotidae teeth & some large bone frags. These however were not found in the same dark sand, in some cases they were half in the dark sand giving the appearence of being independant from them.

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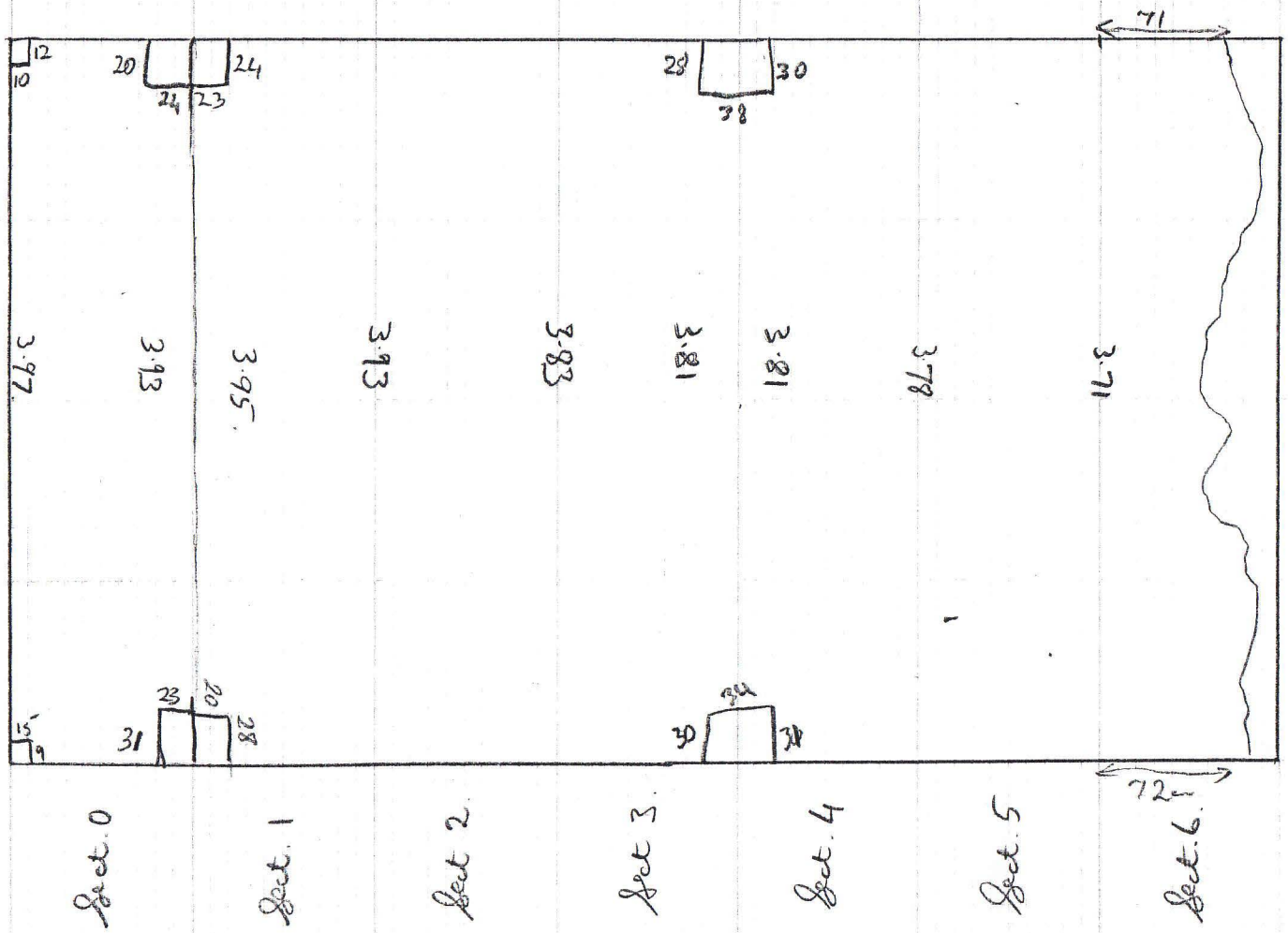
At a consistant level of ± 15' below the surface there were which contained very many fossils

Excerpts from Dr Hendey's field notebook from Langebaanweg 1969 excavations



CHEMFOS

1969/1 24/7/1969 Floor plan.



196911

Soil samples. 30/7/1969

Section 3

21 cms.

47

73

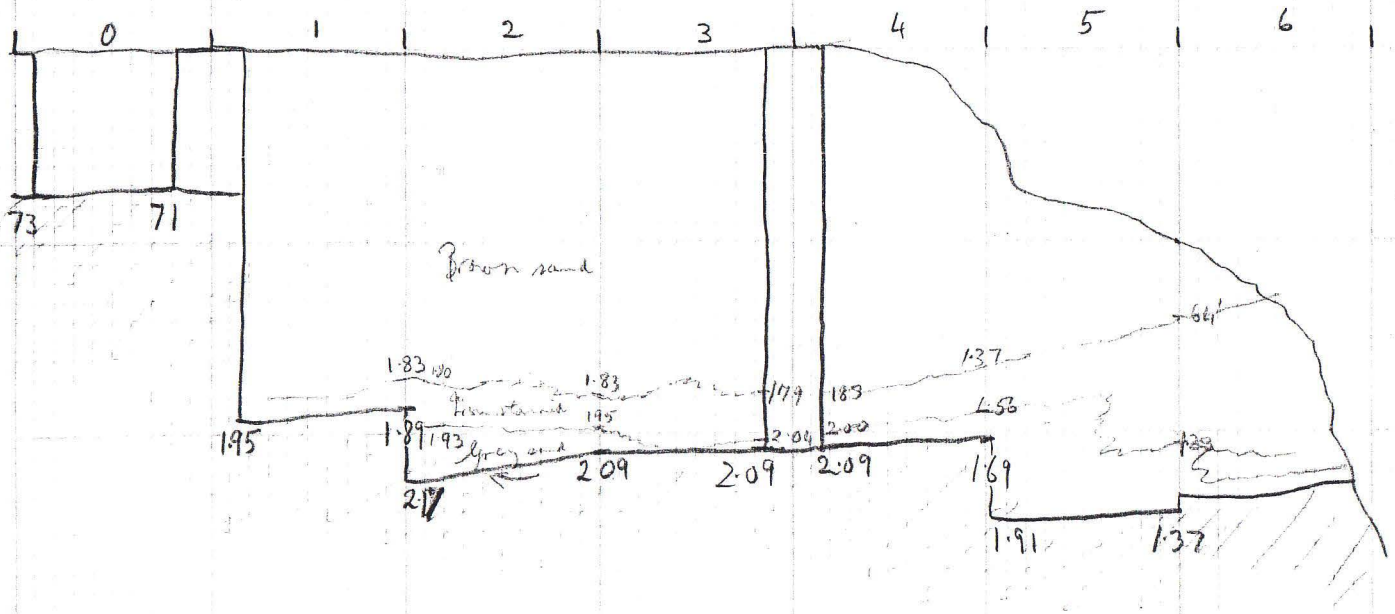
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1·37

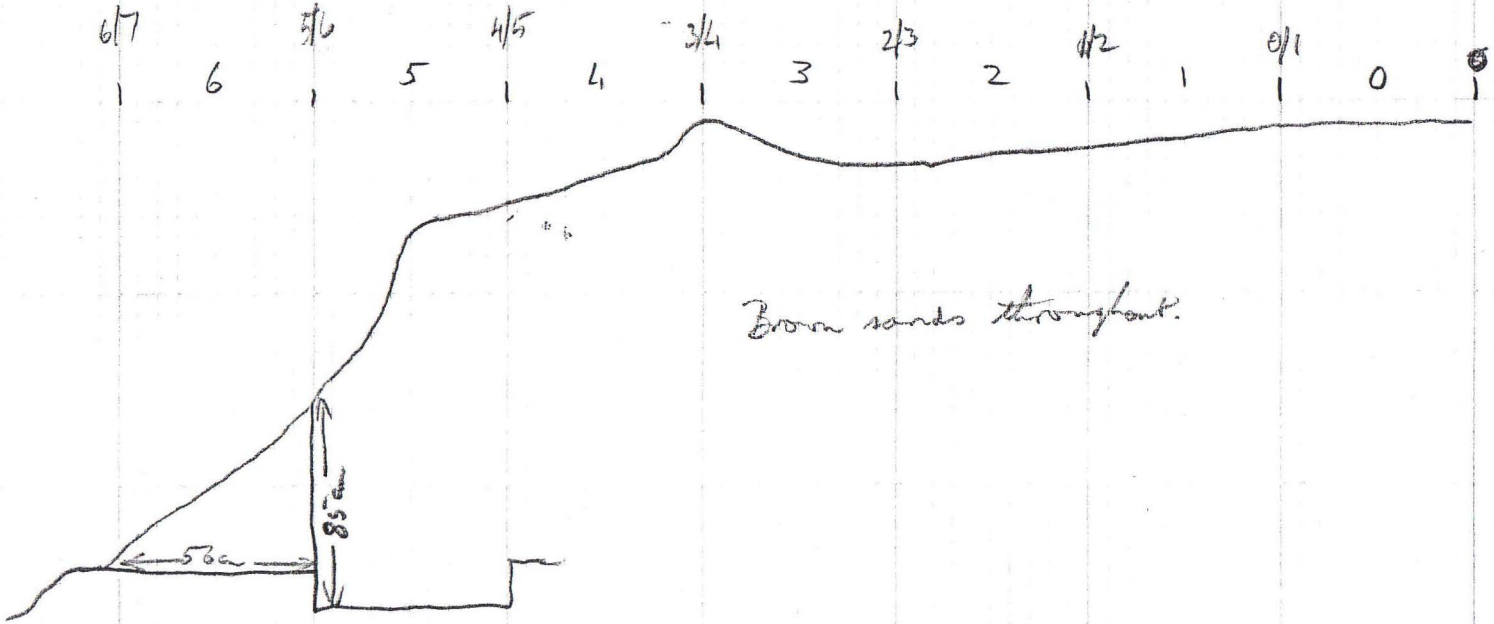
1·65

1·92

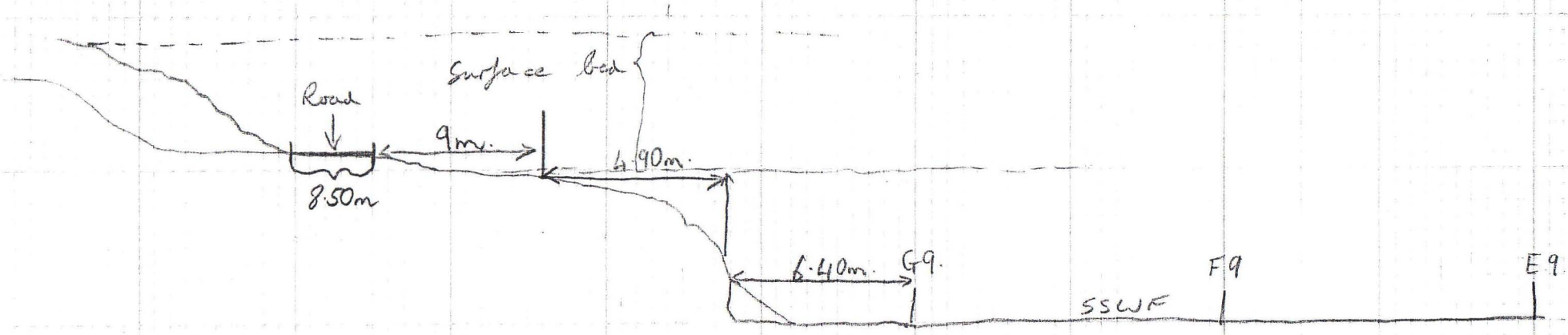
1969/1 North Wall 24/7/1969



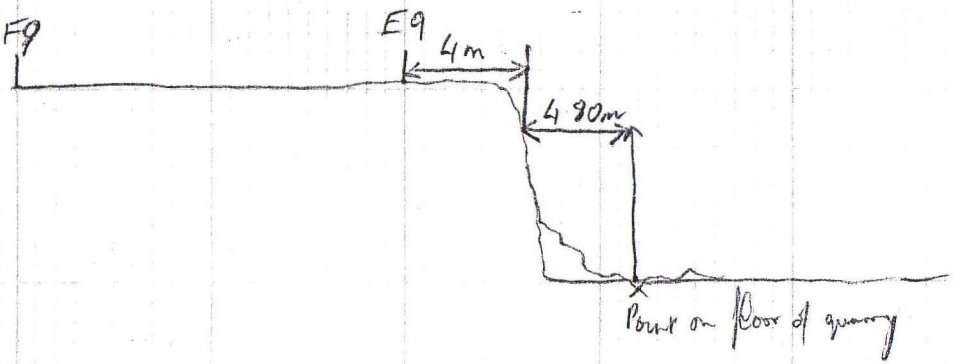
1969/1 South Wall 24/7/1969.

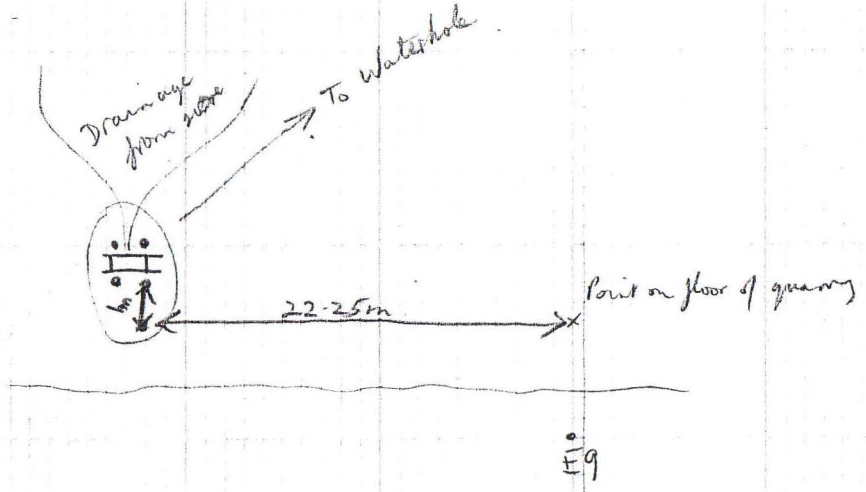


1969/1 24/7/1969



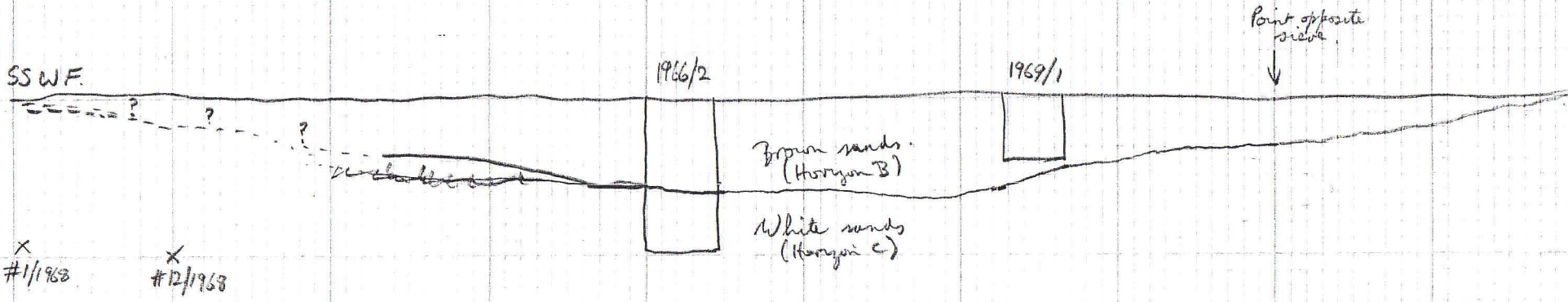
1969/1 24/7/1969





0 .75m 0

1969/1 24/7/1969



Excavation LBW/E/1969/1

This excavation was sited on the lower west wall of 'E' Quarry, its north line being 1 metre south of the '9' line of Grid A (see plan). Seven sections measuring 1 metre by 4 metres were laid out and numbered 0 to 6 from west to east.

Each section was excavated in spits of arbitrary depth varying from 25 cms to 45 cms in thickness, except in those instances where the ground was discarded. Observable fossils in the discarded spits were collected.

In the spits in which all ground excavated was sieved, observable in situ fossils were recorded 3-dimensionally. The ground from these spits was placed in buckets, lowered to the floor of the quarry, where the buckets were then transported by wheelbarrow to the sieves.

The ground was then worked through a set of two sieves, the upper with $\frac{1}{4}$" mesh, and the lower with $\frac{1}{8}$" mesh.

The sieve concentrate was placed on wooden trays to dry. Some rough sorting of identifiable pieces into cardboard boxes was done before the concentrate was placed in paper bags.

The fossils exposed in the cutting were wrapped in aluminium foil and placed into paper bags. In those cases where the fossils were in good condition no foil was used.

The excavation proceeded along the following lines:

(1) All loose surface soil, except that in Section 0, was taken up & sieved.
(2) Section 3 was taken as the key section and all ground from it was sieved.
(3) By the time Spit 4 of Section 3 was reached, fossils were being recovered in sufficient quantities to warrant sieving of all ground excavated thereafter.

(4) An exception was made in the case of Sections 5 ~~&~~ ~~6~~ over the wall of the quarry. The presence of erosion channels across these sections, and the poor condition of the fossils resulted in much of the ground being discarded.
The condition of the fossils was thought to be due to their proximity to a surface in which weathering & erosion has been proceeding constantly for more than four years.
Spits 6, 7 & 8 of Section 5 were sieved, the last two as a single unit, but the material recovered is excluded from the analysis which follows.

(5) Sections 0 & 6 were excavated simply ~~as a matter of convenience~~ to facilitate entry & exit from the excavation. No ground from these sections was sieved.

(6) It had been the intention to stop the excavation at the contact between Horizons B & C, but it was in fact stopped sooner / ~~in the~~ Spits 6 & 7 on horizons of ~~reddish~~ brownish (? iron stained) sand overlying a greyish sand was encountered. These horizons apparently differed markedly from the brown sands encountered in Spits 1 to 5 and ~~were divided~~ appear to follow the surface of the B/C contact.
It may well prove that the B/C contact in future be placed at the contact of the brown sands & the ? iron stained & grey sands. Alternatively these horizon could be designated B/C Intermediate Horizon.

(7) Spit 7, Section 1 was not excavated, this being the top of the next step to be left for the purposes of security in the section, and to simplifying entry & exit to the excavation.

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At a later stage Sect 0 ns to be deepened by about 25 cms

3.

In order that the free standing faces on the W. walls of Sections 0 and 1 may be about 1 metre each in height. This will be followed in Sections 2, and 3 as well by which time the base of the quarry will have been reached.

Excerpts from Dr Hendey's field notebook from Langebaanweg between 1969 and 1972 including quarry maps and reports



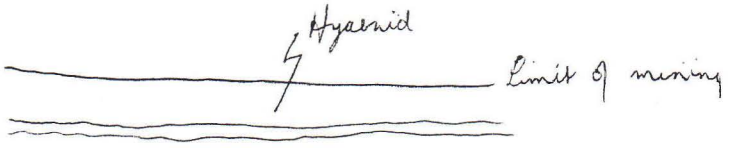
CHEMFOS

3/12/1968

Datum B set up.
±102 m. ~~W~~ of E. Face (Elephant site)

Hyaenid remains scattered immediately west of B
Some in situ pieces recovered, in very hard light-coloured sand.
Most other pieces from filled-in troughs left by dragline scoop (which run ± N-S.)

In this area a few centimetres of loose white sand is left on top of a thin indurated horizon (? a phosphate rock) below which the loose sand continues & is wet. (? the indurated horizon is marker of water-table.



In this area remains of at least three hyaenids are now known.

With the Datum B hyaenid was part of the mandible of a small ~~carnivore~~ (of which only some teeth could be saved). This is identical to the small ~~carnivore~~ found earlier in the W. Wall area (which appears to have come from Horizon C as well).

Between Datum B & the East Wall parts of at least three separate Tragoceros skulls were found (1 mandible, 1 M^3 + M^3 + 1 LM^3 + 1 RM^3). The crushed braincase found on 6/11/1969 may also be Tragoceros & the only horn-cores known from this general area are also of Tragoceros. This is remarkable since the common bovid in the W. Wall area is the alcelaphine (or 2 alcelaphines). ((From Baard's Quarry the most common bovid

In this area remains of at least three hyaenids are now known.

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Certain	Probably	Probably
Elephant	Anancus	
Giant pig		Small pig (but ??)
Large hyaenid		Small hyaenid
Rhino		
Giraffid		
Trogocerus.		Alcelaphines

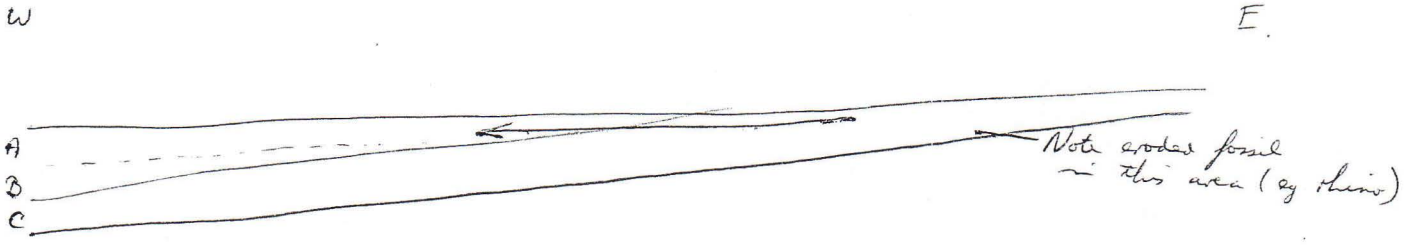
Horizon ~~X~~ 1 in the E Wall area has thus yielded:

1. Elephant (~~n. gen. prob.~~ M. subplanifrons – cf. Maglio)
2. Large hyaenid (cf. H. namaquensis)
3. Trogocerus
4. Giraffid (Libytherium) H c. found by Hedmon + p-c pieces by myself.
5. Rhino.

(Most if not all 1967 rhino remains were probably from Horizon 1 ~~A~~)

Large hyaenid can now be seen to be different from smaller form from Horizon ~~X~~ 2, by relatively much larger (+ more primitive?) M'. Otherwise sys is the only other certain discriminant.

Suggested succession

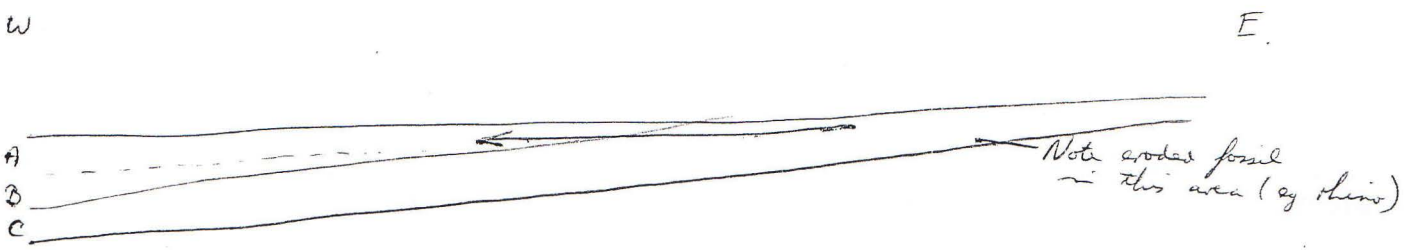


A/B derived from C further E. B only fossiliferous since it is lower than A, but no other real distinction of two should be combined A/B.

∴ C is only horizon with uncontaminated faunal assemblage. A/B has C fossils (derived) & probably contemporary remains.

C fauna as now known for certain. (See ~~ff~~ page)

Suggested succession



A/B derived from C further E. B only fossiliferous since it is lower than A, but no other real distinction of two should be combined A/B.

∴ C is only horizon with uncontaminated faunal assemblage.
A/B has C fossils (derived) & probably contemporary remains.

C fauna as now known for certain. (See ~~fp~~ page)

The fossils around Datum B are all very light coloured, whereas further east towards the elephant site they become

mostly in plate-like formations.

? does this extend west towards Datum B, but beneath the fine sands exposed on the surface in this area.



17/12/1969

Octonyx striatus 27975 near 5 m signpost south of Melsetter.

Zones in area centred ± 60 m N.W. of Datum B.
2 soft sand (wet) bordering on drainage channel

Vert. site 17-18 m W.N.W. of Datum B

27/1/1970.

Met Shell engineer (Mr. Fernie) at site. 3000 gal. tank to be delivered & erected at site in few months time.

Very poor collecting.

4/2/1970

Visit with Bob Brain, Graham Avery & Tony Tankard.
Also to Elandsfontein.

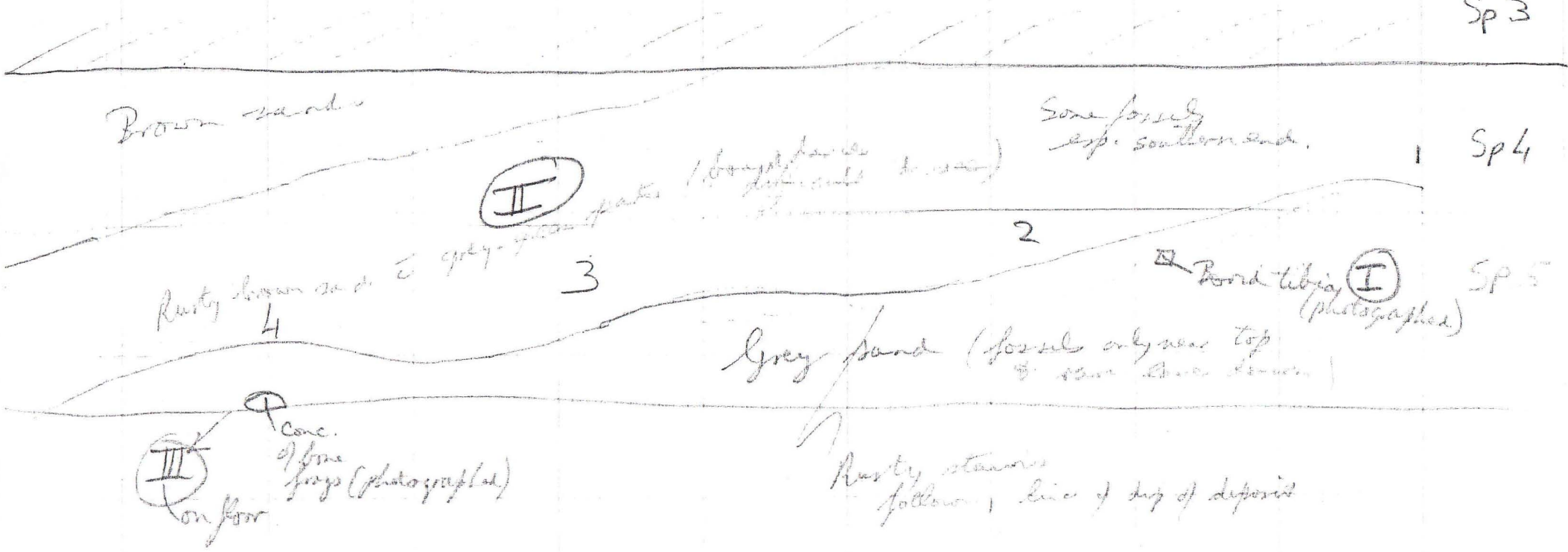
3/6/1970.

Visit with Frank Schweitzer & Frank Botha.
Fair quantities of bone recovered from May bottom cut area. (See Progress Plan #1)
(Finds reported by Graham B. on 31/5/1970)
Drag-line was digging deeper in S.E. corner of quarry as an experiment, & fossiliferous horizon very thin immediately on basal marker. Experiment to be discontinued because of slimes problem.
Most of fossiliferous deposit below water-table & recovery of specimens difficult.

It seems clear that the whole area between Beaver B & May B-C is underlain by fossiliferous deposit, but mining has not been deep enough.
Erosion will probably bring new specimens to light (as for example, part of Ursyanzacbeorus skull found today ±40 SE of B), but this part to be backfilled in about 5 years time.

May B-C area yielded parts of rhino skull (some collected by Graham & Nicholas), ostrich, seal, hyaenid, giraffid, other rhino remains, pig mandible frag, etc.
(Add 3/6/70 species to horizon 1 faunal list).

1970/1 Sect 2/3 Wall.



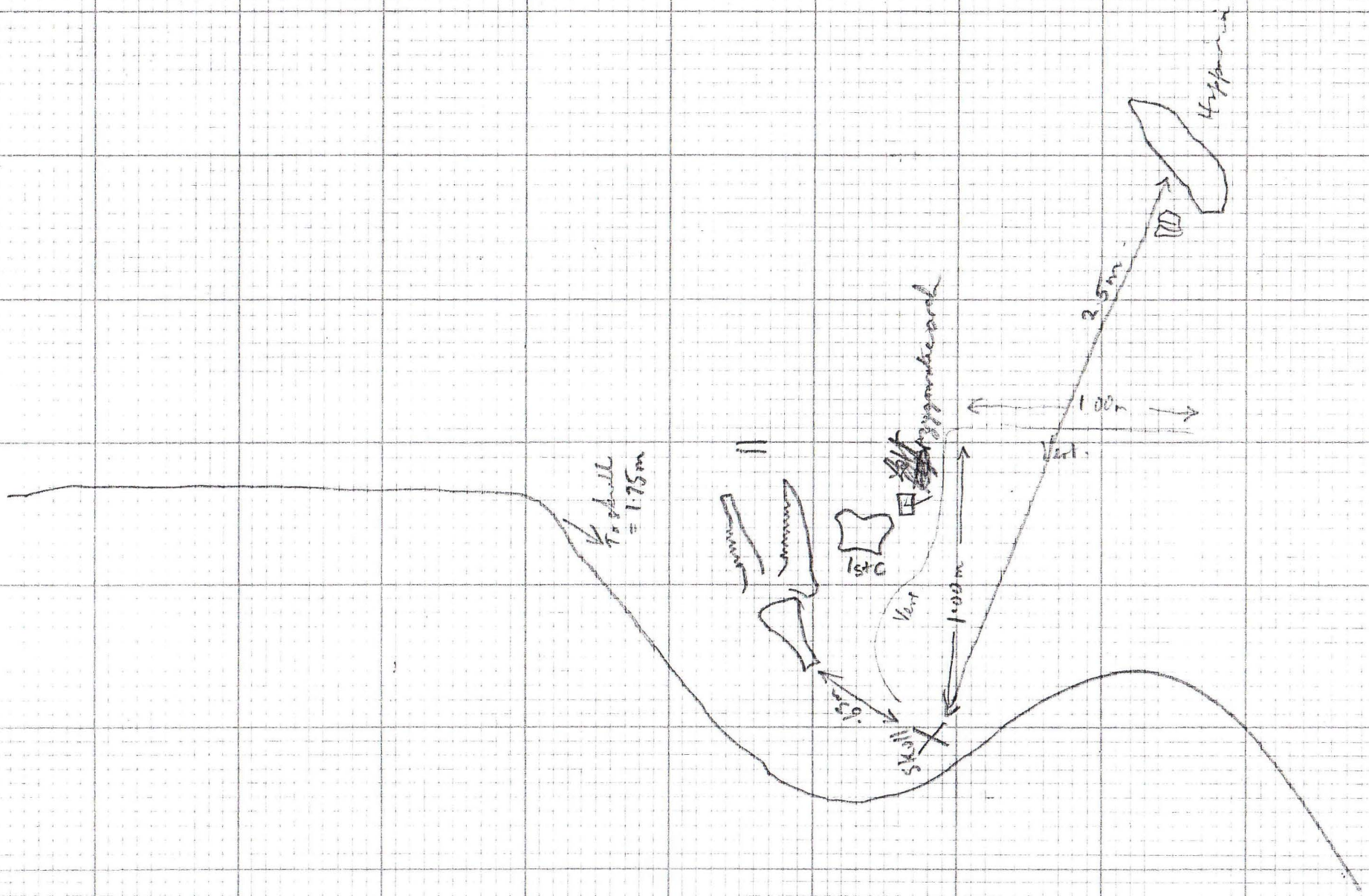
1–4 points levelled
2 = 1 m from N. Wall
3 = 2 m "
4 = 3 m "

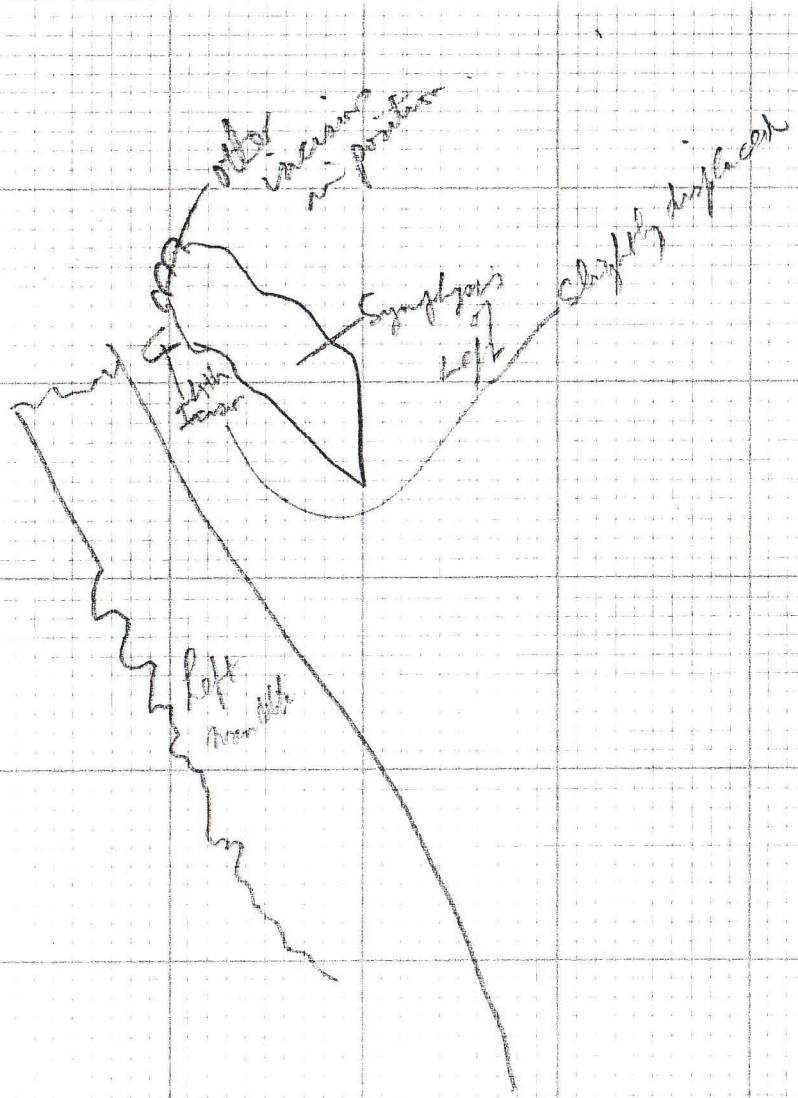
Soil samples:
- I Grey sand
- II Rusty brown sand + g.g.s.
- III Clayey sand around root
- IV Brown sand. Sect. 3, Sp 3 N. Wall.

Tragocerus spec. at head of stream.

Remains of more than one Tortoise found near skull

— most collected large parts of carapace & plastron articulated

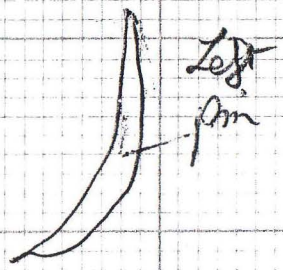

2.5m
1.00m
1.00m
1.75m
1.5m
1.5m
1.5


16/8/70
Left
Left

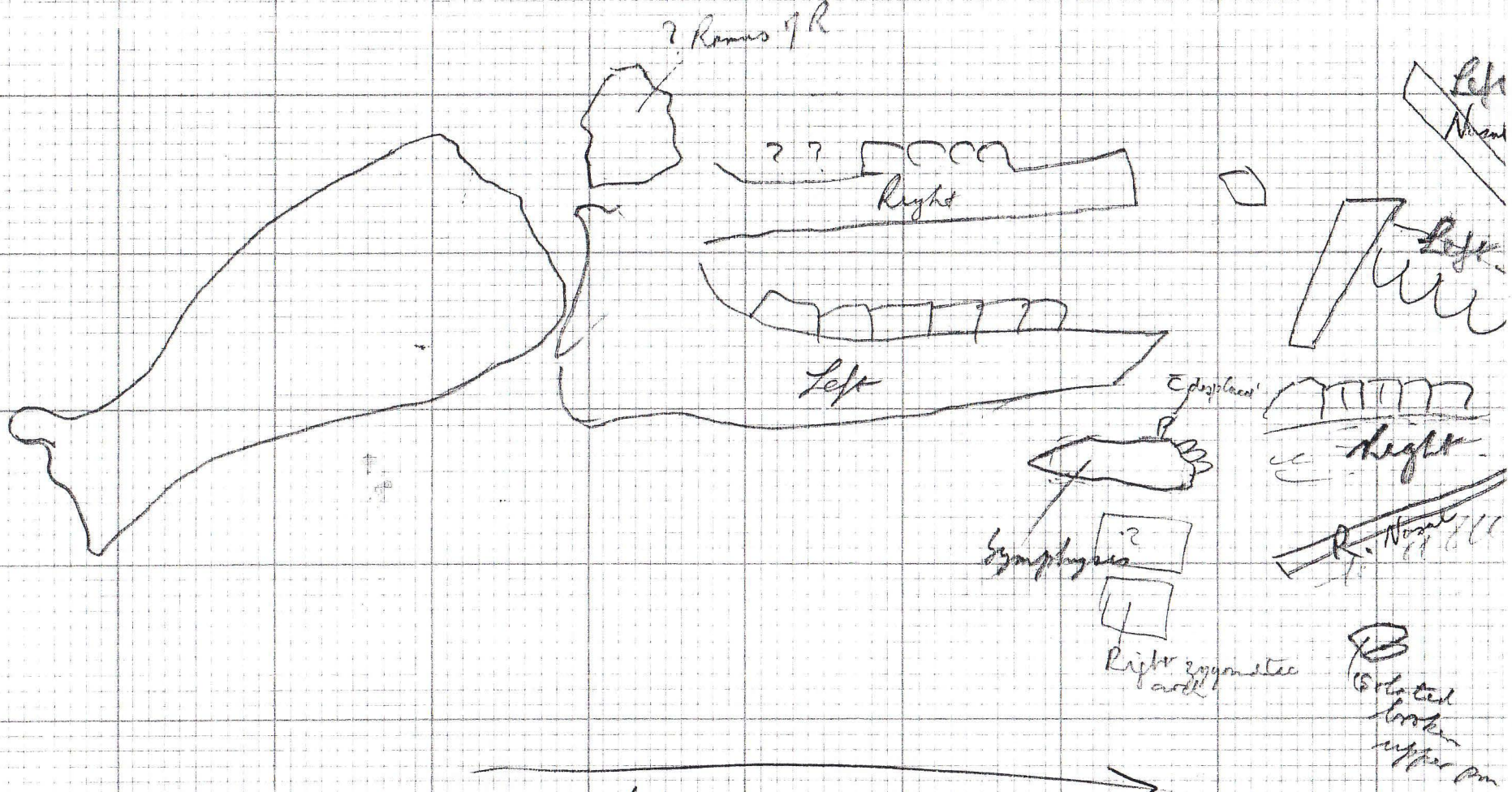
Right pm.
1.50 m S.W of skull.

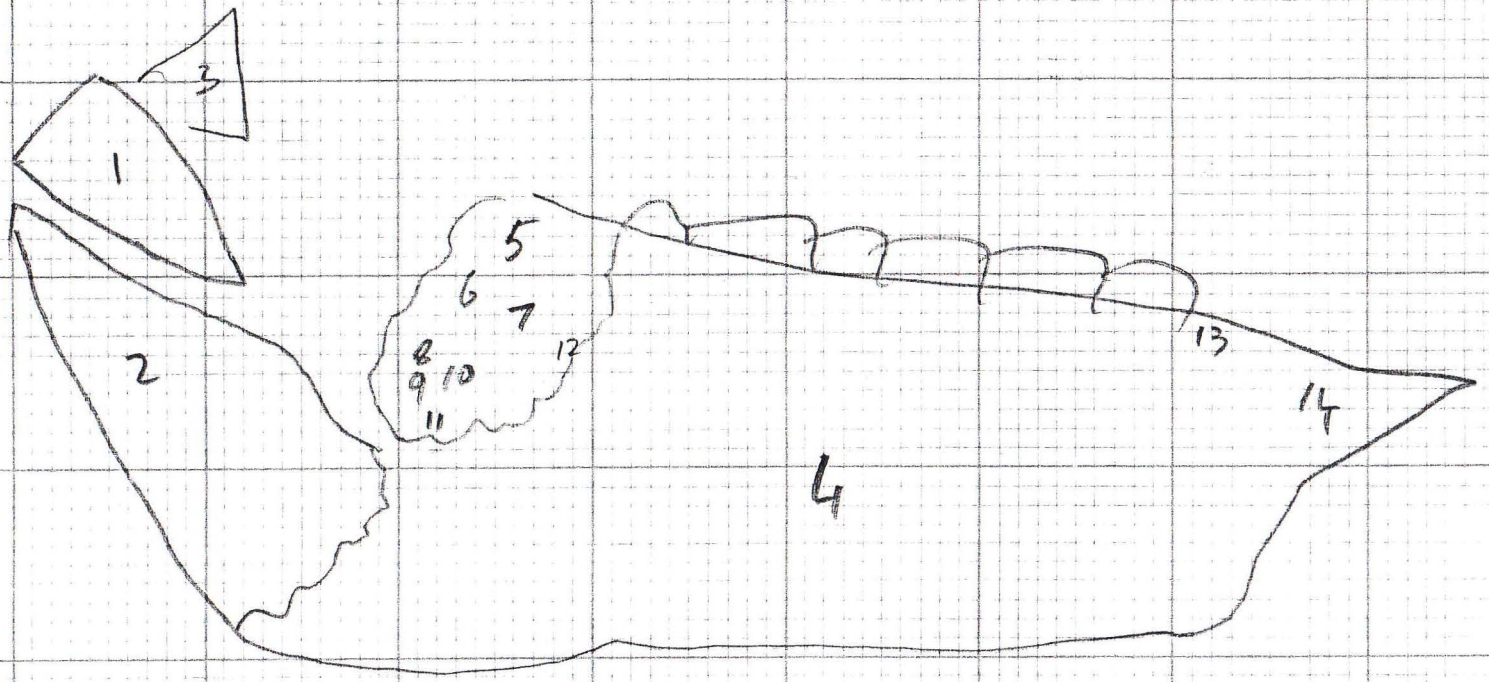


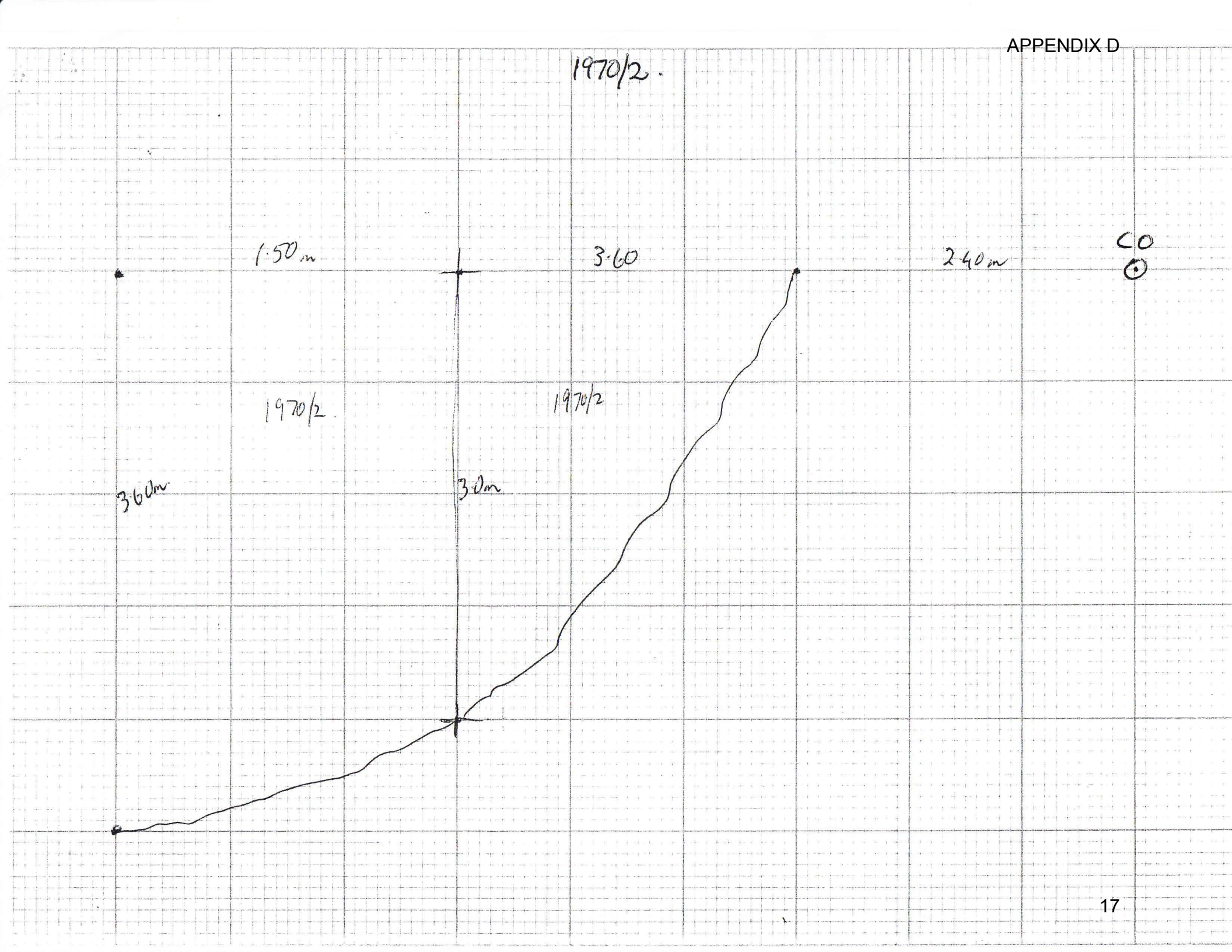
Right I, + C
below left nasal.

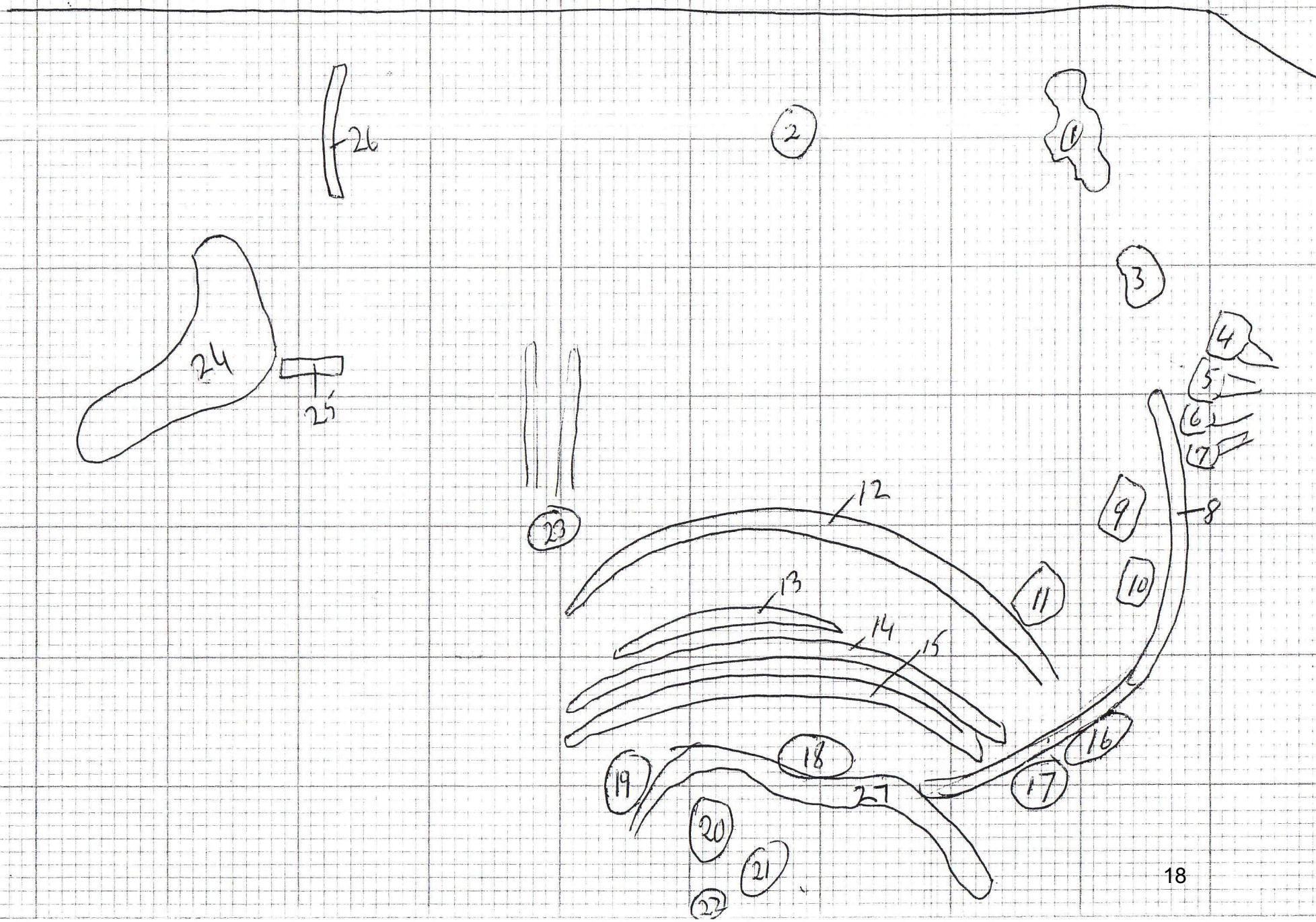


Association of mandibles etc.

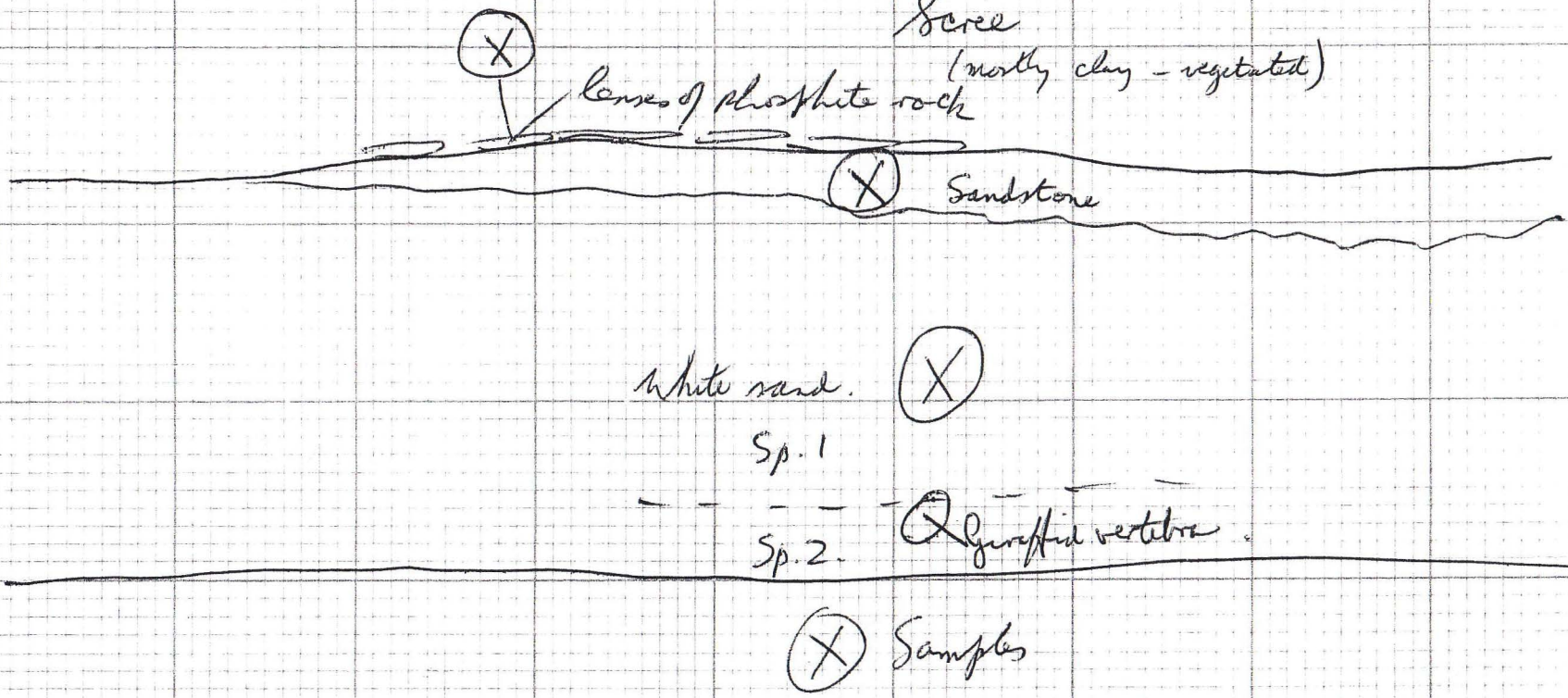


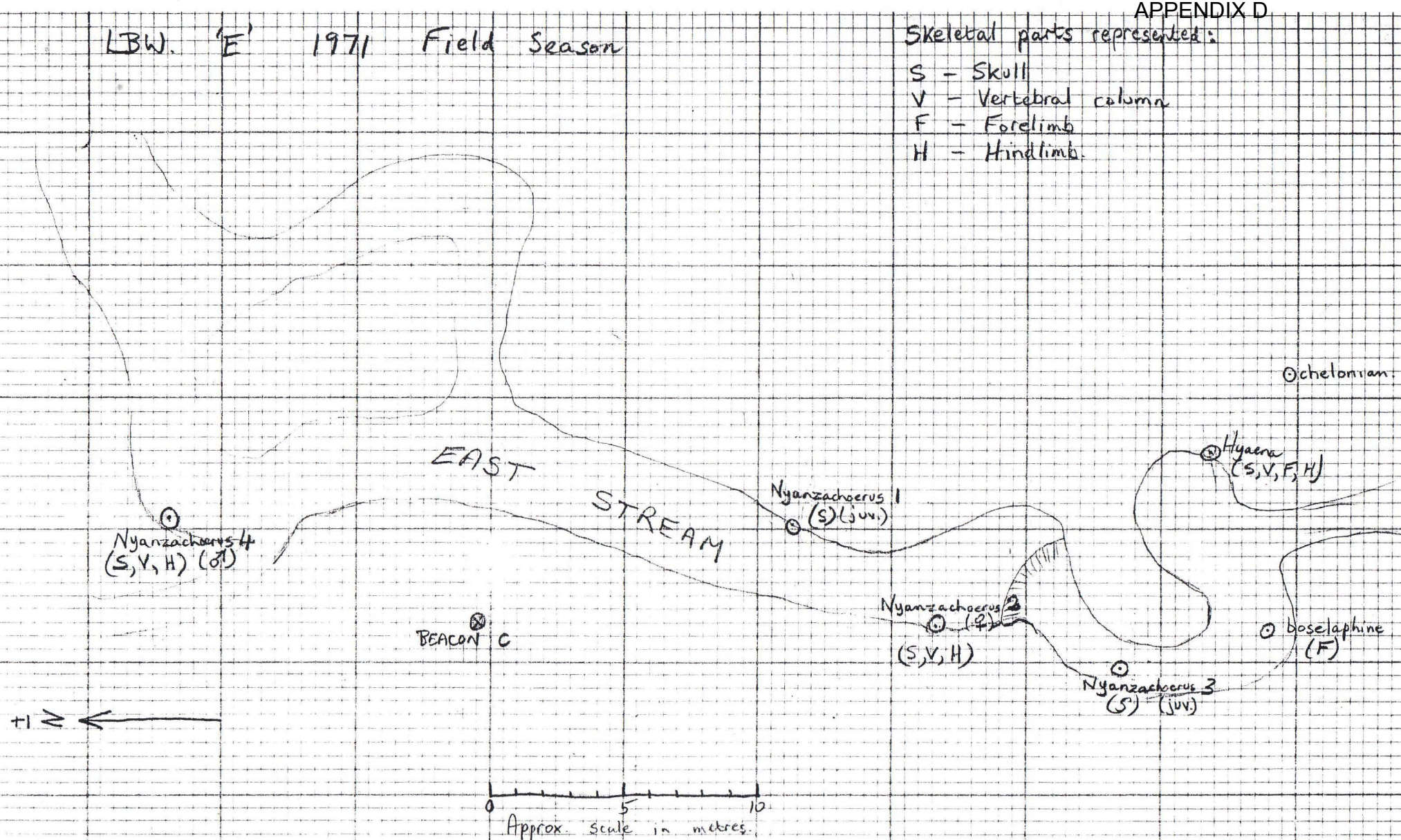

1
2
3
4
5
6
7
8
9
10
11
12
13
14


1970/2.
1·50m
3·60
2·40m
CO
1970/2.
1970/2
3·60m
3·0m

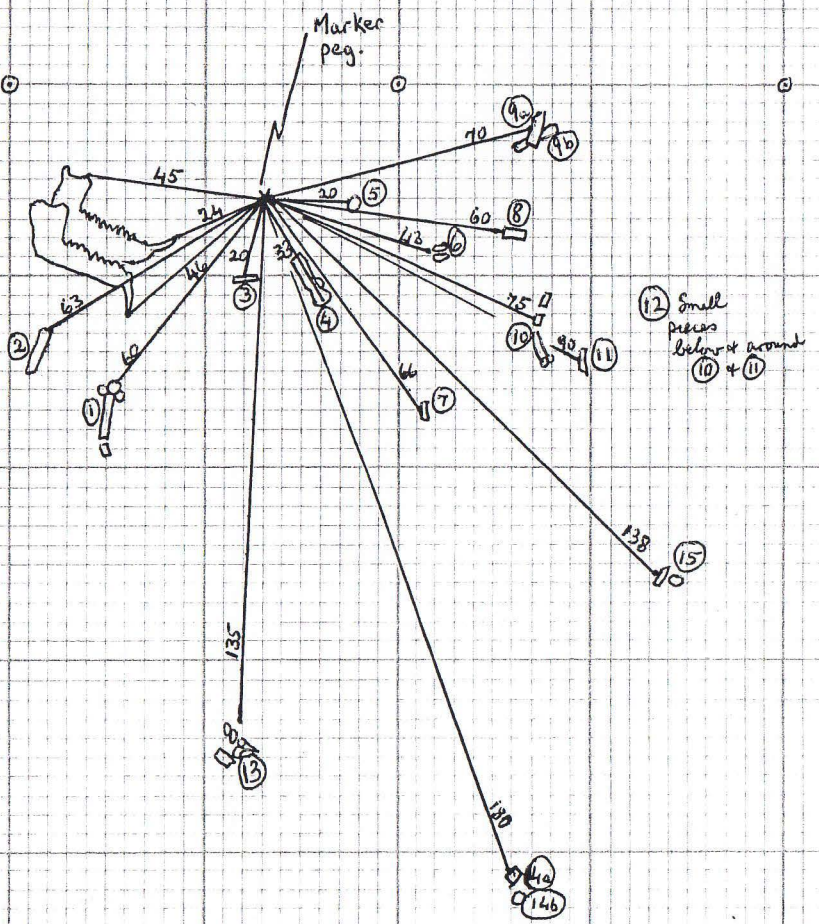

26
2
1
3
24
25
4
5
6
7
23
12
8
9
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11
13
14
15
16
17
18
19
20
21
22

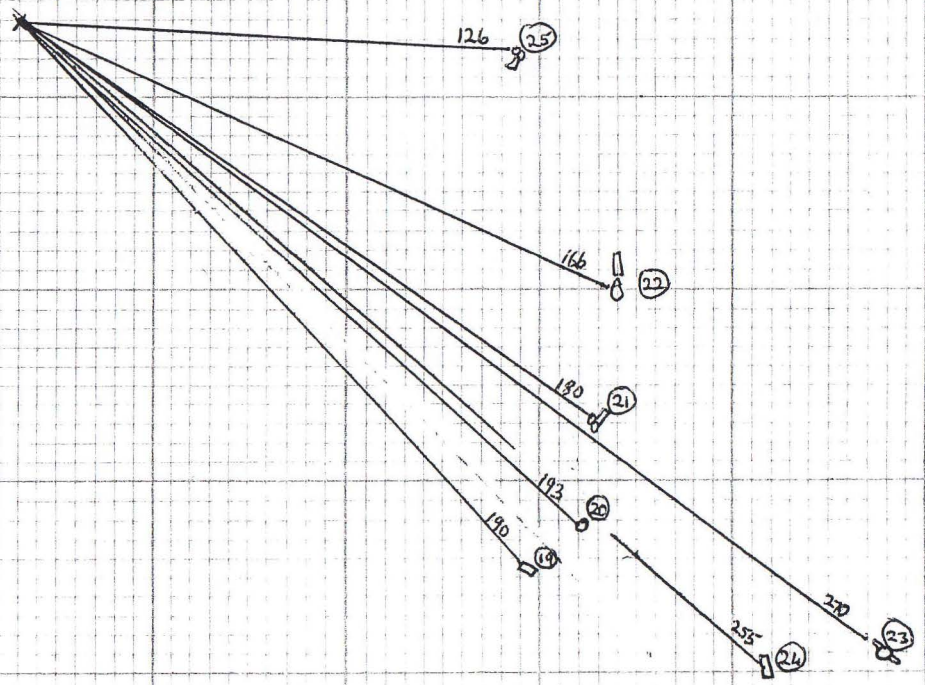
W. Wall of 1970/2 19/8/70

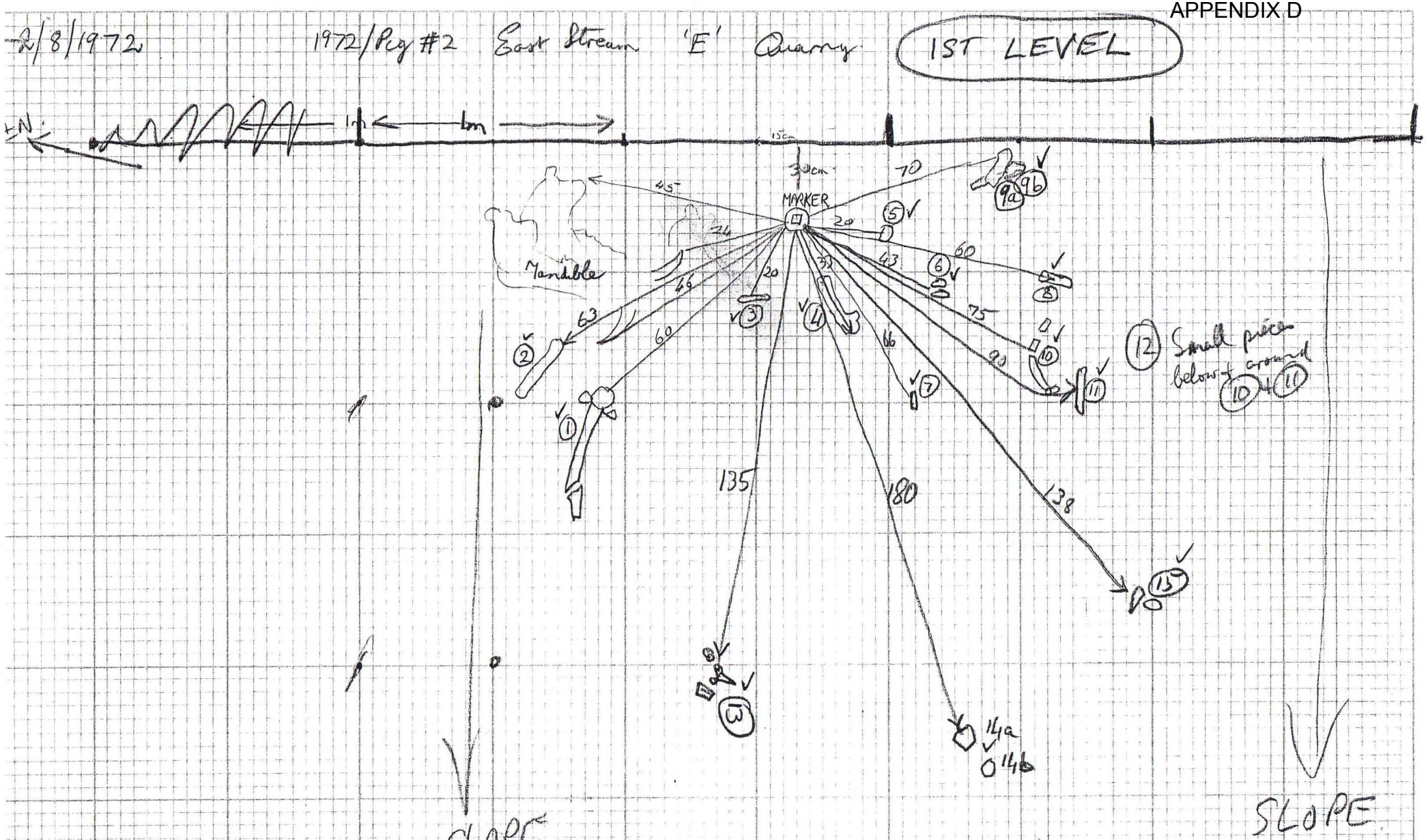



LBW. 'E' 1971 Field Season
Skeletal parts represented:
S - Skull
V - Vertebral column
F - Forelimb
H - Hindlimb.
EAST
STREAM
Nyanzachoerus 4
(S, V, H) (♂)
Nyanzachoerus 1
(S) (juv.)
Nyanzachoerus 2
(♀)
(S, V, H)
Nyanzachoerus 3
(S) (juv.)
Hyaena
(S, V, F, H)
chelonian.
boselaphine
(F)
BEACON C
+1 m
0
5
10
Approx. scale in metres.

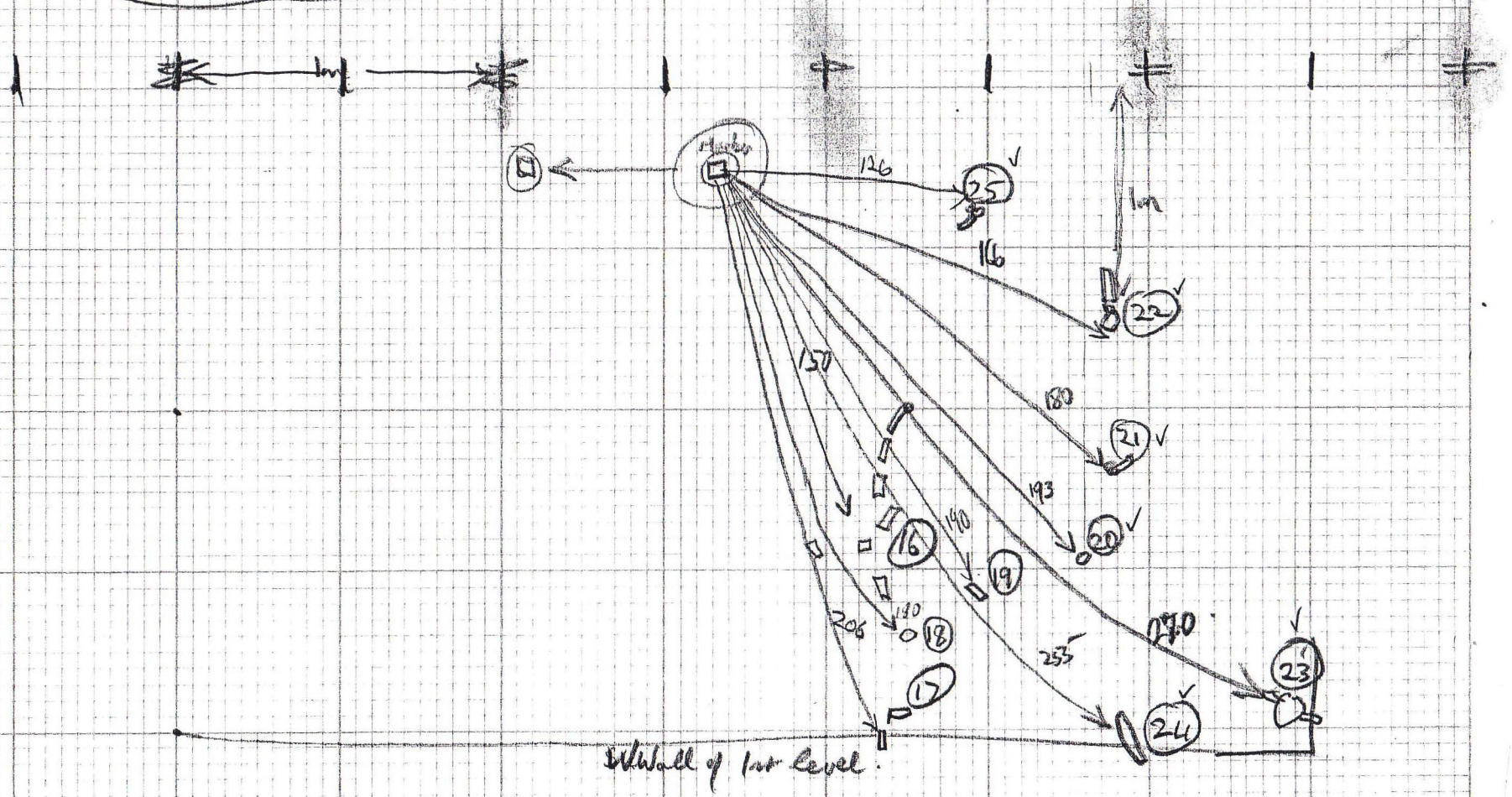
East Stream, Langebaanweg 2/8/72 - 10/8/1972 Nyanzachoerus 1972 #2. (L)



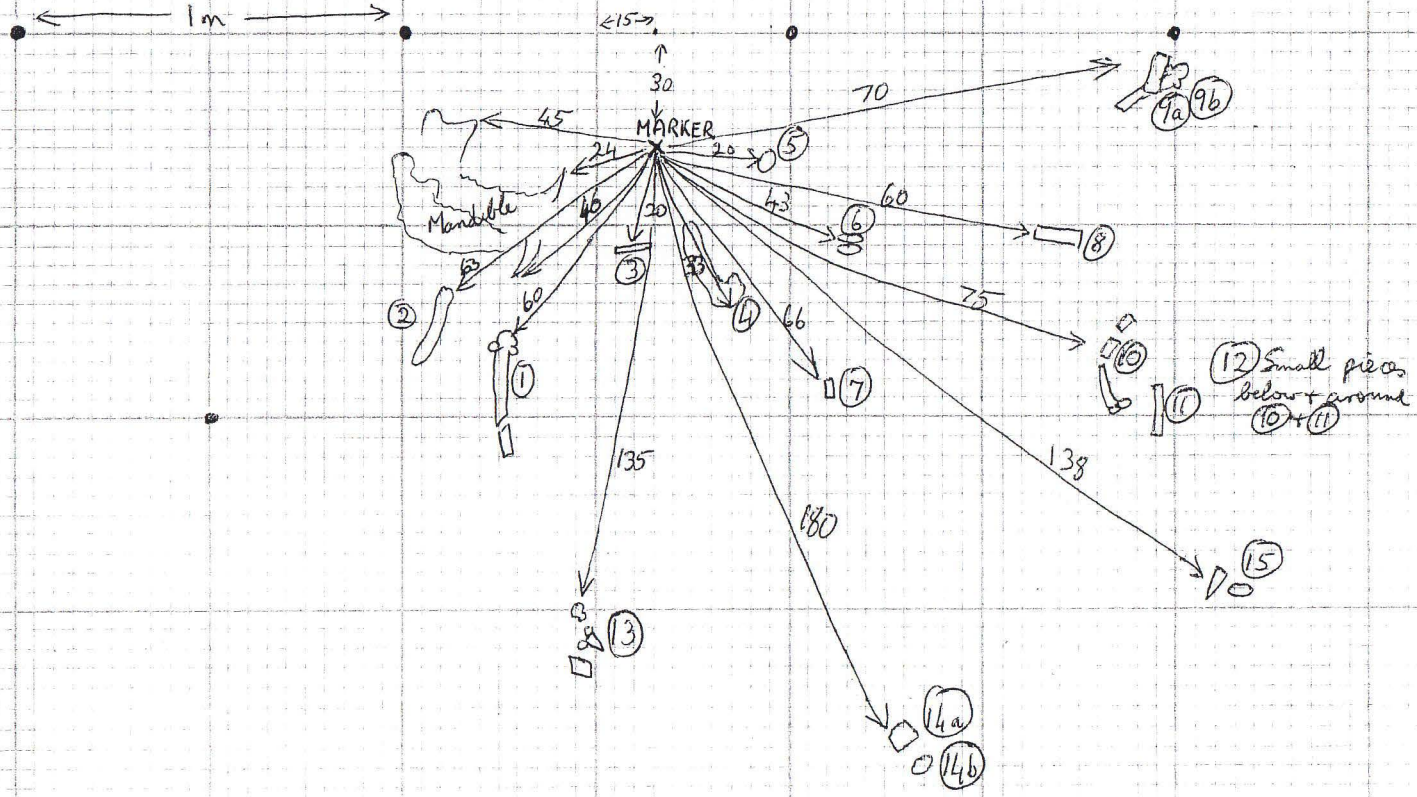

126
25
166
22
180
21
193
20
190
19
330
23
255
24


2/8/1972
1972/Pcg #2
East Stream 'E' Quarry
1ST LEVEL
1m
1m
15cm
30cm
MARKER
Mandible
45
24
63
60
20
46
75
43
60
70
20
66
93
75
135
180
138
SLOPE
SLOPE
Small piece below ground
12
1
2
3
4
5
6
7
8
9a
9b
10
11
13
14a
14b

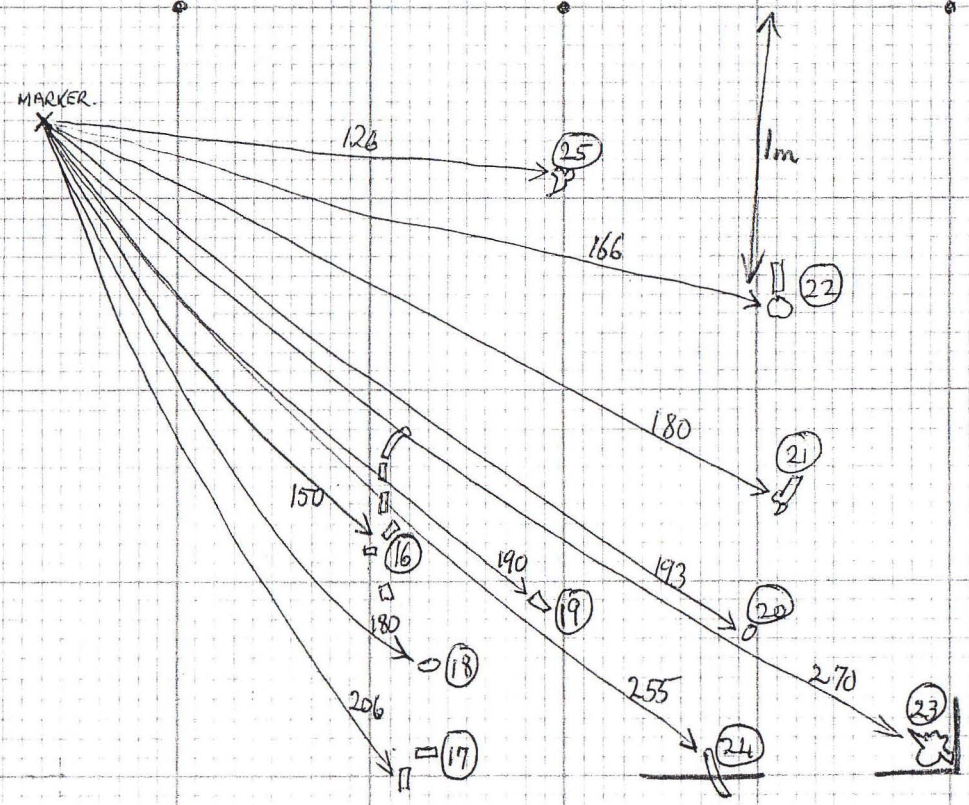
1ST LEVEL (cont)

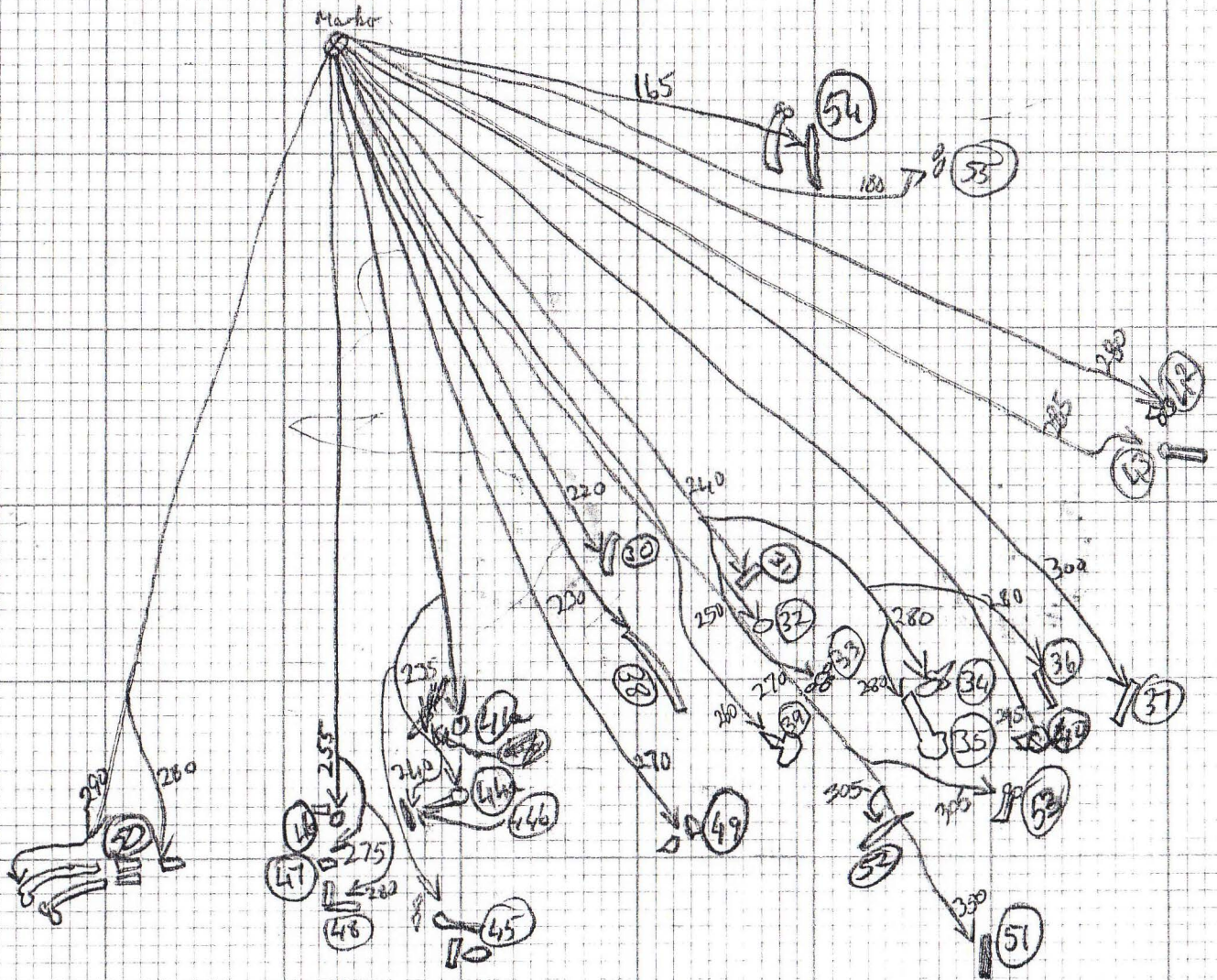


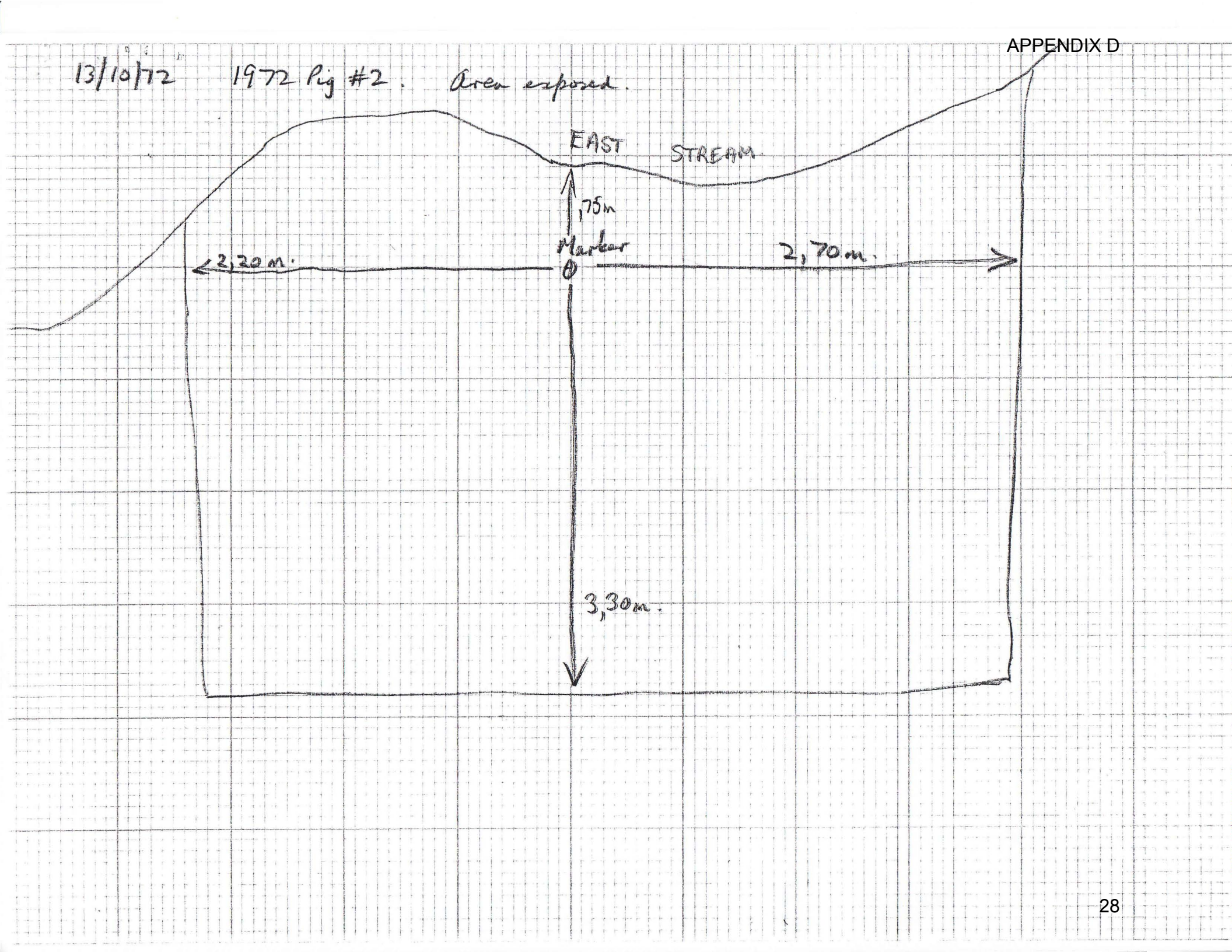
2/8/1972 1972 Pig #2 East Stream 'E' Quarry 1ST LEVEL.



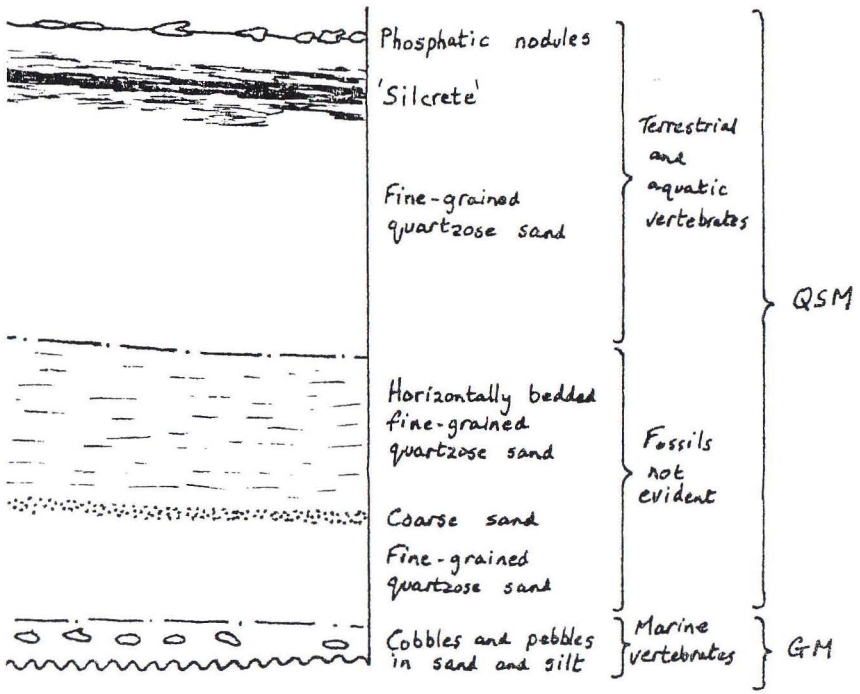
1ST LEVEL (cont).



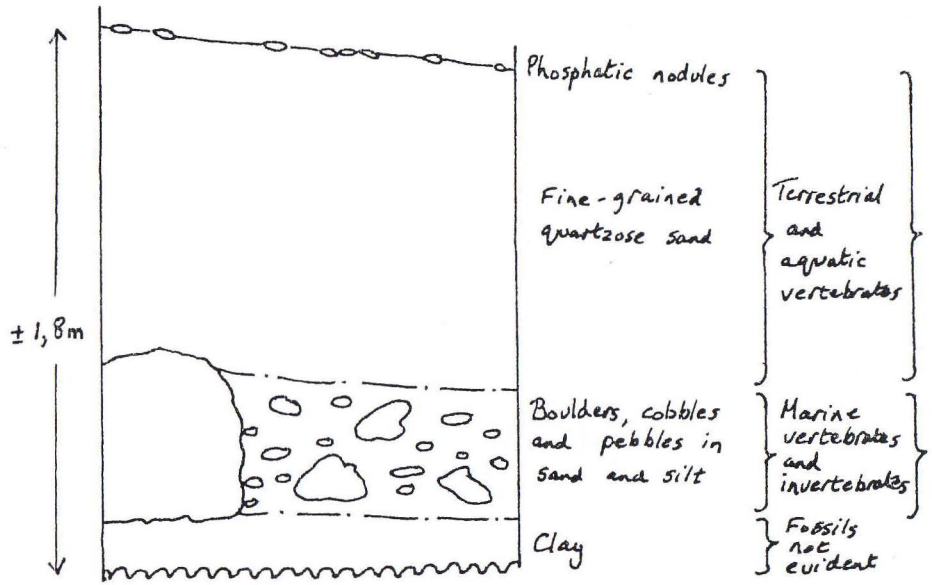

10/8/1972
1972 Rg #2
East Stream
E' Quarry
(1ST LEVEL)
Marker
165
180
54
55
280
285
52
53
220
240
30
31
250
32
280
300
33
34
36
37
38
270
39
49
235
41a
41
240
44a
44
40
42
305
43
54
51
330
290
280
52
255
46
275
47
260
48
45


13/10/72 1972 Pig #2. Area exposed.
EAST STREAM
1,75m
Marker
0
2,20m.
2,70m.
3,30m.

BDT 1/1971



BDT 2/1971



LANGEBAANWEG

(1) 'B' Quarry (Varswater bed)

a. Basal marine gravel:

Variably developed with boulders, cobbles and pebbles mainly of a 'phosphatic siltstone', which might be the primary source of the phosphate in overlying deposits.

In situ fossil fauna exclusively (?) marine, including: molluscs (rocky shore fauna - Haliotis, Patella etc.), sharks (at least 7 species), sting ray, eagle ray, skate, bony fish and whale. Some derived terrestrial vertebrate remains are known (rolled tortoise scutes are especially noticeable).

b. horizon 1:

White sand and silt overlying gravel, and regarded as an estuarine deposit. Variably developed, but probably averages 1 to 2 metres in thickness. East of 'Main Stream' its upper limit is marked by an horizon of phosphatic nodules and phosphate-cemented rock (the 'basal marker' of mining operations in this area). In the west this marker horizon is absent, and horizon 1 is overlain by the phosphatic sands of horizon 2.

Fossil fauna is rich and varied, terrestrial and aquatic vertebrates occurring:

(i) Sharks (very rare; only 1 species known), bony fish (catfish and others - not common), tortoise (extremely abundant), lizards, frogs and birds (common in some places, and including seabirds such as cormorant and penguin [Simpson, 1971] and others such as ostrich and francolin).

(ii) Small mammals - Chrysochlorid (golden mole) and bathyergid (rodent moles) especially common. Many other rodents, a rabbit, insectivores and viverrids.

(iii) Large mammals - Many species including Hipparion, Nyanzachoerus, a boselaphine, machairodont and hyaenids. Seal is rare.

(iv) Very large mammals - Mammuthus subplanifrons, a gomphothere.

Ceratotherium praecox and a sivathere.

c. horizon 2:

Brown phosphatic sands recorded only west of 'Main Stream' and possibly laid down at the same time that the marker horizon in the eastern parts of the quarry was developed. Average thickness probably about 2 metres.

Fossil fauna also rich and varied and essentially similar to that of horizon 1. However, the nature of the material preserved differs in some respects (eg. there is a much higher proportion of fragmented and splintered bone), and there are differences in the types of animals represented:

(i) Nyanzachoerus not recorded.

(ii) Hipparion, proboscideans, rhinoceros and sivathere known only from fragmentary remains which might be derived from the underlying horizon 1.

(iii) Commonly occurring Bovidae are two alcelaphine species, and boselaphine is either exceptionally rare or entirely absent.

(iv) At least one of the hyaenids present is not recorded from horizon 1, and at least one of the horizon 1 hyaenids (Crocuta) is not known from horizon 2.

(v) Seal is common.

(vi) A small suid (cf. Diamantohyus sp.) is known only from horizon 2.

It is possible that even if horizon 1 was laid down sub-aqueously, deposition was in shallow and fairly still waters on the fringes of the postulated estuary, ie. in an area accessible to very large mammals. On the other hand horizon 2 may have been laid down in somewhat deeper and faster flowing water which truncated horizon 1, especially in the eastern parts of the quarry. Horizon 2 was probably deposited not long after horizon 1. All the 'D' Quarry fossils are regarded as late Pliocene in age, with an inferred age of about 4 million years.

The fossils in horizon 1 are thought to represent the

remains of animals which died natural deaths (note the evidence of fire) or which were killed by predators (principally felids and viverrids). There is evidence that many of the carcasses were subjected to the attentions of scavenging hyaenids. During the deposition of horizon 2 similar circumstances probably prevailed, but in this instance seals may have played a more significant role as predators and/or scavengers.

It is considered that the sampling of the 'P' Quarry deposits during the past 5 or 6 years has been adequate to give a clear picture of the total vertebrate fauna of the Langebaanweg area in late Pliocene times. There are probably few sites in sub-Saharan Africa which have yielded so comprehensive an array of species. For this reason it is likely that absentees from the faunal list are the result not of an inadequate fossil record, but the fact that such species were not present in this, and perhaps other parts of South Africa at the time. These absentees include primates, Hippopotamus, Deinotherium, chalicotheres, porcupine and crocodiles.

(2) Baard's Quarry (Langberg bed and another)

The relationship of deposits in Baard's and 'P' Quarries is still uncertain, but it is certain that the Baard's Quarry fauna is partly Pleistocene in age.

The Pleistocene species include:

Mellivora cf. capensis (a more primitive Mellivora is known from 'P' Quarry)

Hyaena cf. brunnea

"Stegodon" (known only from material now in Chicago)

Equus cf. capensis (helmei)

Diceros bicornis

Other species (eg. Hipparion albertense and Mammuthus subplanifrons) are apparently contemporaneous with the 'P' Quarry fauna.

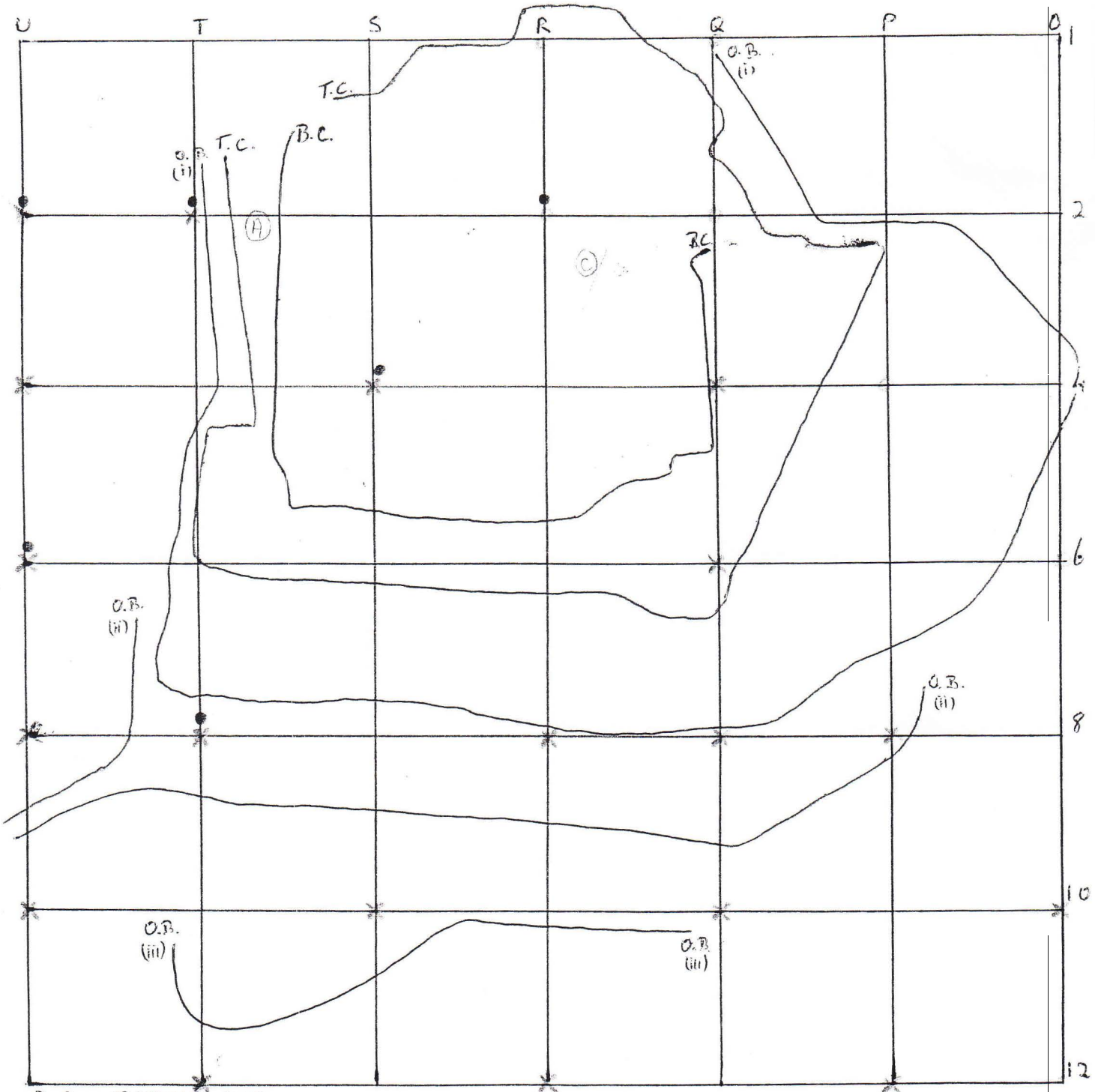
This distinction between earlier and later elements is

not the same as that suggested by Boné & Singer (1965) for the Langebaanweg fauna as a whole. Their distinctions had a different basis and are still regarded as invalid.

Q.B. Hendey
Cape Town
1st September, 1971.

NOT FOR CITATION

LANGEBAANWEG 'E' QUARRY JUNE 1971

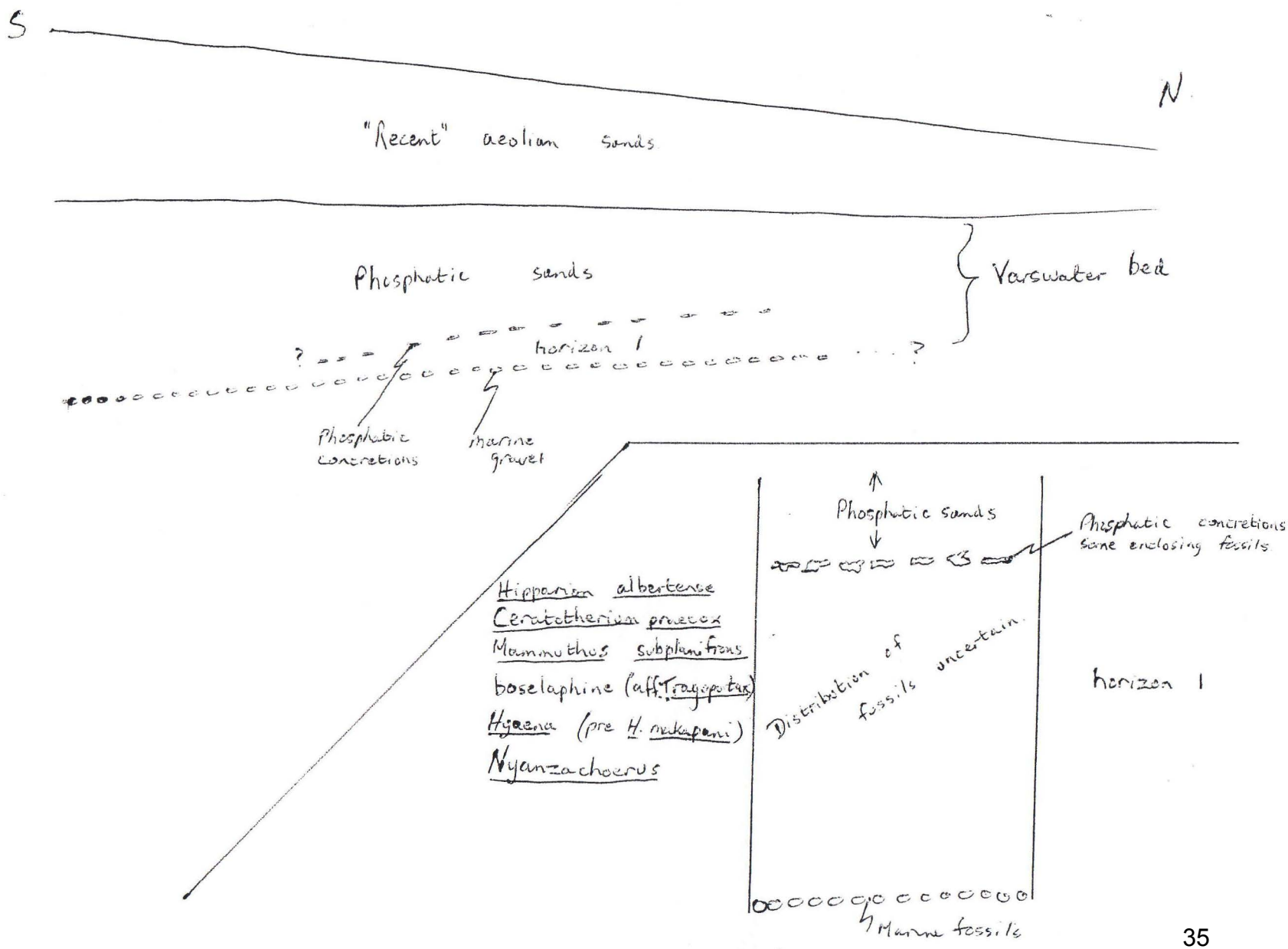


B. C. - BOTTOM CUT
T. C. - TOP CUT
O. B. - OVERBURDEN FACES

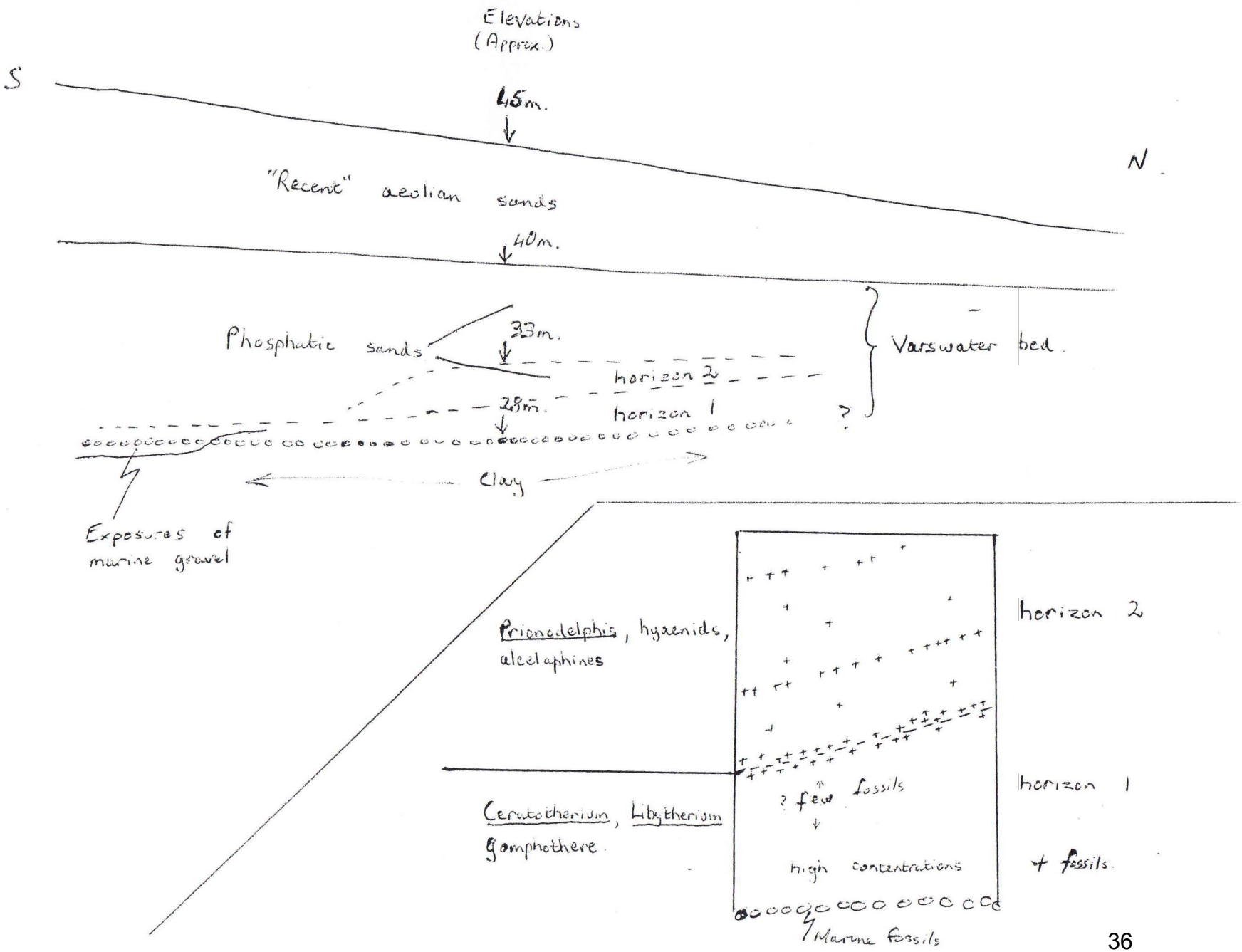
SCALE 1:5000

× Gravel intersected by borehole
○ No gravel " " "
● Terrestrial fossils from borehole

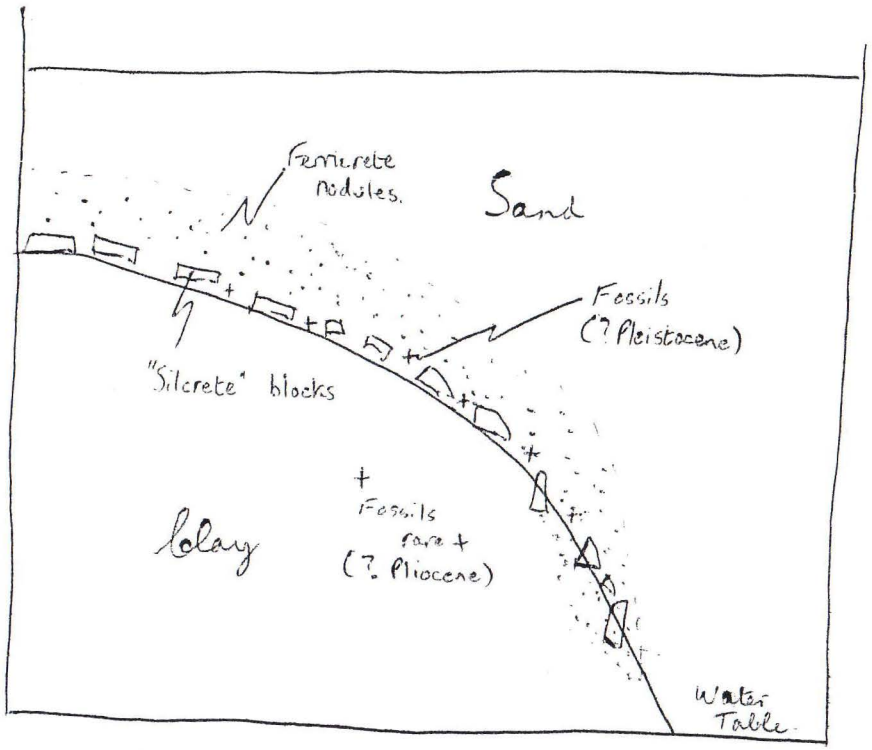
'E' QUARRY, EAST STREAM AREA



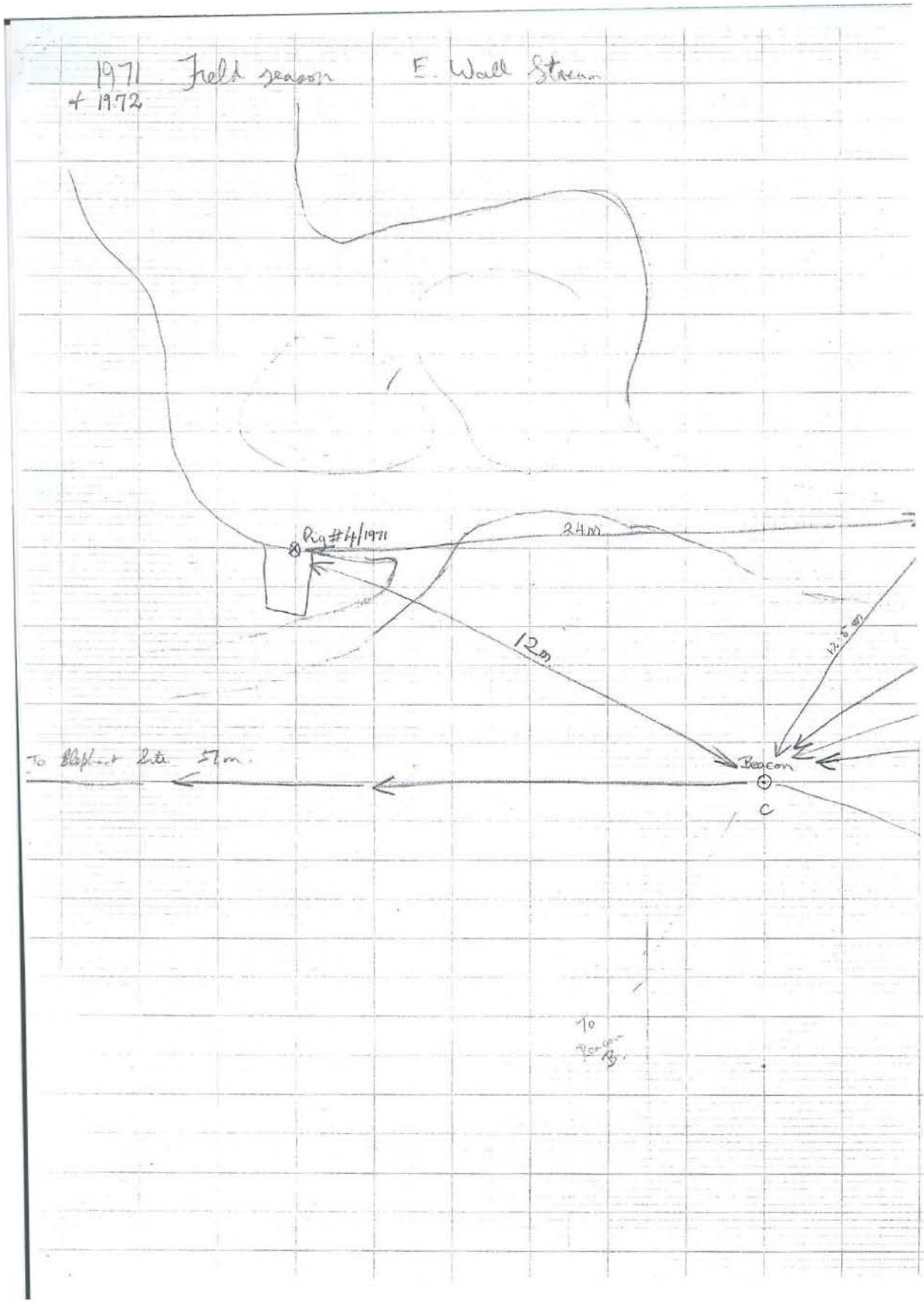
E QUARRY, WEST WALL.

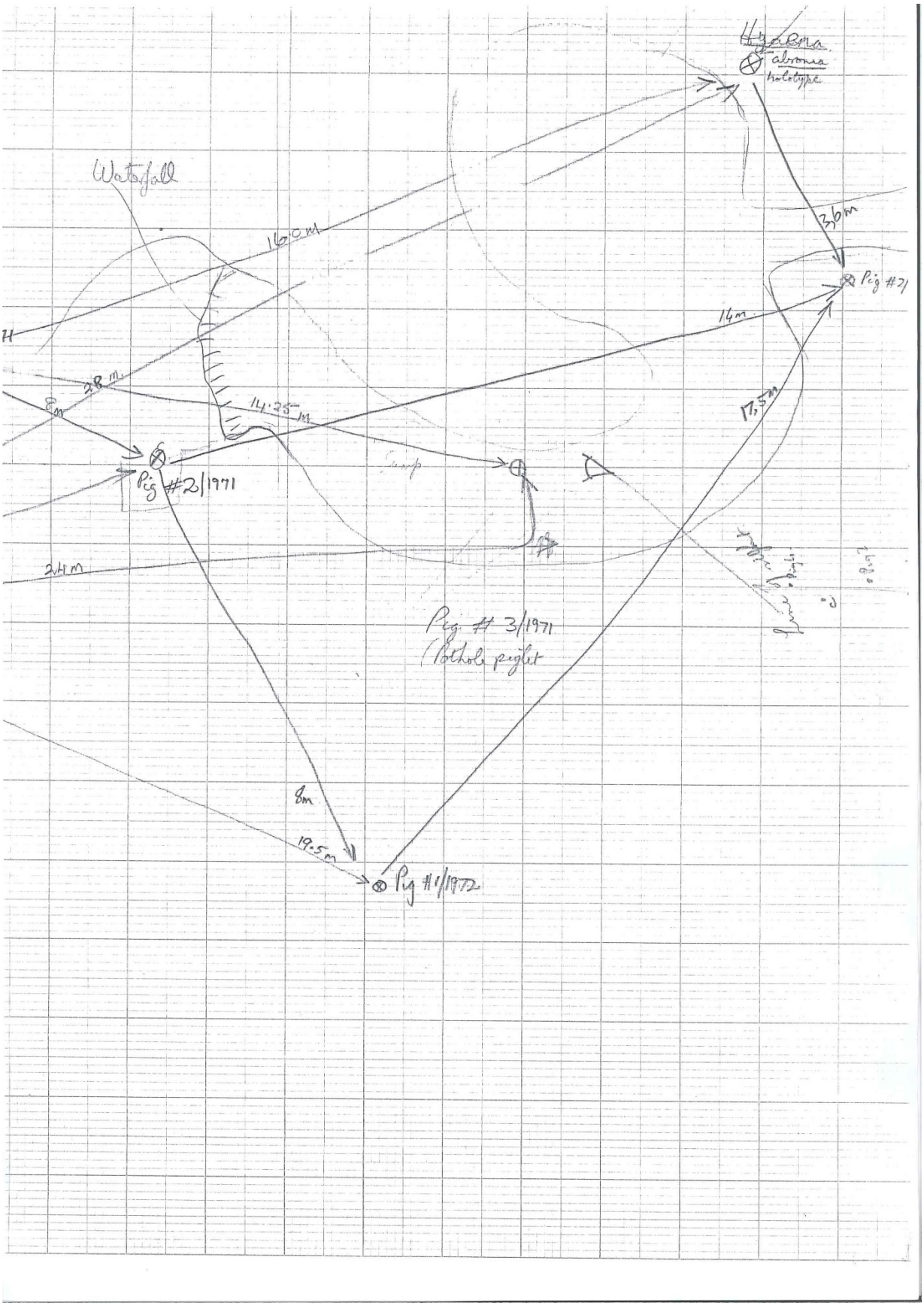


BAARD'S QUARRY.



Sketch of East Stream dated 1971/1972 from Dr Hendey's field notebook

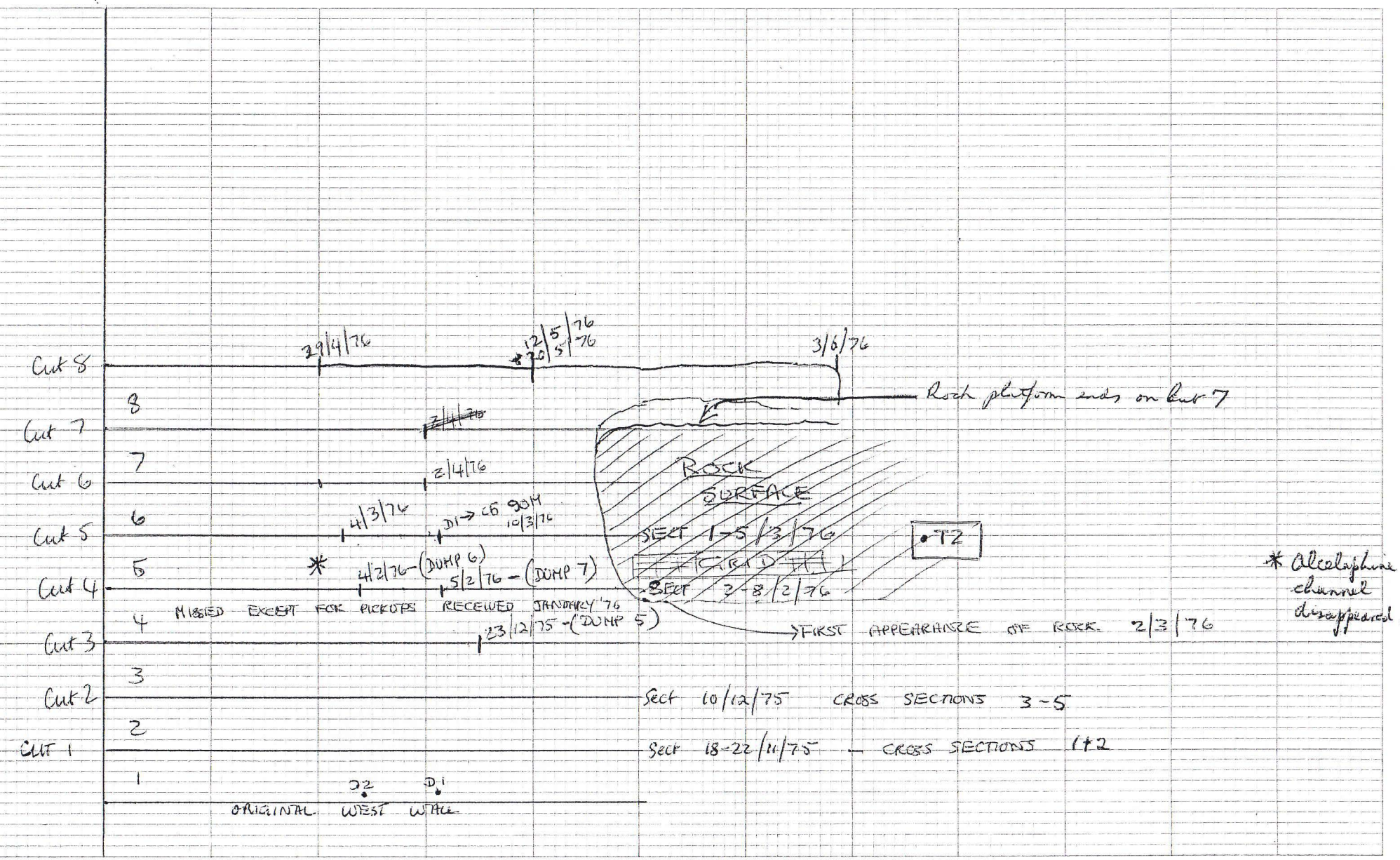



Hyalinobatrachium
abrunna
holotype
Waterfall
160 m
36m
Pig #7
14m
28 m
8m
14.25 m
Pig #2/1971
17,5m
Camp
24 m
Pig # 3/1971
Bathole pigbet
8m
19.5m
Pig #1/1972

Excerpts from Dr Hendey's field notebook from 1975-1976, featuring section drawings and notes from the Bottom Cut West Wall excavations



BCWW – CUT SUCCESSIONS AS FROM NOVEMBER 1975

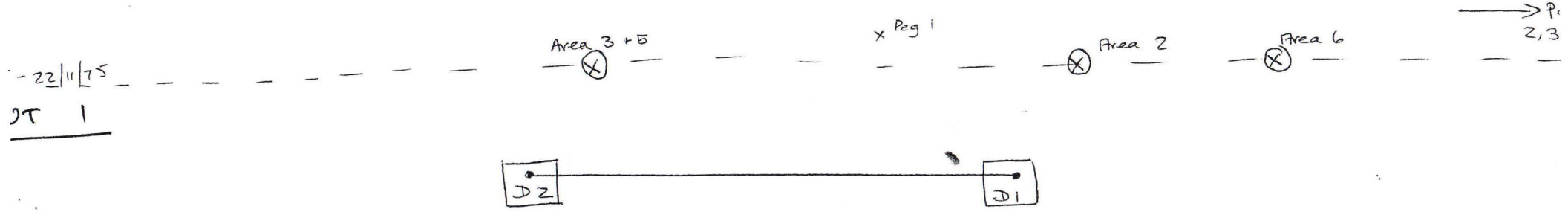


ngebaanweg – 'E' Quarry – 10/12/75 CUT 2

B.C.W.W.

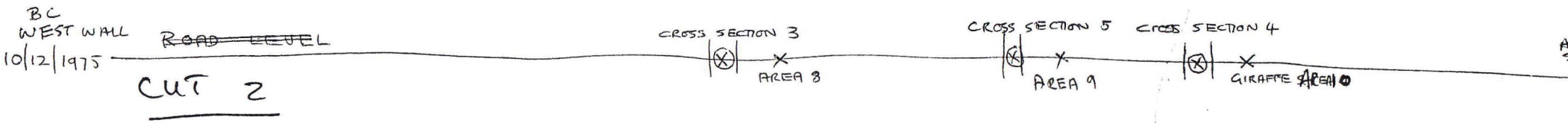


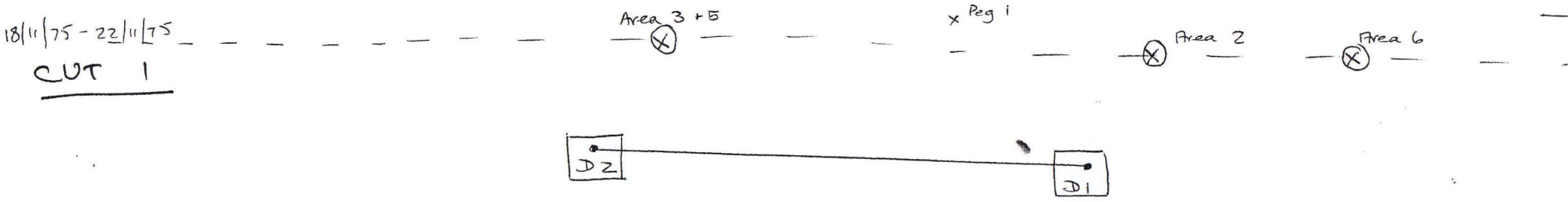
CUT 2



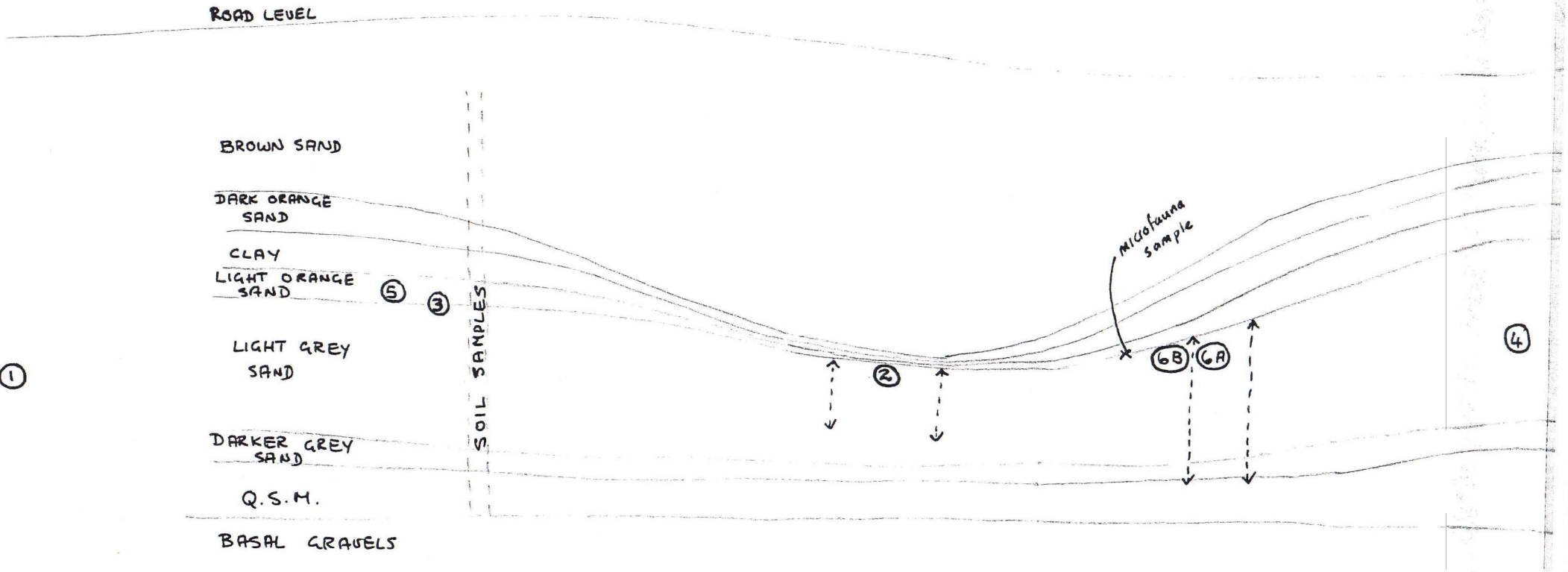
Langebaanweg – 'E' Quarry – 10/12/75 CUT 2

BC.WW.



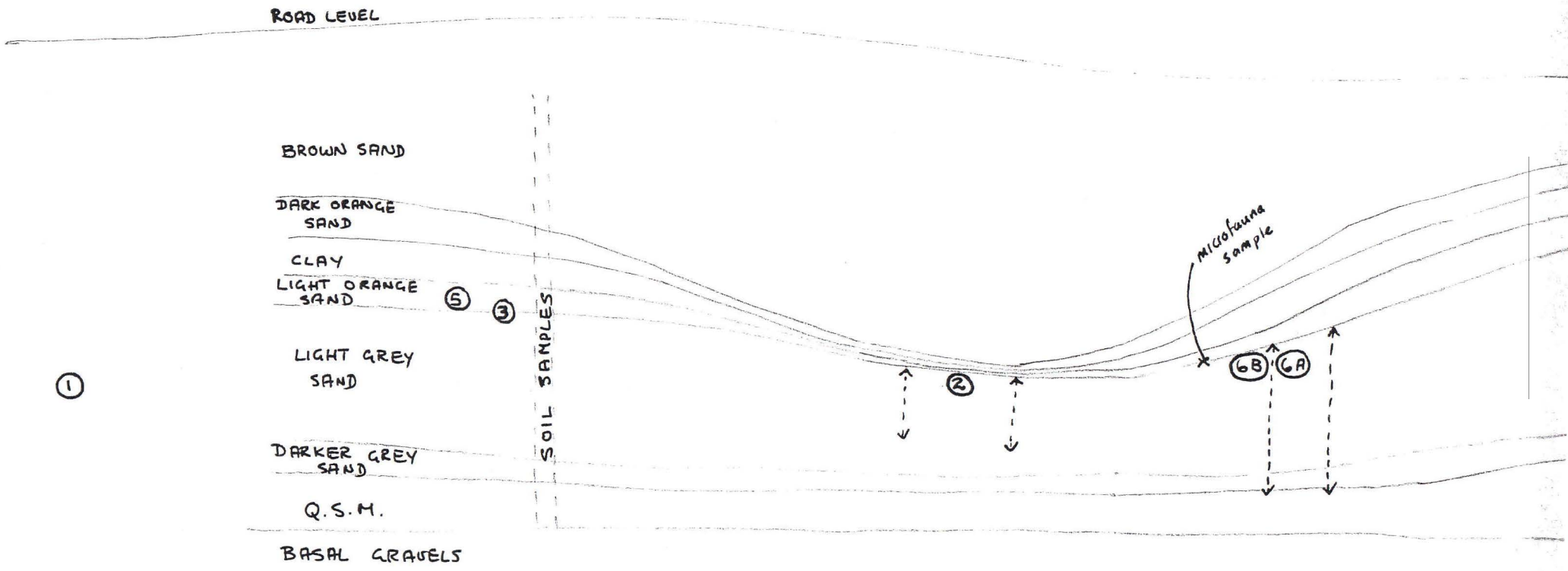


ANGEBAANWEG - 'E' QUARRY 18/11/75 - 22/11/75

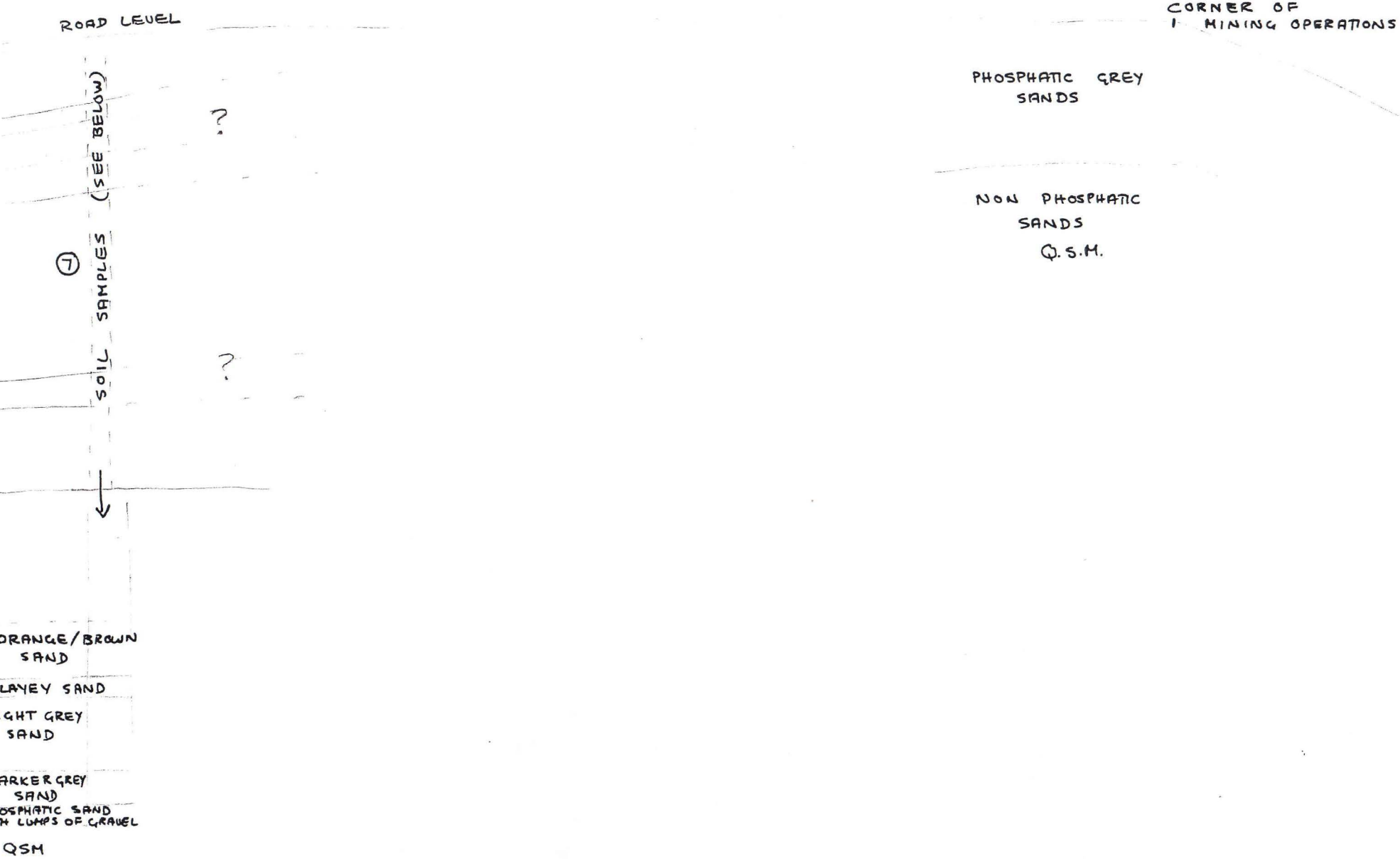


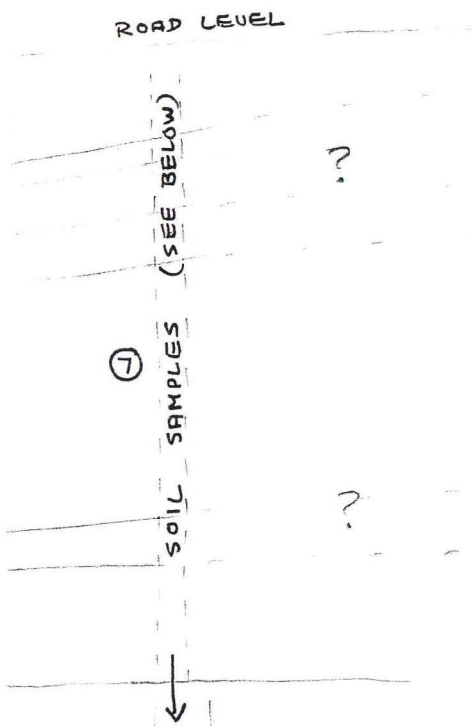
site – coll. Isaac & Jessie. Dump sieve
se & seal site – coll. Isaac & Polly. Dump sieve
selaphine site – coll. Isaac & Melanie. Occurs at junction between light orange sand and light grey sand.
ephant tusk site – coll. Isaac & Jessie
elaphine p.c. site – coll. Melanie.
orse & seal site – coll Isaac & Polly
ixed – coll Isaac – dump sieve - Jessie.
mphothere tooth site – coll Jessie & Polly

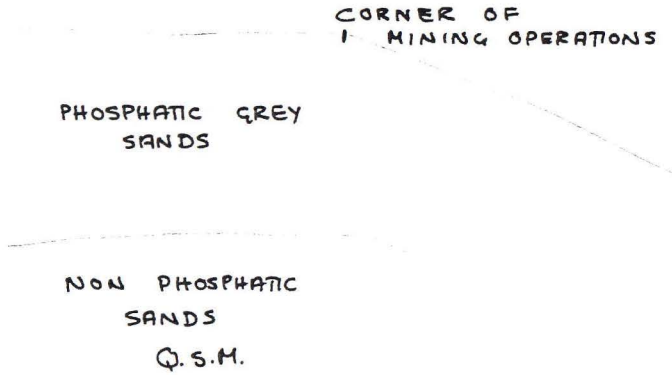
LANGEBAANWEG - 'E' QUARRY 18/11/75 - 22/11/75



① Pig site - coll. Isaac & Jessie. Dump sieve
② Horse & seal site - coll. Isaac & Polly. Dump sieve
③ Boselaphine site - coll. Isaac & Melanie. Occurs at junction between light orange sand and light grey sand.
④ Elephant tusk site - coll. Isaac & Jessie
⑤ Alcelaphine p.c. site - coll. Melanie.
⑥A. Horse & seal site - coll Isaac & Polly
⑥B Mixed - coll Isaac - dump sieve - Jessie.
⑦ Gomphothere tooth site - coll Jessie & Polly


ROAD LEVEL
(SEE BELOW)
SOIL SAMPLES
7
?
?
ORANGE/BROWN SAND
LAYEY SAND
GHT GREY SAND
ARKER GREY SAND
OSPHATIC SAND
H LUMPS OF GRAVEL
QSM
CORNER OF
MINING OPERATIONS
PHOSPHATIC GREY SANDS
NON PHOSPHATIC SANDS
Q.S.M.


ROAD LEVEL
(7) SOIL SAMPLES (SEE BELOW)
?
?
ORANGE/BROWN SAND
CLAYEY SAND
LIGHT GREY SAND
DARKER GREY SAND
PHOSPHATIC SAND WITH LUMPS OF GRAVEL
QSM


CORNER OF MINING OPERATIONS
PHOSPHATIC GREY SANDS
NON PHOSPHATIC SANDS
Q.S.M.

Langebaanweg 'E' Quarry 18/11/75 – 22/11/75

Brown sand – contains virtually no bone – sample taken from above site 6 – sieved – contains mainly fragments of tortoise. Dump 4 sample taken from here.

Light orange sand – bone in better condition – boundary between light orange sand and lighter grey sand – not very clear.

light grey sand – bone in this sand in better condition near areas (3) and (5) than it is near areas (2) and (6) – where it is very crushed and fragmented.

light grey sand – near areas (2) and (6) contains many fairly large rolled pebbles. At area (6) there is ~~an or~~ a layer of sandy gravel (sample taken) beneath light grey sand. Above the light grey sand at areas (2) and (6) the clay layer is actually a clayey sand (very thin band) containing very crushed bone and a fair quantity of microfauna (sample taken)

QSM – no bone definitely found in this layer.

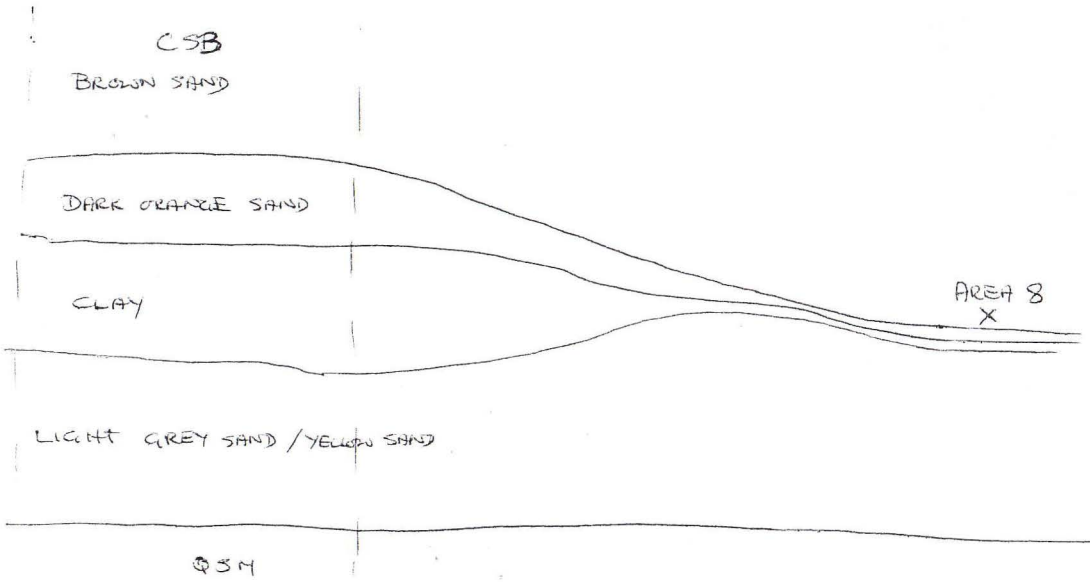
NORTHERN CORNER – Nar phosphatic sand risen to half-way up the wall – overlain by phosphatic grey sand containing very few fossils.

Stratigraphy between site (7) and northern corner – very indistinct.

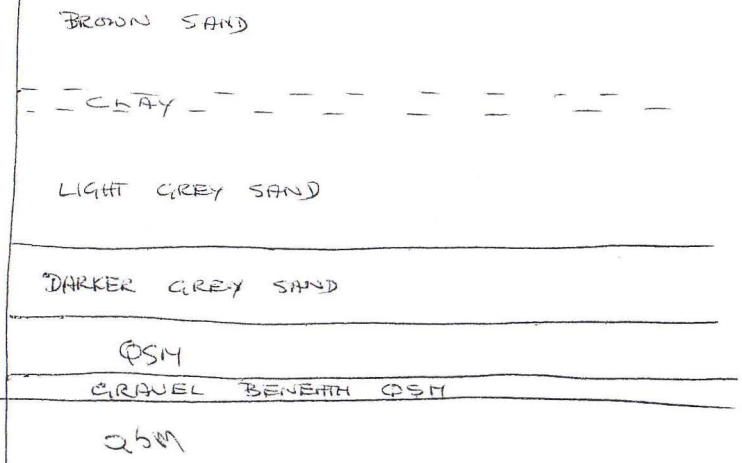
10/12/75 CUT 2

9-11/12/75

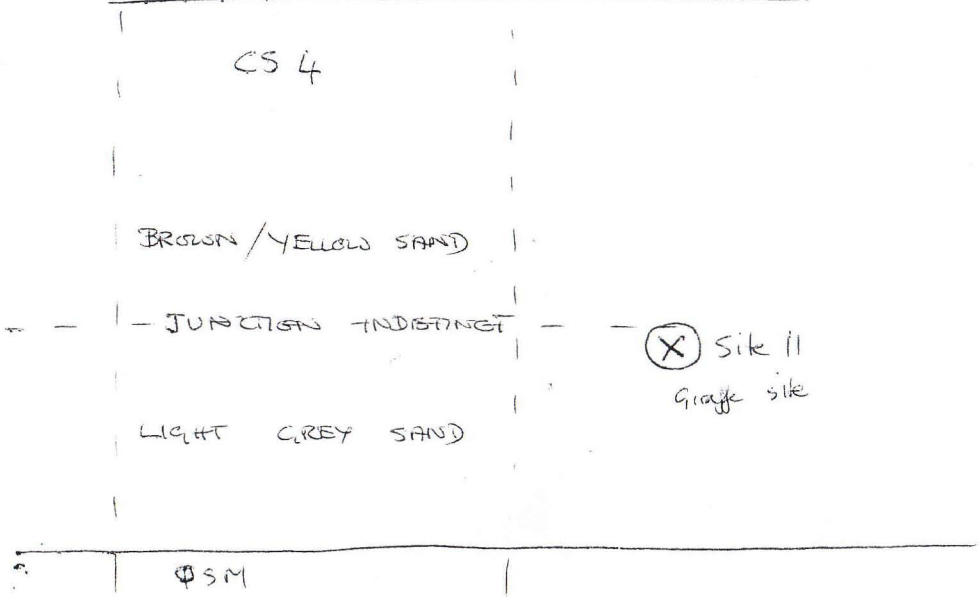
CROSS SECTION 3 and AREA 8



CROSS SECTION 5



SITE 11 and CROSS SECTION 4



9/12/75 - 11/12/75

Langebaanweg - 'E' Quarry 10/12/1975 CUT 2

D1 –	CS 3	42°	23,5 m
"	Area 8	50°	22,2 m
"	Area 9	74°	17,7m
"	CS 4	95°	17,5m
"	Area 11	122°	20,9m
"	Peg 1	23°	7,2M
"	Peg 2	169°	13,8M
"	Peg 3	176°	21,5m
"	Peg 5	172°	30,5m
"	CS 5	60°	17,0M.
"	Area 2	131°	3,9m
"	Area 6	158°	10,3m
"	Area 5 & 3	8°	18,2m

D1 – D2 – 22,5 M

D1 taken as top of pipe (ground level to top of pipe 0,7 m)

Back Sight (D1) 8,2

CROSS SECTION 3

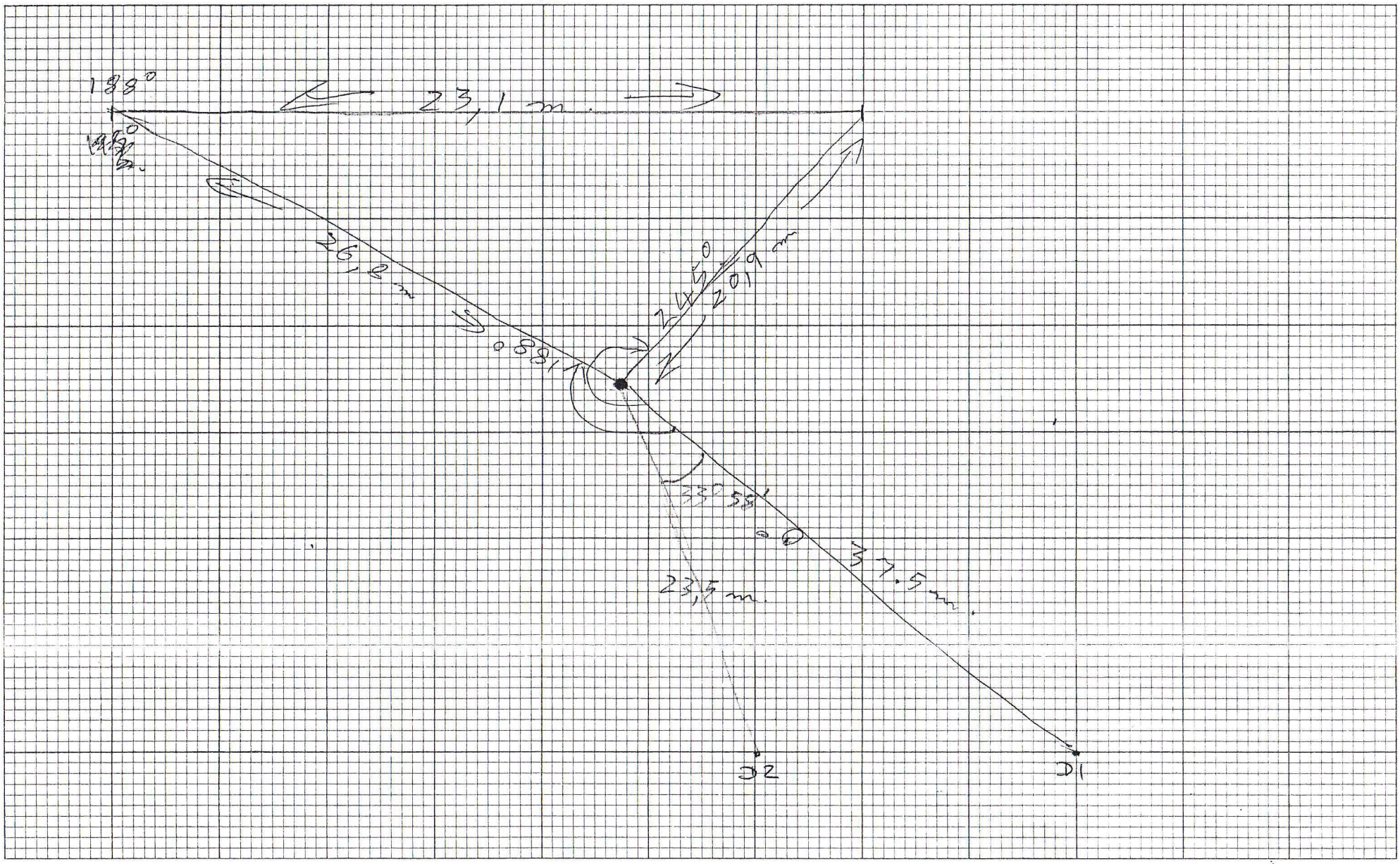
FORE SIGHT	RISE	FALL	
1,65		6,55	TOP OF QSM
		7,7	LIGHT GREY SAND / CLAY JUNCTION
0,5		0,0	CLAY / DARK ORANGE SAND JUNCTION
0,0			
(+ 0,5	[illegible]	~~7,7~~)	DARK ORANGE SAND / BROWN SAND JUNCTION
AREA 8			
		7,9	
0,3			LIGHT GREY SAND / CLAY JUNCTION
		7,99	
0,21			CLAY / DARK ORANGE SAND JUNCTION
0,0		0,0	DARK ORANGE SAND / BROWN SAND JUNCTION
CROSS SECTION 5			
1,74		6,46	BOTTOM OF QSM
1,53		6,67	TOP OF QSM
1,15		7,05	TOP OF DARKER GREY SAND
0,7		8,13	LIGHT GREY SAND / CLAY JUNCTION (INDISTINCT)
0,31		7,89	CLAY / DARK ORANGE SAND or BROWN SAND JUNCTION (INDISTIN
CROSS SECTION 4			
0,29		7,91	LIGHT GREY SAND / BROWN-YELLOW SAND JUNCTION (INDISTI
SITE 11			
0,1		8,1	LIGHT GREY SAND / BROWN-YELLOW SAND JUNCTION (INDISTIN

CUT 2

Photos.

① W.W. next to cross section 3
② ③ WW cross section 3. X 2.
④ WW next to giraffe site: CS4
⑤ social!
⑥ WW cross section 5 + Isaac
⑦ " " " 5
⑧ WW
⑨ WW ~~total~~

B.C.W.W. CUT 4 2/2/76 - 8/2/76



CUT 4

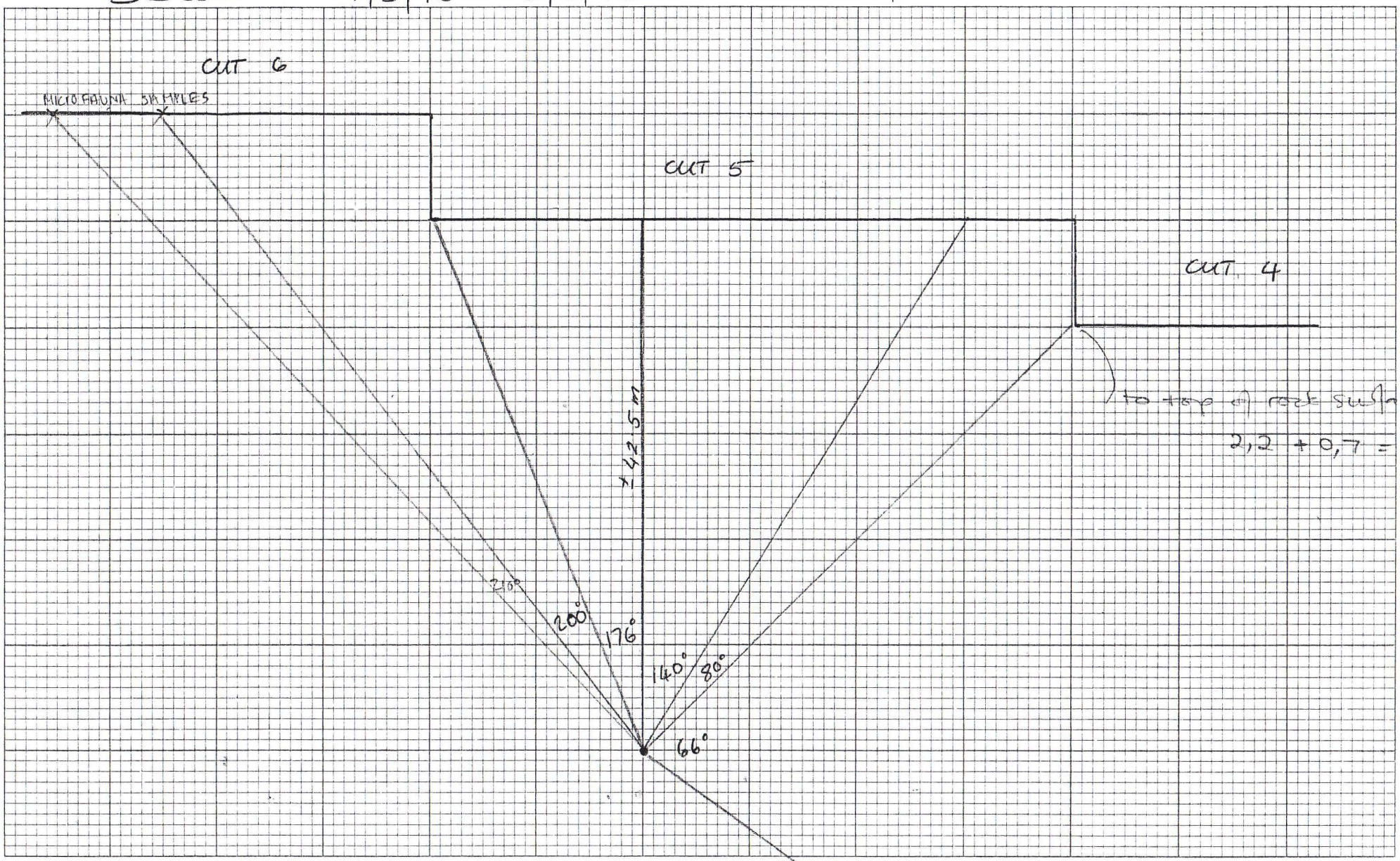
L. Readings: ARC.

Staff readings.

~~188°~~	~~1,88~~	~~—~~
188°	1,91	— 26,8 m.
195°	1,82	
200°	1,33	
205°	1,20	
210°	0,97	
215°	0,99	
220°	0,95	23,1 m.
225°	0,76	
230°	0,76	
235°	0,57	
240°	0,41	
245°	0,22	— ~~21 m.~~ (20,9 m).

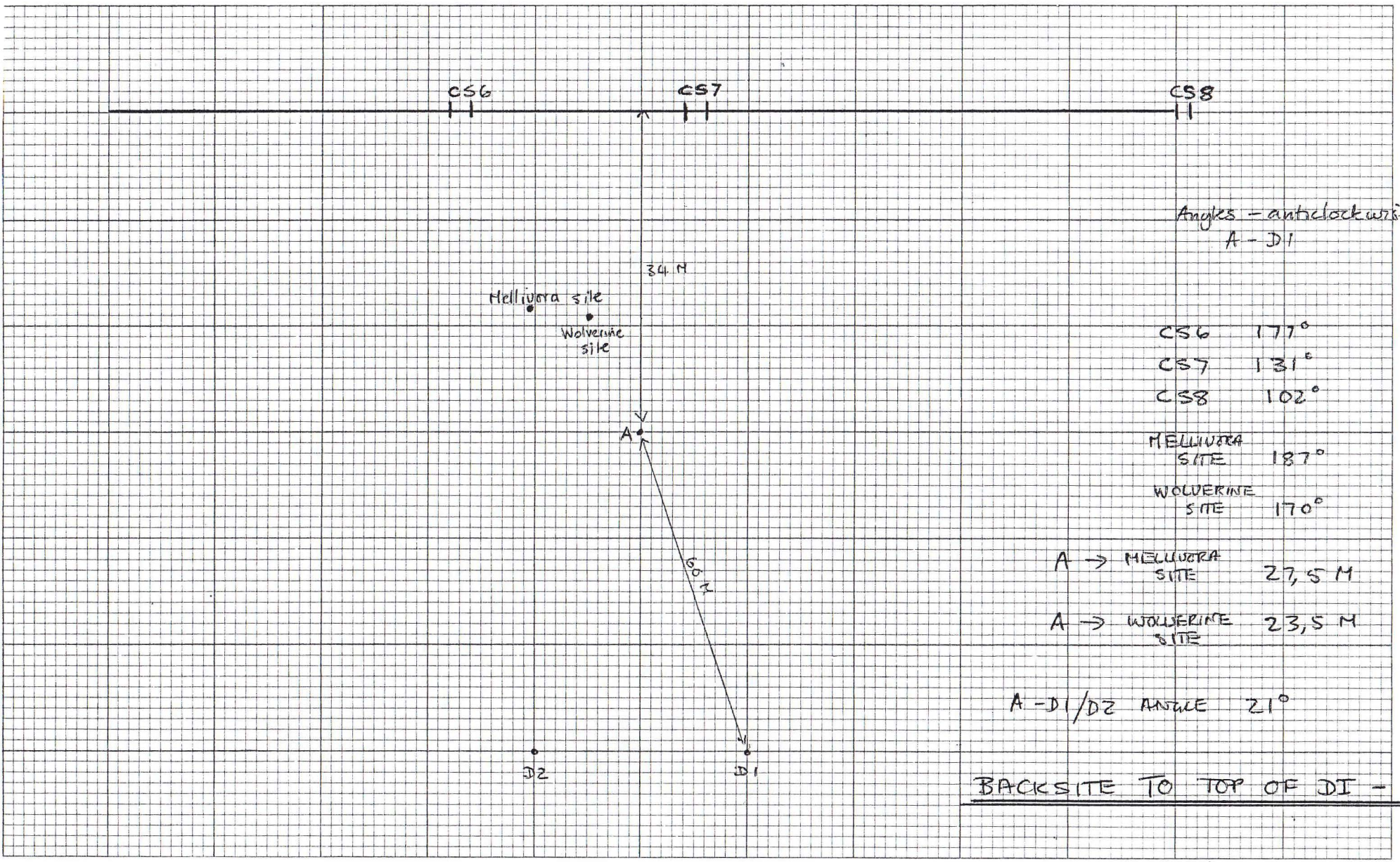
Langebaan

BCWW 1/3/76 – 5/3/76 CUTS 4–6



D1 Backsite 2,2 (top of D1) (4/3/1976)

BCWW CUT 7 26/4/76 - 30/4/76.



Angles = anticlockwise
A - D1

CS6	177°
CS7	131°
CS8	102°
HELLIVORA SITE	187°
WOLVERINE SITE	170°

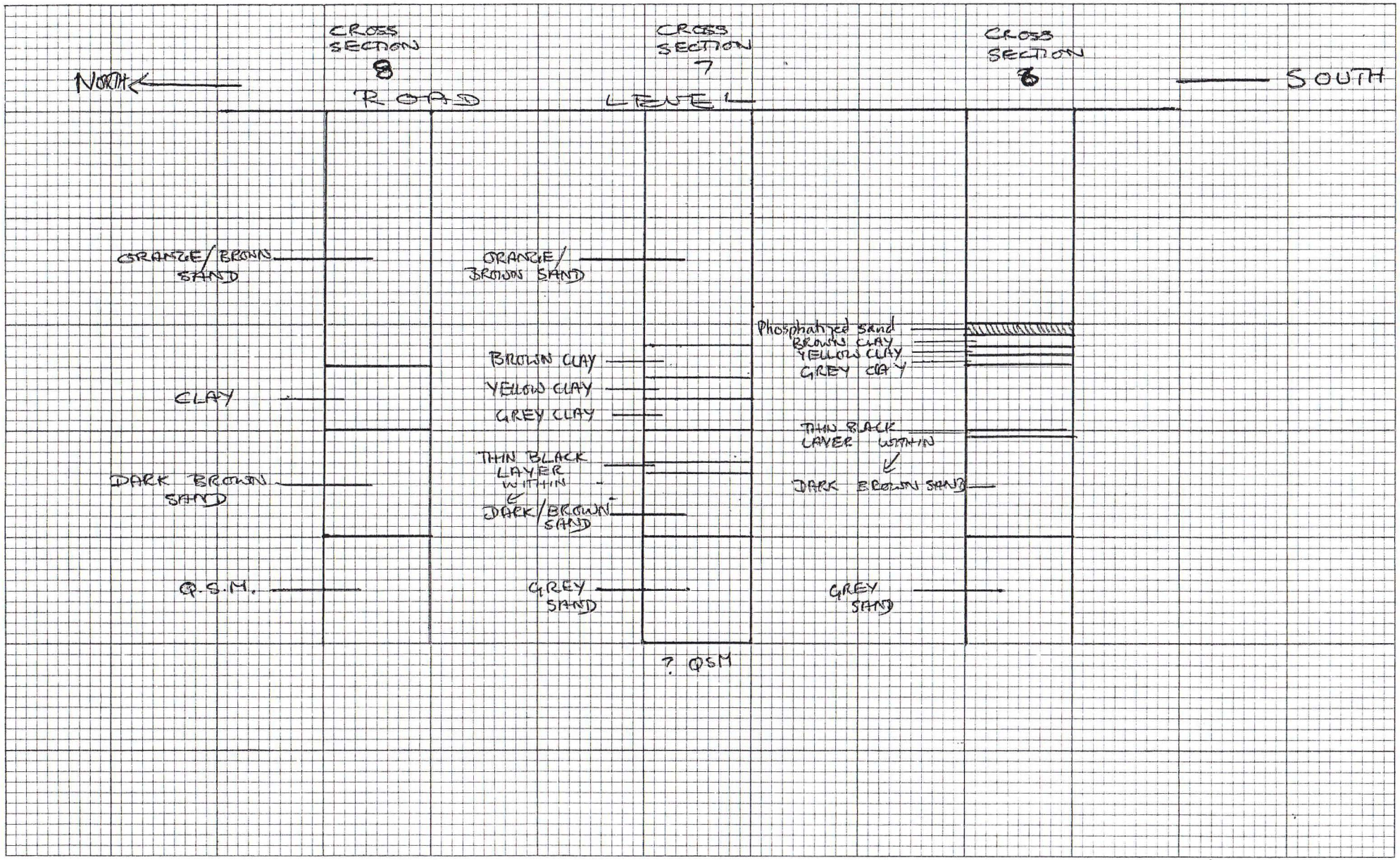
A → HELLIVORA SITE 27,5 M

A → WOLVERINE SITE 23,5 M

A - D1/D2 ANGLE 21°

BACKSITE TO TOP OF D1 - 0,5 M

BCWW Cut 7 26/4/76 - 30/4/76



BCWW CUT 7 26/4/76 – 30/4/76

photographs

No 9 CS 8

No 10 CS 8 close up.

No 11 CS 6 close up showing DBS, clay, + rock layers.

No 12 " " (+) scale.

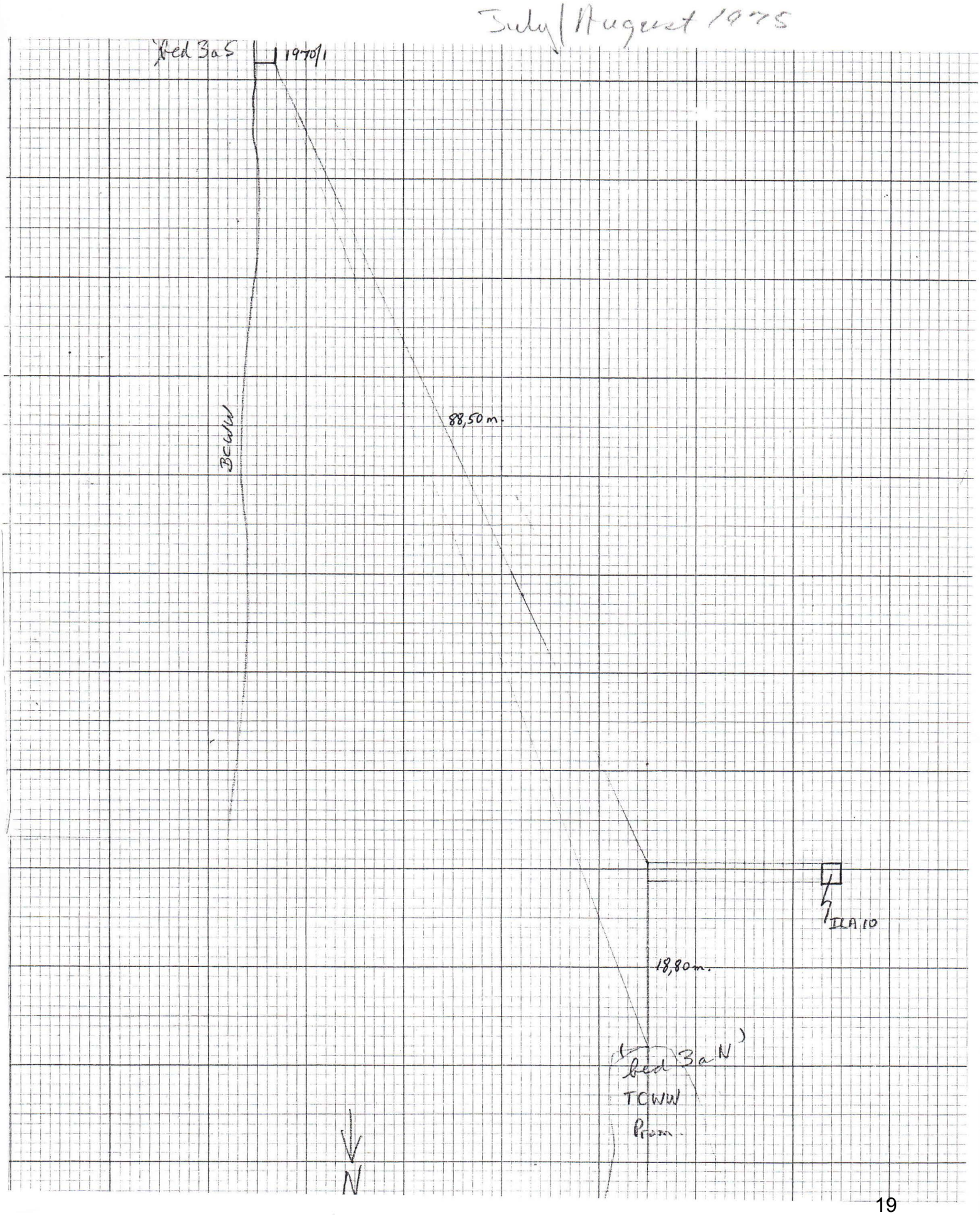
Nos 13+14 Personal.

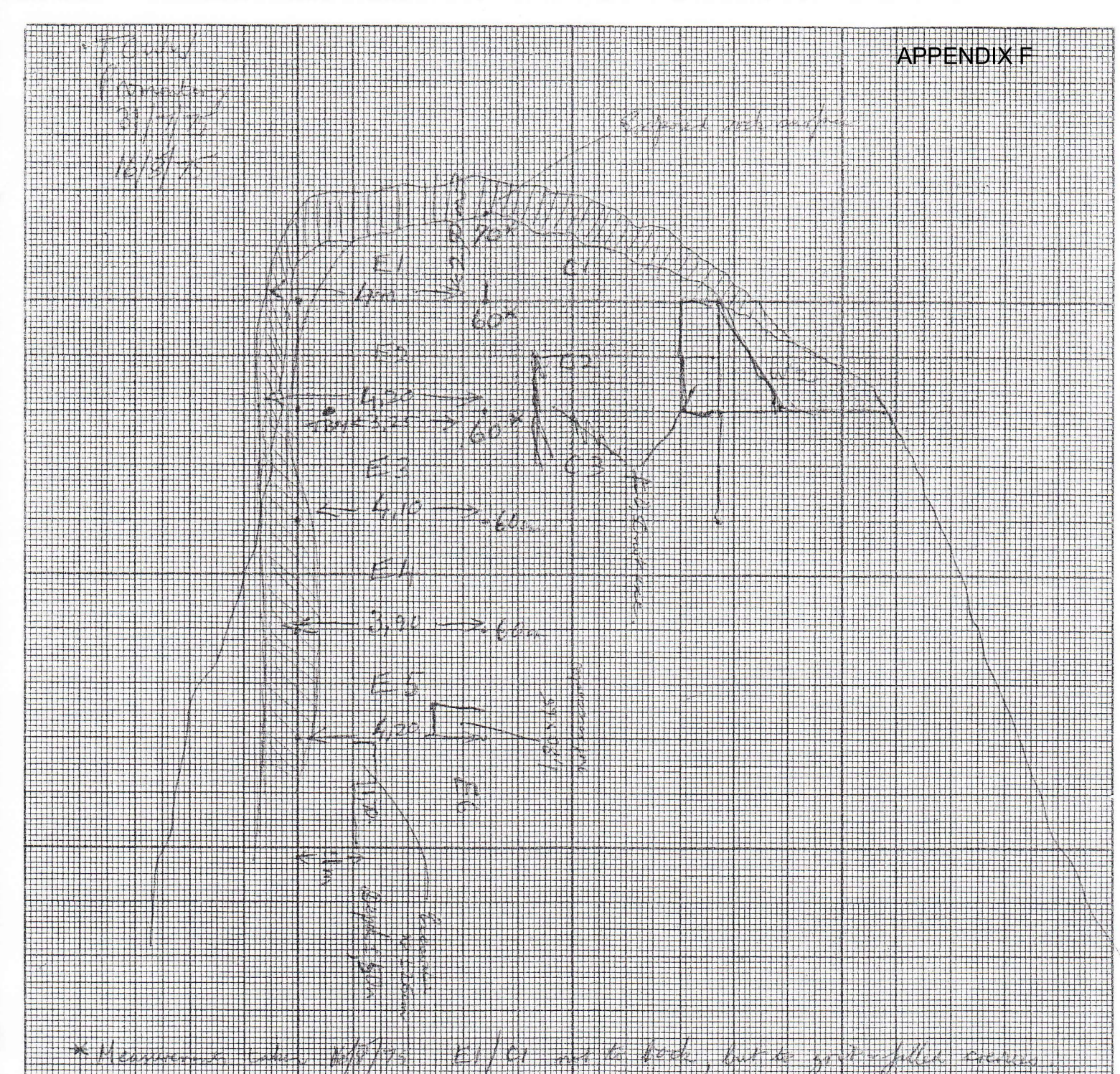
No 15 CS 6

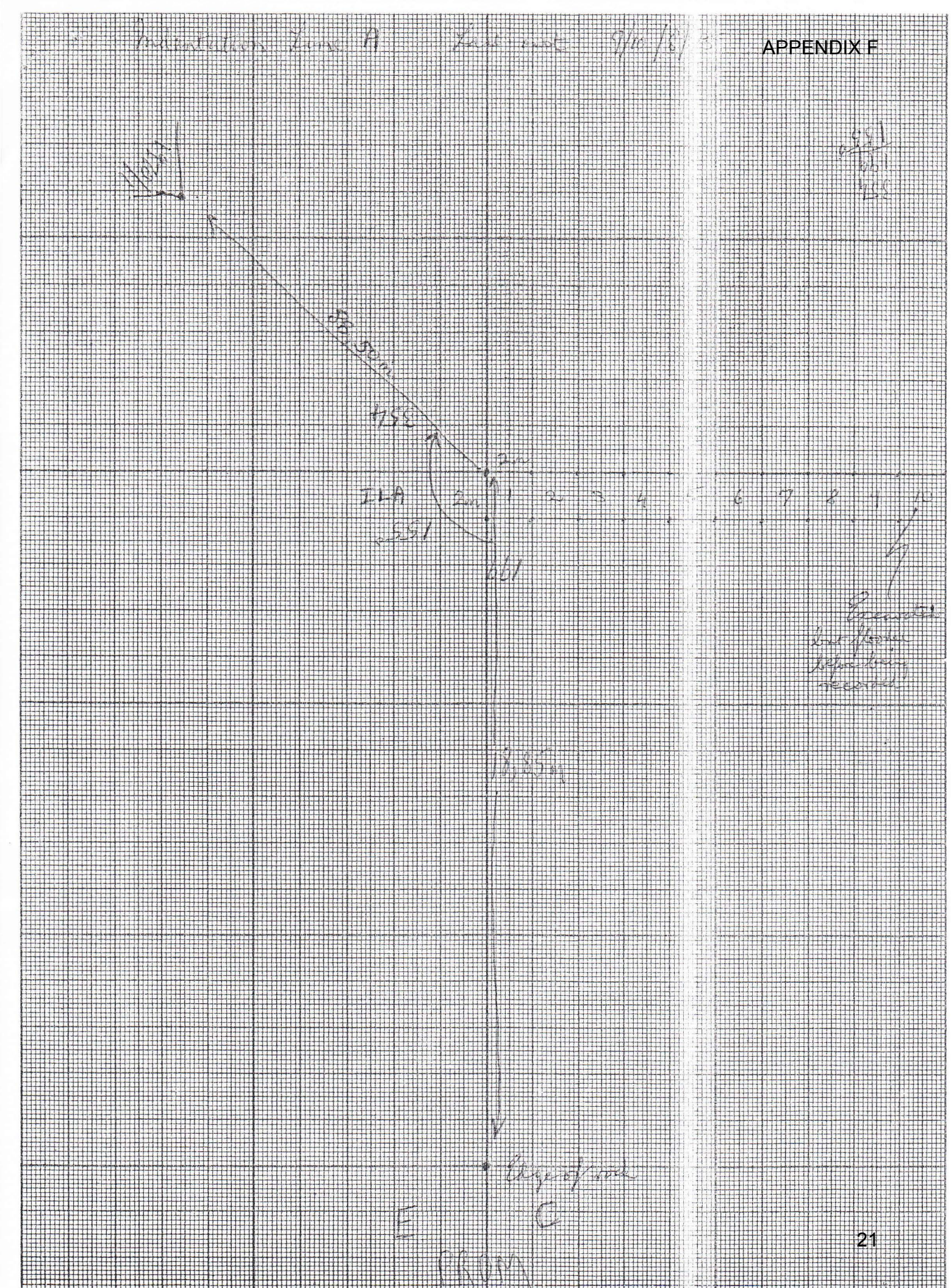
No 16 CS 7

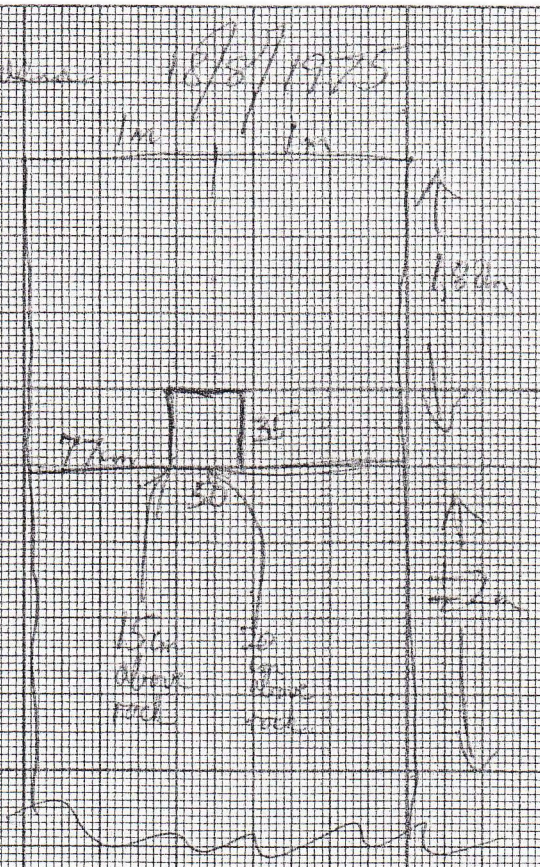
No 17 CS 7 close up showing DBS + clays

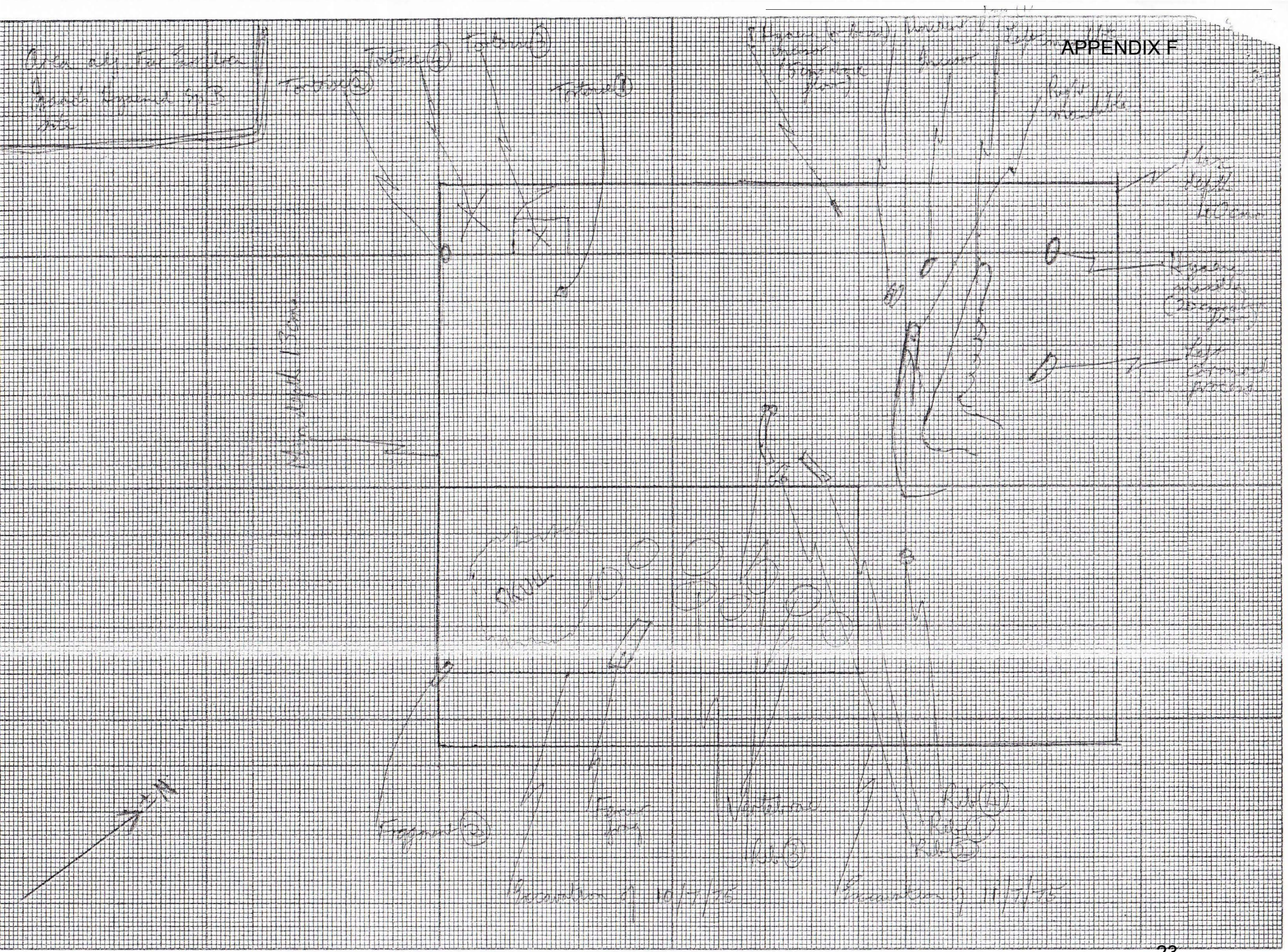
No 18 CS 7 organic horizon within DBS (close up)


July/August 1975
Bed 3a S
1970/1
Beacon
88,50 m.
ILA 10
18,80m.
Bed 3a N'
TCWW
Room.
N









Excerpts from Dr Hendey's field notes indicating origins, contents and locations of fossiliferous dumps at Langebaanweg



Dump #1

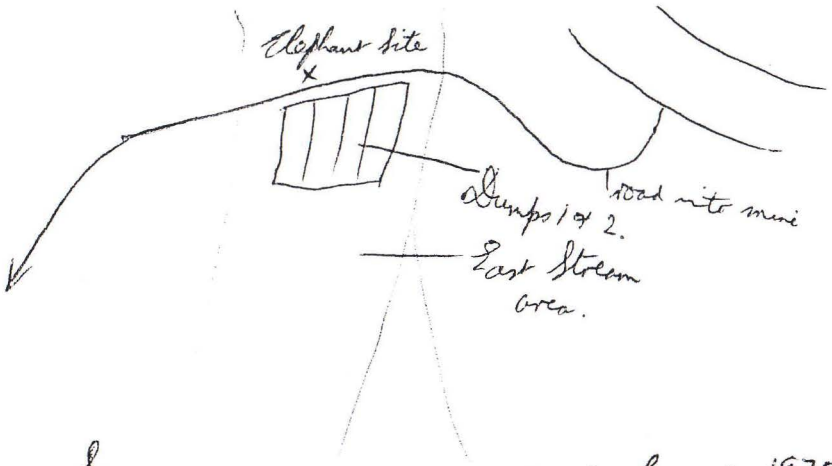
Part of Dump #2 (see over). Put separately because scraper exposed part of Percrocuta skeleton and one extra load was taken from this area & became Dump 1.

Screening was commenced early — January 1975 completed, & sorting of concentrate also completed during 1975.

Dump #2

Dumps 1, 2 & 3 were removed from the mine by a scraper during October 1974. All were from the East Stream area (Quartzose Sand Member).

Dumps 1 & 2 (a unit) were from immediately south of the road into the mine where it crossed East Stream



Screening was commenced early in 1975 & was completed during the year. Most of the concentrate was sorted during 1975, but some boxes from the fine-mesh screen have been stored away unsorted.

Dump #3

Dump #3 was taken from just north of the road indicated on previous page (around Elephant site).

Most, if not all of the deposit is Quartzose Sand Member, but there is a complication here because present in the area was the horizon of phosphate concretions which apparently is at or very near the upper limit of the QSM.

The fossils at the concretion horizon are more highly concentrated (or often cemented in the concretions). Some may be contemporaneous with deposition of the lowest level of the Pelletal Phosphorite. The main reason for suspecting this is that in one of the 1974 pit excavations (Test Pit 4) some alcelaphine teeth were found at this level. No alcelaphine remains* are known from deposits which are certainly QSM, but they are abundant in the PPM.

* Note specimen from area 13

For a brief period during 1975 some of Dump 3 was screened, but thereafter it was left as a reserve dump to be dealt with when there were no other more pressing committments.

This dump seems to be less fossiliferous than Dump 1/2, probably because the Elephant Site area was extensively pitted during the 1974 winter field season & Dump 3 includes a fair amount of deposit already checked.

Screening of Dump 3 was continued & completed during the summer of 1976/77.

Further sorting of this concentrate commenced early in May 1977.

Dump #4

One tip-truck load from upper levels of Bottom Cut, West Wall between 1966/2 and 1969/1. (From 1st new cut into West Wall) (ie. Cut 1, BCWW.) 14/11/75

Very little recovered - above 'grey sand' - brown sand higher up on BC.

Bed 3a S of Pelletal Phosphorite Member.

Dump #5

One tip-truck load from lower levels of BCWW. – 'grey sand'
23/12/75 – from Cut 3.
Bed 3a S of Pelletal Phosphorite Member

Small quantity noted during 1976 & more in 1977

(Screening started 24-12-75).

Dump 6

4/2/1976. 1 truck load.

Cut 4, BCWW

- mainly 'grey sand' ± ½ sieved - very little recovered.

Bed 3a S of Pelletal Phosphorite Member

Dump 7.

5/2/1976

Cut 4, BCWW. ± Opposite D1 (further north than Dump 6)

'Grey sand' Bed 3a S of Pollctal Phosphorite Member.

Small quantity sorted during 1976

Dump 8.

April 1977.

Large load (? + 100 tons) from south end of 1976/2 excavation Bed 3a N of Pelletal Phosphorite Member

A small quantity of concentrate brought back to C.T. late April 1977 & sorted.

Sorting continued at intervals during 1977 & 1978

Dump 9

Removed 11-17/8/1977 from area immediately west of 1976/2.

Bed 3a N of PPM.

(But note complication of white sand at base in this area ?? is it @ SM) (yes) (This applies also to Dump 8 & 10).

Screening commenced on about 17/8/1977

Dump 10

Removal commenced 11-17/8/1977 from area immediately North of 1972. 100's of tons. Bed 3a N of SPM, but underlying QSM also removed in large quantities.

QSM in this area is not richly fossiliferous, but the Dump 10 fauna does contain material from this deposit. Possibly all these, Glyptodonteras & Euphracteras from QSM; also most (? all) tortoise & most bird. Some toxodaphine may be.

Dump 10 composed overwhelmingly of gigantic teeth (+ bones, but bones in poor condition & poorly collected), which formed the bay deposit abutting rock platform.