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Chapter 1

Initial investigations of Acheulean hominin behaviour at Elandsfontein

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Introduction

The stone tool industry known as the Acheulean is one of the longest and least understood parts of human prehistory. Much of what we know about the million plus years represented by the Acheulean period comes from studies of the 'large cutting tools' (Kleindienst 1973) that define this industry (McNabb *et al.* 2004; Kuman 1994; Mithen 1996). However, the lifeways of these ancient populations are not readily characterized by these tools. At one time in the history of archaeological thought, it was suggested that the Acheulean reflected a period of human technological history notable for its lack of variability (Clark 1970 1988). However, it is now realized that Acheulean behaviour is not only variable on a continental scale (e.g. compare (Cruz-Uribe *et al.* 2003) with (Rabinovich *et al.* 2008)) but also on the scale of a single buried landscape (e.g. Dominguez- Rodrigo *et al.* 2009). In South Africa, the Acheulean time period has a long history of research (van Riet Lowe & van der Elst 1949; van Riet Lowe 1927). Several localities within South Africa were excavated many years ago and have thus far not received a more detailed analysis (e.g. Montagu Cave (Keller 1973) and Amanzi Springs (Deacon 1970)). However, this research has largely focused on the large collections of large bifacial forms found in the interior of the country. Acheulean sites along the Western Cape are common but rarely completely described. Most Acheulean localities known from South Africa are surface occurrences with little to no site integrity. There are rare cave localities, the value of which is set off by extreme stratigraphic complexities. Finding sites where hominin behaviour can be traced over large areas with good stratigraphic controls (as has been done in East Africa (Potts *et al.* 1999)), is difficult. Like much of Pleistocene archaeology in southern Africa, providing a solid chronometric framework for the very few buried Acheulean localities continues to be a challenge. Despite these difficulties the richness of the Acheulean archaeological record of South Africa in general, and the West Coast of South Africa in particular, warrants further investigation. Acheulean sites along the Western Cape coast are relatively common but few are completely described.

Here we describe a preliminary investigation of recent archaeological research at the locality of Elandsfontein along the West Coast of South Africa. Although this region has a long history of research, we hope to provide a unique perspective on Acheulean hominin behaviour

from the study of the artefacts and the context of the surrounding environment. Here we describe the preliminary results of the first three years of a project based out of the University of Cape Town that represents a multi-institutional and multi-disciplinary effort. Currently the implications of this research for Acheulean hominins are limited by the constraints of an on-going research project. However, our early research indicates that 1) archaeological sites that represent isolated instances of hominin behaviour can be recovered *in situ* at several locations around the Elandsfontein landscape; 2) these archaeological sites consistently appear in a similar stratigraphic context that is constrained by *a*) the paleotopography of the ancient landscape and *b*) the complicated geomorphological processes that resulted in the burial of these localities; 3) aeolian sediments in the Elandsfontein area contain multiple fossiliferous horizons and the oldest of these is at least >780 Ka; 4) multiple lines of environmental evidence suggest that the environment of the West Coast during the Middle Pleistocene was very different than the present day.

Acheulean archaeology of the West Coast of South Africa

The record of human technological evolution in the Early Pleistocene has played a major role in the archaeology of the West Coast of South Africa for several decades (Drennan 1953; Singer & Crawford 1958; Singer & Wymer 1968; Klein *et al.* 1999, 2007; Klein 2000a,b). However, despite this long history of research, the number of well documented sites is relatively few. Previous research has documented that the Quaternary sequences that cover much of the West Coast include sporadic Acheulean occupations (Hardaker 2005) with rare large concentrations of stone artefacts and associated fauna (Shackley 1980). Mostly these occurrences are associated with the numerous aeolian sediments that blanket much of the West Coast of South Africa (Roberts *et al.* 2009). The majority of these sites represent individual scatters of artefacts or isolated finds and thus have not been the subject of intense study.

However, there are a few localities which have been the subject of intense archaeological investigation. The youngest of these localities is the site of Duinefontein which is most likely one of the youngest Acheulean localities in southern Africa with an age estimate (~270 Ka; (Cruz-Uribe *et al.* 2003)) that overlaps with the beginning of the MSA elsewhere in Africa (McBrearty

and Tryon 2005). The remarkable preservation of fauna associated with Duinefontein allowed for a study of bone surface modifications. This indicated, to the excavators of the site, that hominins were not involved with the accumulation of the faunal material at Duinefontein (Klein *et al.* 1999). In fact, the low density of artefacts combined with the large size of the tortoises found at Duinefontein suggested to them that Acheulean hominins lived at very low densities on the ancient landscape.

Recent surveys of Quaternary deposits on the West Coast have documented Acheulean occurrences in large 'blowouts' where aeolian erosion has removed surficial sand bodies to expose the underlying Quaternary sediments (Hendey 1982). The most recently studied of these is the Anyskop blowout located about 1 km south of the Mio-Pliocene Langebaanweg locality (Kandel *et al.* 2006). Systematic survey at this locality documented the frequent occurrence of large cutting tools scattered sporadically around the 1.8 km² area but no major concentrations of artefacts were recovered. Conard (2003) suggested that the material was probably transported to this area over considerable distances (>5 km). Conard also noted the similarity in shape and raw material between the large cutting tools collected at Anyskop and those described by Singer and Wymer at the Cutting 10 locality approximately 19 km southeast (see below).

By far, the locality with the longest history of research is the large 4km long blowout most often referred to as Elandsfontein. Over the course of the last 6 decades it has alternatively been referred to as 'Hopefield' or 'Saldanha' (usually associated with the calvarium recovered there (Drennan 1953)). Elandsfontein is the main subject of the present study and thus a review of the long history of research is warranted here.

A history of research at Elandsfontein

As early as the turn of the 20th century farmers living in the vicinity of Hopefield town had noticed a growing aeolian erosional feature (Singer and Wymer 1968). The local community made several attempts to quell the extent of the erosion and in the process noticed the presence of large quantities of fossil bones that were being uncovered as the strong south-easterly winds stripped away the overlying sands. Unfortunately, because the bones were phosphate-rich, many farmers collected the fossils and destroyed them to be used as fertilizer in their fields (P. Haarhof pers. com.). It was not until the 1950s when archaeologists and palaeontologists began conducting surveys of the area, that the large quantity of fossil material that was eroding out of the Quaternary deposits was documented. In 1953 the recovery of a hominin calvarium in the south-western portion of the dunefield brought international attention to the region (Drennan 1953) and throughout the 1950s unsystematic collection of thousands of artefacts and tens of thousands of fossil bones.

The outstanding preservation of these specimens allowed

for the description of many species that had not been previously well known (Hooijer & Singer 1960, 1961; Keen & Singer 1956; Ewer & Singer 1956; Singer & Keen 1955) but unfortunately this material has no provenience within the dunefield. Some fossils were collected with information about specific deflation bays, but this was not systematic. Material that was collected was heavily biased towards specimens that were indicative of species level designations (for fossils) or techno-typological affinity (for artefacts). This unfortunately rendered the remaining surface collections largely devoid of these important forms and stripped any biostratigraphic indicators from the various collection areas. One of the most detailed accounts of the geology of the area was developed by Mabbutt as part of his Master's degree work at the University of Cape Town (Mabbutt 1956). His regional geology and mapping of surface exposures of Quaternary deposits still represents the most comprehensive published document on the geology of the locality. Mabbutt's work has largely been ignored mostly because of the influence of the concept of 'pluvials' (widely accepted at the time) on his interpretations. However, the detailed map he provides for the entire dunefield is unparalleled in subsequent descriptions. Initial archaeological investigations directed by R. Singer engaged the help of R. Inskeep. This campaign conducted a series of excavations that documented the geology that underlies the large calcrete formations present in various parts of the dunefield (Inskeep & Hendey 1966), however, none of these excavations exposed a clear archaeological horizon.

In the early 1960s Singer recruited the assistance of H.J. Deacon and J. Deacon to conduct a series of systematic excavations in the area. H.J. Deacon's geological background helped him recognize that many of the horizons that Mabbutt had described as stratigraphic entities actually represented various degrees of diagenetic processes, some possibly associated with ancient pedogenic activity (Deacon 1998). These excavations were never fully described despite their extensive size (one of the many 'calcrete cuttings' is approximately 80 square metres in lateral extent and 4 metres deep). One of the most difficult aspects of the early work was mapping the localities because the movements of the dunes would frequently obscure sites and datums. To combat this problem Singer initiated the placement of galvanized poles set in drums of concrete. This served the initial excavation procedures well although subsequent dune activity has destroyed many of these markers. By 1966, Singer's project had developed a map of the entire dunefield that has not been published to our knowledge. Throughout the 1960s, Inskeep continued conducting surface collections although these were now delineated by 50 foot grids and marked by wooden pegs, which were also destroyed by wind action over the course of the next 40 years and are now scattered throughout the dunefield. Descriptions of these surface collections and an associated map of these localities were never published. In 1966 Singer employed the assistance of John Wymer and another 17 excavations were conducted across the entire dunefield as well as in the sandveld outside the

areas of modern deflation (Singer & Wymer 1968).

Only one of the Singer and Wymer excavations was fully described. This locality, which is most often referred to as 'Cutting 10', was very large and recovered numerous fossils and artefacts. Despite the size of the excavation (>240 m² of excavated surface) the density of excavated material was quite low (3 artefacts or fossils/m²). Other features of this excavation were also highly unusual. Despite the presence of 47 large cutting tools *in situ*, the excavation recovered only 129 fragments of small chipping debris (Singer & Wymer 1968). Although Singer and Wymer (1968) do not describe the material, the excavated collection included several core forms that are simple chipped cobble cores reminiscent of Oldowan core forms (i.e. Mode I). Detailed descriptions of the faunal material from this locality suggest that Cutting 10 'was more a butchering site than a campsite' (Klein 1978: 69). Currently, the exact location of Cutting 10 is unknown even after numerous attempts by the original excavators to relocate the locality. Despite the large investment in the 16 other excavations conducted in 1965–6, these were never fully described with Singer and Wymer only reporting that 'at each cutting loose, pale brown ferruginous sand overlay a consistent level of fragmentary bones and artefacts' (1968: 69). The initial publication of this material references a monograph that was never completed. Site reports submitted to the national heritage authority reference a map of excavation localities but it is not included in any of the documentation. Thus the collections from these excavations cannot be used to understand landscape variation in hominin behaviour as their locations are unknown. An associated geological study of the sediments around the excavations at Elandsfontein suggested that dunes, such as those that dominate the modern geomorphology of the region, were not present when the artefacts and fossils were deposited (Needham 1962). In 1971, Butzer made a brief visit to the site and based on his observations and sediment samples collected there, he offered a modified interpretation of the geology (Butzer 1973). His observations largely coincided with Mabbutt's and Deacon's descriptions, yet his interpretations differed with reference to the presence of large ferricrete ridges that cross-cut the dunefield. Although the interpretation of these ridges has caused some debate (Butzer 2004; Roberts 1996), all interpretations of them suggest they post-date the artefact occurrences and therefore have little to do with the interpretation of Acheulean hominin behaviour.

Research at Elandsfontein lay dormant for the next 10+ years. G. Avery began systematic surface collections in the area in the 1980s mainly focused on large areas where there were high densities of faunal material. These collections proved to be hyena accumulations as indicated by the high frequency of coprolites associated with this material (Avery 1989). The large collection of surface collected fossils that was gathered by Singer and others in the 1950s and 1960s was subsequently re-analysed by Klein and Cruz-Urbe (Klein 1978, 1983, 1988; Klein *et al.* 2007; Klein & Cruz-Urbe 1991). These analyses

provided the first detailed description of mid-Pleistocene environments on the West Coast of South Africa. Descriptions of the carnivore guild, as well as bovids and cape dune moles documented how different mid-Pleistocene interglacial environments on the West Coast were relative to the present day. Assessments of the flora and fauna of the modern Western Cape suggest that the diversity of large bovids, as well as elephants and hippopotami found in the Elandsfontein Main (the name used to refer to the surface collections of the 1950s–60s) collection, could not be supported by the sandveld vegetation that exists in the region today.

In addition to these environmental inferences, the detailed description of the fauna allowed for an assessment of the approximate geochronological age of the collection based on the biostratigraphy. The presence of the extinct alcelaphine *Rabaticeras* which has a last appearance close to 600 Ka and the extinct long-horned buffalo *Pelorovis antiquus* which has a first appearance at about 1 Ma, provides end members for the age estimate of the surface collections of fauna from Elandsfontein. Recent studies that focus on feeding ecology (i.e. mesowear) and isotope chemistry of ancient animals, as opposed to taxonomic uniformitarian analogies, indicate that bovids and equids at Elandsfontein were consuming far more browse than would be expected for these species (Kaiser & Franz-Odenaal 2004; Stynder 2009; Luyt *et al.* 2000). One of the main concerns with these studies of the paleoenvironments of the Elandsfontein site is the fact that they derive largely from surface collections. The high frequency of horns cores and dental remains in the museum collections attests to the nature of the bias in the collection procedures in the 1960s. At present the only collection from Elandsfontein that is *in situ* and unbiased is the Cutting 10 collection. This collection differs dramatically from the Elandsfontein Main collection in terms of the species and elements represented (Klein 1978).

Despite the limitations of the documentation of site context, Elandsfontein represents the best studied collection of Acheulean artefacts and associated fossils on the West Coast of South Africa (Archer & Braun 2010; Singer & Wymer 1968; Inskeep & Hendey 1966; Volman 1984). Along with Cave of Hearths (McNabb & Sinclair 2009; Mason 1961), Wonderwerk (Chazan *et al.* 2008), and Kathu Pan (Porat *et al.* 2010), Elandsfontein represents one of the very few localities in South Africa where *in situ* evidence of the behaviours and habitats of Acheulean hominins can be recovered. Unfortunately, Elandsfontein currently provides relatively little concrete evidence about hominins in South Africa during the Pleistocene. The artefacts that have been described from the locality represent surface collections that may or may not include Late Pleistocene elements (Malan 1962). Even the *in situ* collection from Cutting 10 did not include the types of modern sieving operations that allow for complete collection of the entire technological system (Singer & Wymer 1968). The association between the recovered fauna and the artefacts is based on surface indications that are the result of severe collector bias

(Klein & Cruz-Urbe 1991). Even the age of the Elandsfontein collection is based on the relationship between possibly mixed surface collections and the biostratigraphy of species from East Africa. The only certain feature of the Middle Pleistocene from Elandsfontein is that the habitat that existed when the majority of the fossils were deposited was very different from the current interglacial. Hominins clearly were present on the Western Cape landscape in the mid-Pleistocene, and they clearly transported stone to the Elandsfontein region (Archer & Braun 2010; Braun *et al.* 2008), but the reasons for doing this are unknown. Here we report on the first systematic excavation campaign at Elandsfontein in 20 years.

Excavations at Elandsfontein 2008-2011

The systematic excavations in the Elandsfontein area were initiated with three major goals related to the Middle Pleistocene deposits in our research area, which includes a large area south of the Elandsfontein property in the West Coast National Park. First it was important to determine if concentrations of artefacts that were behaviourally associated with the well preserved fauna could be recovered from the Quaternary sediments in this region. Previous assessments had suggested that this was the case (Singer & Wymer 1968), however recent interpretations of the collections have suggested that the majority of the fauna were only fortuitously associated with the stone artefacts (Klein *et al.* 2007; Deacon 1998). Determining the association of artefact concentrations and fauna would only be possible with a detailed understanding of how the site-scale geological context of individual archaeological localities fit into the overall regional scale geology of the region. Second, it was important to determine if the surface collections that have so far influenced the interpretation of the Elandsfontein area (e.g. Klein *et al.* 2007) represent similar patterns to those found in *in situ* collections. Third, once these two aspects of the archaeological record at Elandsfontein were determined it would be necessary to determine how hominins fit into the ecology of the Middle Pleistocene of the West Coast. Here we will largely focus on the first goal.

The renewed excavations at Elandsfontein have been conducted in conjunction with a campaign to map and document the extent of fossiliferous deposits within the greater dunefield area. The recent expansion of certain types of vegetation, most notably *Acacia mearnsii*, also known as 'black wattle', has stabilized the dunes systems in much of the southern part of the dunefield and obscured the fossiliferous horizons. In an attempt to document the presence of the fossiliferous horizons, extensive foot survey and field GIS mapping has documented the relative location of different exposures of different types of sedimentary bodies at surface (Figs 1 & 2). Based on these surveys, we have determined that there are currently at least 31 000 m² of fossiliferous deposits associated with large amounts of silica-rich nodules in the northern half of the dunefield (Fig. 2). In addition to these

exposures, there is another 25 000 m² of Quaternary sediments that are iron bearing, some of which have formed solid layers of ferricrete that are similar to those described in previous geologic surveys of the area (Butzer 2004; Roberts 1996). In most instances, these ferricrete horizons overlie the nodule-rich fossiliferous horizon, although the geomorphological processes that have modified the dunefield are so complex that this stratigraphic relationship cannot be consistently inferred for the entire dunefield and must be tested with large scale systematic geological trenches. This has been the major focus of our geological investigations at Elandsfontein.

Thus far our research team has conducted 5 major excavations located in bays 0109, 0209, 0509, 0609 and 0110 (Fig. 2). These were focused in the northern part of the dunefield where exposures of quaternary sediments are more easily visible and the encroachment of alien species of vegetation has not lessened the aeolian transport of sand (Table 1). Excavations were concentrated in areas where the iron bearing Quaternary sediments can be found overlying the nodule rich horizon that is usually associated with the fossiliferous horizon. In each of these excavations we have documented the presence of three separate horizons.

The distinction between these horizons is not obvious because the frequent movement of aeolian sands results in relatively indistinct sedimentary transitions; however the upper horizon of these excavations is usually associated with an iron-rich nodular horizon. These iron-rich nodules (previously described as 'ferricrete') tend to have an outer crust which is enriched in iron-bearing minerals and when these are exposed at surface, resultant oxidation and weathering of these nodules stain the surrounding sands to deep reddish brown. This horizon ranges from 1–2 metres thick in some areas of the dunefield to a thin 15 cm horizon in other locations. Below this horizon is a massive sand body that is associated with non-calcareous nodules that range in size from 1 cm to large blocks that can be up to 15 cm wide and 10 cm thick. This horizon is usually associated with the fossils and artefacts. These nodules sometimes encrust the fossils and other times they can be seen in accumulations between the fossils. Geochemical and petrographic analyses of these nodules are ongoing but the presence of these nodules in and around the fossils suggests that they represent a subsurface post-depositional process. The nodular horizon sometimes continues down-section from the fossiliferous horizon which is almost always concentrated within a 15–30 cm horizon. The nodules can be found as deep as 1 metre below the fossil and artefact horizon in some places. Below the nodular horizon the sand tends to be lighter in colour. This sand body has, on average a smaller grain size than the sand above it. This sedimentary unit bears the non-calcareous nodules and fossils, although all sands from the section yield average grain sizes that range from 0.22 to 0.26 mm. This lower light coloured sand horizon bears some resemblance to what Mabbutt (1956) referred

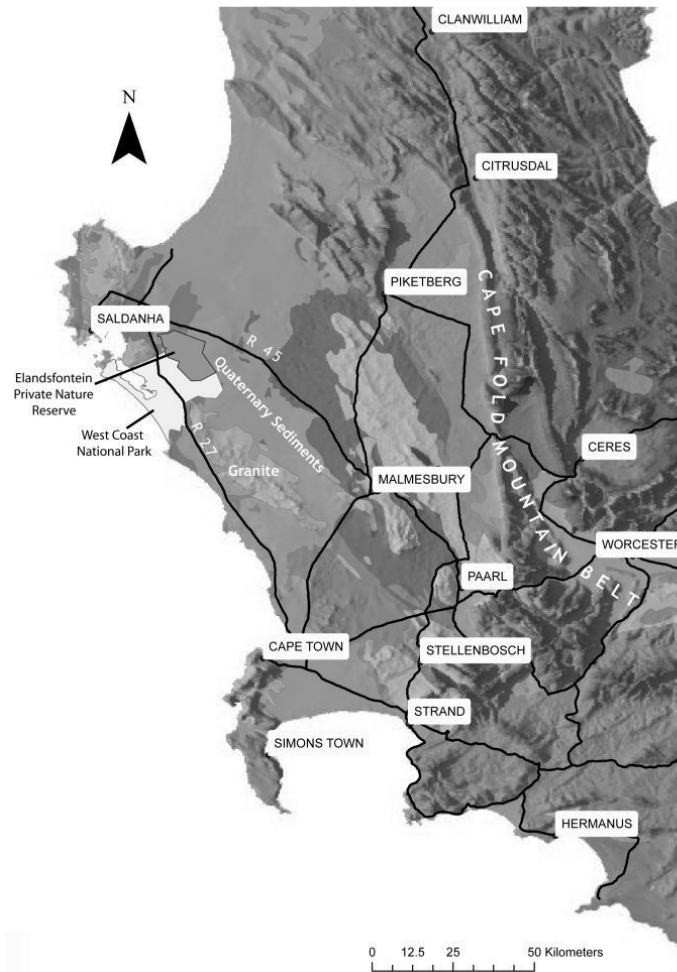


Figure 1: General map of the West Coast of South Africa with descriptions of major locations along it.

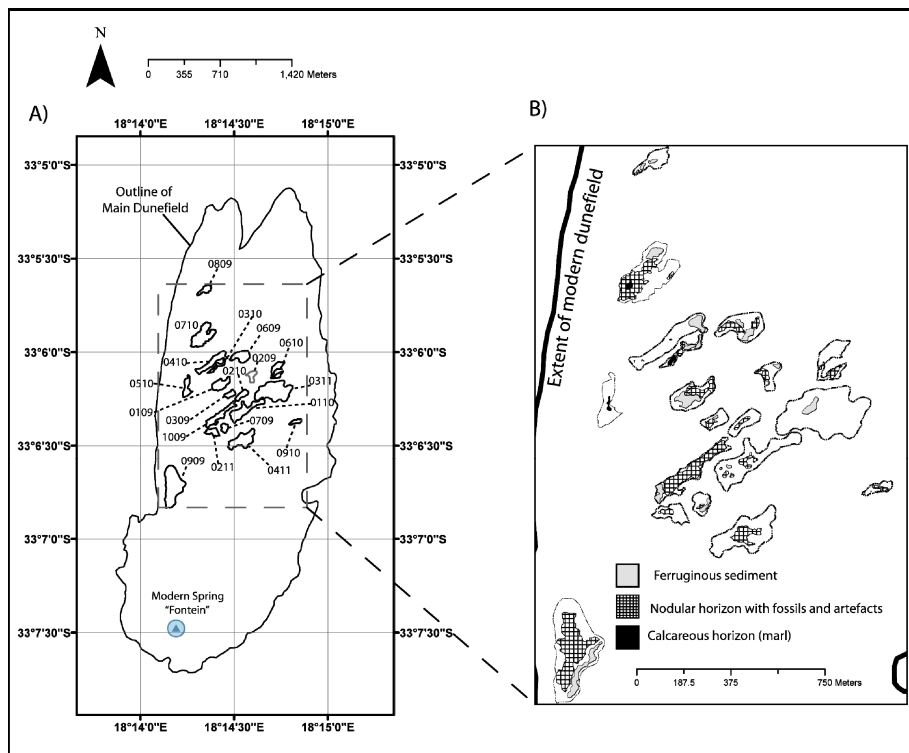


Figure 2: Map of the research area. A) The Main dunefield area showing those deflation bays that have been investigated in by the current research team. B) Inset map of the deflation bays that have been mapped by the current research team. The map indicates the presence of different surface exposures. Outlines of the bays indicate the crest of modern dune sand.

Excavation	Area Excavated (m ²)	Total Artefacts Recovered	Total Faunal Specimens Recovered ¹	Biostrat. Age	Northing	Easting
0109	12	34	200	None	-33.1005	18.2424
0209	79	1013	3117	< 1 Ma (<i>Pelorovis</i> cf. <i>antiquus</i> ; <i>Kolpochoerus</i> sp.; <i>Sivatherium</i> sp.)	-33.2434	18.2434
0509	8	107	210	None	-33.1040	18.2410
0609	12	89	111	None	-33.1015	18.2408
0110S/SW	16	140	429	< 1 Ma (<i>Pelorovis</i> cf. <i>antiquus</i>)	-33.1057	18.2410

¹-Macrofauna and microfauna combined

Table 1. Major excavations conducted by the Stone Age Research Group between 2008-2011.

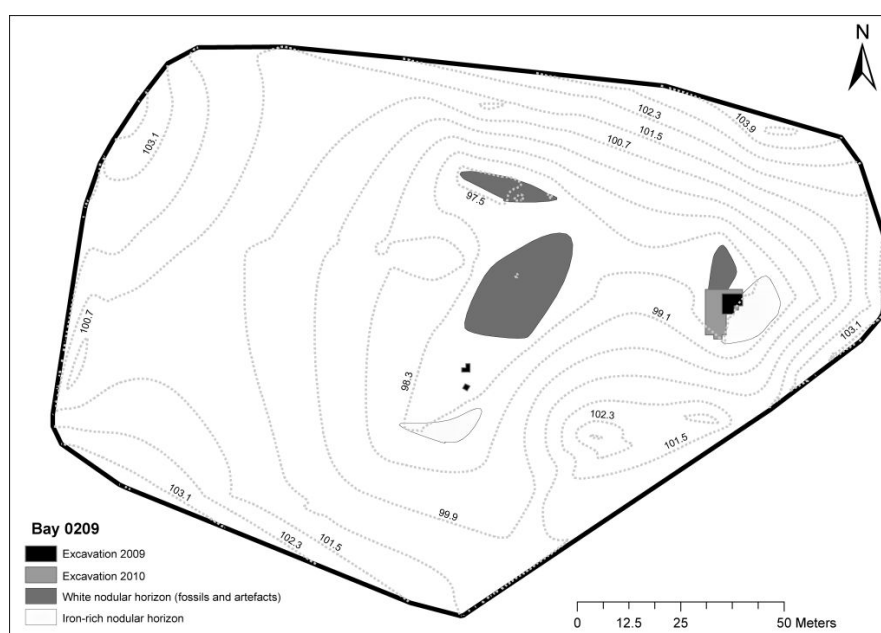


Figure 3: Map of the 0209. This bay was the subject of intense excavation and surface collection between 2009 and 2011. Contours are based on heights taken with a total station relative to a local datum set at an arbitrary 100.0 m Z.

to as ‘Silver Grey Sand’. Mabbutt’s interpretation of these sediments is that they are the result of marine sedimentation during the Miocene. It is difficult to determine if this horizon is the same horizon that Mabbutt described but subsequent geological trenches associated with the present excavation campaign suggest that this sand body is Quaternary in age and is likely the result of aeolian deposition and not marine deposition.

All of the excavations conducted in the dunefield area documented the presence of *in situ* instances of artefacts and fossils that appear to be laterally and stratigraphically distinct. We are currently in the process of describing the material recovered from these various excavations. However, the high density of material recovered from the 0209 excavation warrants more in depth investigation and here we concentrate our efforts on this material.

Excavation of the 0209 Locality

In 2009 our excavation team was conducting a series of surface surveys in the northern part of the main dunefield

area (Fig. 3). This survey documented the presence of well-preserved fossils and stone artefacts in an area that included two prominent outcrops of ‘ferricrete’. Of particular interest was the presence of multiple artefacts produced on volcanic materials as well as several complete fossils with white nodules adhering to bones (suggesting they had not been subjected to extensive aeolian erosion, as this outer coating of the white nodules tends to erode quickly after exposed at the surface). At the centre of the bay, an initial excavation was conducted through 40 cm of modern dune sand before Quaternary sediments were reached. It was clear from these excavations that the modern dune sand was covering a surface that had already been extensively deflated and fossils recovered from these initial excavations were badly damaged and artefacts had also been eroded. These excavations (referred to as 0209 West) were stopped and a second excavation was initiated on the eastern extent of the bay. This particular area had a large exposure of the iron rich nodular horizon that was surrounded on three sides by high modern dunes. To the north of this ferricrete outcrop there was a limited exposure of the

white nodular horizon. At the surface were several well preserved fossils, including three vertebrae that were still linked together in anatomical position and several artefacts.

Initial localities in the eastern part of the bay were excavated into ferricrete horizon exposing ~50 cm of overlying sediments above the nodular horizon with a high density of artefacts and fossils. Excavations were extended to 16 m² in 2009. The recovery of hundreds of artefacts and fossils including large bifacial implements prompted the expansion of this excavation to another 63 m² in 2010. These excavations recovered hundreds of artefacts and thousands of fossils. Although the northern extent of the excavations began to intersect with the modern erosion of this surface, almost all fossils and artefacts were recovered in a discrete 30 cm thick horizon that was at least 30 cm below the ferricrete horizon. The fossils and artefacts recovered from the 0209 excavation represent a wide array of faunal elements of a variety of animals, both macro and microfauna. Specimens attributed to Rhinocerotidae, which may represent a single individual, are the most abundant. Of particular interest were the recovery of Acheulean tools (large cutting tools) and a partial articulated skull of a *Pelorovis/ Syncerus antiquus*. Although the archaeological material recovered from the 0209 is important for understanding the behaviour of Middle Pleistocene hominins, it is necessary to first investigate the possible post-depositional process associated with the formation of this locality.

As with all open air localities, the artefact and fossil assemblages represents an open system and various processes can remove or modify the frequency of certain elements in the assemblage. In the Elandsfontein area the complexities of multiple episodes of sand emplacement as well as complex Aeolian processes requires the investigation of site integrity before any inferences of behaviour can be developed. In his description of the 1964 excavations Deacon described the scenario succinctly with 'at Elandsfontein, association must be proven and not assumed' (H.J. Deacon, pers. com. 2009). The strong south-easterly winds of the Western Cape are a major geomorphological force and are constantly remodelling the dunal landscape in the Elandsfontein dune area (Roberts *et al.* 2009; Roberts 1996). It is possible that aeolian processes in the past modified the archaeological assemblages. It is clear that many of the surface occurrences of fossils and artefacts at Elandsfontein have been subject to deflation. The co-occurrence of artefacts that are associated with various time horizons (e.g. Earlier Stone Age handaxes and Middle Stone Age Stillbay points (Singer & Wymer 1968)) provides obvious evidence of the conflation of multiple archaeological horizons in some parts of the dune field. However, the antiquity of this type of activity is not well understood. It is possible that many of the archaeological sites represent multiple events of deflation in the past. As such, we embarked on a series of tests of the integrity of the material recovered from the 0209East excavations.

Site integrity: Does the 0209East locality represent a buried deflation surface?

Unlike open air localities in East Africa where fluvial activity represents the most likely natural process for the movement of archaeological materials (Schick 1986; Nash & Petraglia 1987), sites on the coastal plain of South Africa are much more likely to be modified by aeolian processes. Aeolian processes tend to deflate archaeological horizons which laterally redistribute fossils and artefacts (Kandel *et al.* 2003) laterally as well as vertically. In addition, deflationary processes can preferentially remove smaller parts of the assemblage. In particular lighter elements (microfauna, fish bones) are likely to be removed by wind action (Rick 2002). To test the possibility of the 0209 Excavation being affected by deflation we investigated the fabric of the archaeological assemblage to determine the possible effects of wind action.

One of the most comprehensive studies of the effects of wind activity on archaeological assemblages was conducted at the Geelbek Dune system in South Africa (Fuchs *et al.* 2008, Kandel *et al.* 2003) where a series of experimental assemblages were exposed on the surface of the modern dunes and the movement of these specimens recorded over time. This experiment documented the dramatic movement of archaeological material both laterally and vertically in dune systems. For many of the bones and fossils at the 0209 excavation it is not possible to determine the degree of lateral post-depositional movement, however, there are several indications that specimens have not moved extensively from their original position. There were three separate instances where multiple faunal elements were recovered in near anatomical position (e.g. complete radius and distal humerus of the same individual separated laterally by 20 cm). There two other instances where bones that refit were recovered directly next to each other. In the Geelbek project experiments specimens moved up to 12 m in the course of one year and all of the experimental specimens moved a minimum of 1 m during the course of 1 year of deflationary processes. The work at Geelbek also documented that the strong south-easterly winds tend to align laminar objects with the wind direction or perpendicular to wind direction. This is a result of wind action that creates a hollow in front of long objects. Objects then slip into these hollows oriented in the direction of the wind.

We corroborated this finding by conducting excavations of surface material in the Elandsfontein dunefield that had clearly been deflated (artefacts associated with multiple time horizons represented on a single surface). Our study of object orientation corroborated the finding of the work at Geelbek, in that deflated horizons show artefact orientation with wind direction as well as perpendicular to wind direction (Fig. 4b). In addition, we documented that deflated surfaces tend to have objects that are flat lying because objects have settled down as underlying sediment is removed. Analysis of object orientation at the 0209 East excavation shows that few

objects are oriented in the direction of the prevailing wind pattern but the dip of specimens shows that the majority of specimens are flat lying. This shows some similarities between the deflated surfaces and the assemblage at 0209East locality. However, this is not conclusive because it is possible that all of the specimens were deposited on a flat lying surface. If this were the case then the relatively little dip of the specimens at 0209 actually represent the form of the ancient land surface as opposed to some post-depositional process.

Other studies of the effects of aeolian processes on archaeological materials have documented the preferential removal of smaller items in deflated horizons in coastal dune systems (Rick 2002). In his work on islands off the southern California coast Rick documented the removal of smaller bones (fish) and the preferential concentration of larger mammal bones in deflated horizons (Fig. 5b). Rick's study focused largely on the changes in NISP/m³ (Number of identifiable specimens per cubic metre) in 10 cm horizons. We looked at similar patterns in the 0209 excavation by documenting the relative frequencies of micro and macrofauna within stratigraphic horizons. If the archaeological horizons at Elandsfontein represented buried deflated surfaces we would expect to see a sharp drop in microfauna NISP/m³ as the macrofauna NISP/m³ increases. However an investigation of this pattern in a subset of the assemblage, from a 16 m² section of the 0209East excavation where the initial surface was relatively flat and sedimentary horizons were relatively flat lying, argues against the possibility of deflation at 0209East. In fact, the down-section distribution of specimens follows patterns that would be expected for an assemblage of *in situ* undisturbed fossils and artefacts (Fig. 5c).

Behavioural association: Does the 0209East locality represent an event of hominin behaviour?

Previous analysis of the materials from Elandsfontein focused on the faunal materials. The distribution of elements from these collections suggested to Klein & Curz-Urbe (1991) that most of the specimens recovered from the dune field were the result of natural deaths or carnivore activity. This was based on dental eruption patterns that suggested an attritional death pattern as opposed to that expected for an assemblage that was accumulated by hunters. However, as mentioned before, these collections represent surface collections made over a 6 km² area and over the course of several decades. It was not possible to associate these faunal specimens with artefacts because the provenience of these specimens is largely unknown, unlike at the 0209 East locality which was systematically excavated.

It is difficult to estimate the formation process of archaeological assemblages in coastal dune systems as sedimentation is not constant. It is possible, and in fact likely, that the artefacts were buried and then exposed and then reburied several times. Thus it is highly probable that the artefacts found at these localities do not represent an event where hominins made and used tools

at a particular location but rather the incidental discard of artefacts over a very long period of time that may or may not have any behavioural association with the fossils also recovered at this locality. One way of investigating this pattern is to compare the assemblage of artefacts with experimentally produced assemblages of artefacts. Schick's site formation experiments were developed to investigate patterns associated with fluvial environments (Schick 1986). However, her investigations documented the patterns that are expected from the on-site production of artefacts (Schick 1987, 1991) and these can still be compared to the distribution of artefacts recovered from an archaeological site. Schick's experiments documented that the size class distribution of an assemblage is the greatest determination of artefact transport into and out of a site. Assemblages that had been winnowed were missing the smaller fraction (<2 cm) of the assemblage. Sites where artefacts were carried away from the site were missing the large fraction of the assemblage.

A comparison of the 0209 artefacts and an experimental assemblage developed by Schick (1986) suggest that the size fraction of the materials found at 0209 is actually heavily biased towards the smaller size fraction (K-S Test of two samples; $D=0.607$; $p=0.0002$; Fig. 6). In fact, relative to Schick's experimental assemblage, the 0209 excavated assemblage exhibits frequencies of the smallest size fraction that are over five times higher than the what would be expected from experimental assemblages. There are certainly substantial differences between Schick's experiments and the Elandsfontein collections (e.g. raw material) which may explain the severity of this discrepancy. However, the extremely high frequency of very small fragments speaks to the relatively high frequency of tool production that occurred at this locality. One possible explanation is that larger core forms or flakes were removed from the site after production. Previous analyses of the Elandsfontein material suggest that transport of core forms was a frequent occurrence at Elandsfontein (Archer & Braun 2010).

One of the other ways of determining the formation process of the 0209 locality is with the relative frequency of elements found in the excavation. Assemblages that are accumulated by carnivores tend to have low frequencies of epiphyseal fragments. This is the result of preferential deletion of epiphyses, which have high grease content, by carnivores (Marean *et al.* 1994; Marean & Spencer 1991). The assemblage recovered from the 0209East excavation has a very high frequency of epiphyseal fragments. This frequency is much higher than any recorded from experimental assemblages that were exposed to carnivores, making it unlikely that carnivores had anything to do with the accumulation of this assemblage. Determining whether or not this assemblage is the result to natural death is more difficult. Very few complete mandibles or teeth were recovered from the 0209East excavation. More extensive taphonomic analysis will be the subject of future studies of the 0209 material. However, currently several specimens have been collected with evidence of cut marks and document butchery at the 0209 excavation.

Based on the data we have currently collected it is apparent that hominins were making and using stone tools at the 0209 locality. Although it is currently not possible to determine if all of the bones found at 0209 were the result of hominin activity it is definitely possible to rule out the influence of carnivores as accumulating agents at this locality. There is a definite possibility that both hominins and natural death accumulations are the main agent of accumulation. Although there is some evidence of post-depositional modification at the site, it is possible to exclude the possibility of large scale deflationary process, meaning that 0209East is not a buried deflated surface and may represent multiple events of hominin activity. The high frequency of microfauna from the 0209 locality does provide very interesting possibilities for developing a rich paleoecology of the local area. However, it is also possible that these remains represent multiple events of bioturbation that could affect the overall interpretation of a buried land surface at the 0209 locality. The high frequency of *Bathyergus* (dune mole rat) in the collection heightens the likelihood of bioturbation. Unfortunately the lack of sedimentary structures in the archaeological horizons makes it very difficult to document bioturbation in these sediments. However, preliminary investigation of the microfauna from 0209 indicates that the majority of specimens derive from predation by raptors and not natural deaths. The relatively high frequency of dental material relative to post-crania also supports this assertion.

Geological context of the 0209 Locality

Dune systems are sensitive barometers of fluctuations in paleoenvironments, as archived in their orientation, geometry, internal architecture, composition, granulometry, and diagenesis (Roberts *et al.* 2009). Depositional mode and pedogenic alteration of the aeolian sediments at Elandsfontein provides insight into the environmental and climatic context of the site. The major form of dune deposition along the West Coast is as large dune plumes, which were principally constructed by the strong southerly summer winds (Roberts *et al.* 2009) and the ancient dunes at Elandsfontein follow this general pattern. Many studies along the southern and West Coast of South Africa show that dune deposition and subsequent pedogenesis correspond with orbitally forced climate cycles (Roberts *et al.* 2008; Butzer 2004). Proximity to a sandy beach (aeolian sand source) is a function of sea level and is the primary controlling factor of dune deposition and the majority of dune formation may occur during interglacial periods. Pedogenesis reflecting prolonged sediment starvation likely occurs during glacial periods, as beaches are too distant (offshore) to provide a sand source. A working hypothesis would be therefore that bones and artifacts occurring within the body of a dune relate to a warmer climatic phase, whereas pedogenic features such as calcification, karst development, dune snails and root structures reflect colder intervals. Likewise, sea level through its damming effect on groundwater is likely to

affect the subsurface paleohydrology and the availability of surface waters that would have attracted animals and humans.

Previous geologic work provides an initial foundation for our understanding of the Elandsfontein area (Butzer 1973; Mabbutt 1956), however, it is insufficient to provide the chronostratigraphic context necessary for understanding patterns of Acheulean behavior and the refinement of the stratigraphy and geochronology of the archaeological and paleontological materials is a major component of our current research. In general, outcrops are scarce due to the ubiquitous presence of recent aeolian sand cover. Our preliminary stratigraphic work is based on detailed logging of 1.0–1.5 m deep excavation and test pits which were extended up to 2.7 m below the base of these pits by collecting and recording sediment retrieved by auger.

Our observations from the initial stratigraphic research are consistent with some previous reports of the geology at Elandsfontein. We have observed a lower, highly calcareous sand unit that locally contains vertebrate fossils, ostrich eggshells, gastropods, root-casts and burrows as well as dissolution and re-precipitation features. This unit is well exposed in a large deflation feature on the southwestern part of the main dunefield (previously described as Homo Bay) and forms the topographic high in the southern portion of Elandsfontein. These sedimentological features are characteristic of pedogenesis during periods of sediment starvation in paleo-calcareous dune systems of the West Coast of South Africa and therefore mark significant unconformities in the sedimentary succession (Roberts *et al.* 2009). The strata associated with the Calcrete Ridge are visible in outcrop and in excavated section to the north and east of Homo Bay. An erosional surface separates these lower calcareous strata from predominantly non-calcareous sediment above. These upper, mostly non-calcareous strata contain the *in situ* artifact and fossil horizon which are associated with a discrete interval containing white nodules with little to no carbonate content and overlain by a more diffuse zone of ferruginous sand and nodules. The nodules associated with artifacts and fossils likely represent an interval of pedogenesis, with initial carbonate deposition and subsequent leaching, as suggested by Butzer (Butzer 1973) and observed nearby at the open-air sites of Geelbek where there are similar sedimentary sequences (Felix-Henningsen *et al.* 2003). The 0209 locality is located east of the Calcrete Ridge and geological trenches within the 0209 bay was not able to document the stratigraphic relationship between the archaeological horizon and the lower calcrete rich horizon. Based on surveys of the area between 0209 and the calcrete ridge, we can estimate a stratigraphic distance of 1–4 m. In preliminary excavations north of Homo Bay this unconformity has been documented at 1.3 m below the modern surface and 1 m below the archaeological horizon.

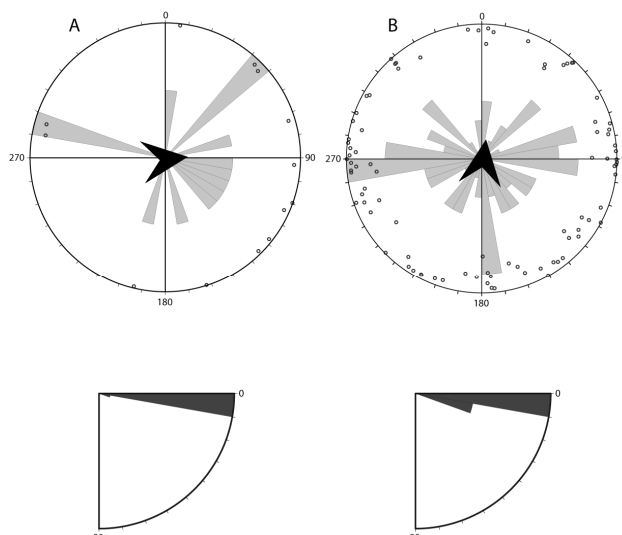


Figure 4: Schmidt diagrams using dip and orientation of specimens with a clear long axis. The lower part of the figure includes relative frequency of the dip of the specimens from each excavation. a) Data collected from the 0209East excavation. b) Data collected from a deflated surface in the Elandsfontein dunefield (0609WEST). Note the arrows that indicate current wind direction. There is no indication that the 0209 materials is oriented parallel or perpendicular to the wind direction. Although there are relatively fewer orientation measurements in the 0209 excavation, we are not concerned with the number of orientations but rather the relationship between the orientation data and the associated wind direction.

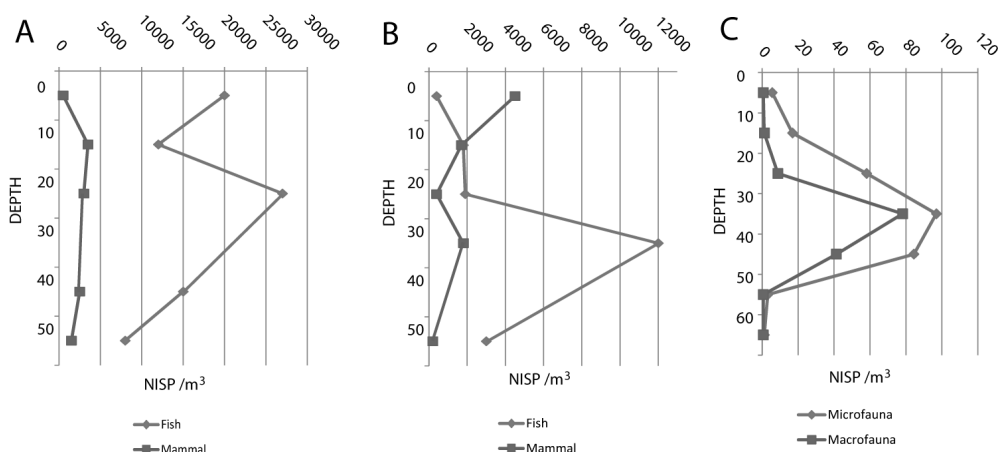


Figure 5: NISP/m³ values for stratigraphic horizons at three separate archaeological localities. a) The frequency of fish and mammal bones at the site of CA-SMI-481 Unit 1 (Rick 2002) showing a clear archaeological horizon that has not been affected by deflation, b) The frequency of fish and mammal bones at CS-SMI-87 East Unit 2. Note the increase in mammal bones near the surface and the rapid decline in fish bones, c) Data from a subset of the 0209 East Excavation showing the presence of a clear archaeological horizon at 40 cm below the surface.

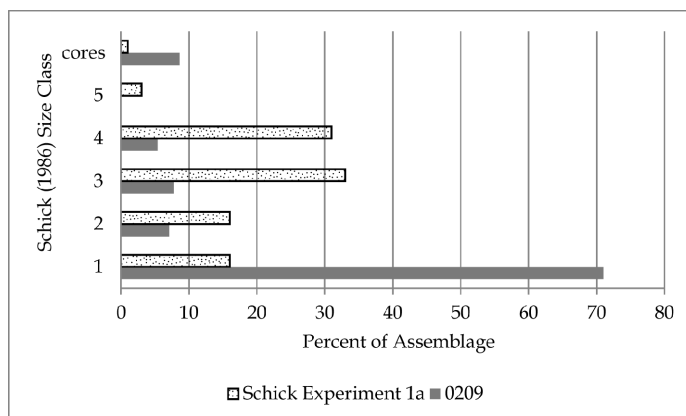


Figure 6: The relative frequency of artefacts from different size classes found in the 0209 excavation. This is compared with data from an experimental assemblage described by Schick (1986) in her site formation experiments. Statistical tests of the difference between these two assemblages are described in the text.

Geochronology

As mentioned above estimates of the age of Elandsfontein Main fauna is based on the co-occurrence on several key indicator species such as *Rabaticeras* and *Pelorovis (Syncerus) antiquus* (Klein *et al.* 2007). Recent geochronological work suggests that both *Rabaticeras* and *Pelorovis (Syncerus) antiquus* occur in deposits that are 1.1 Ma at other localities in southern Africa (Herries *et al.* 2009). Excavations at the 0209 locality have recovered at least three extinct species *in situ* in association with Acheulean tools (e.g. *Pelorovis antiquus*; *Sivatherium* sp., and *Kolpochoerus* sp.) indicating that the collection is younger than 1 million years old. The biostratigraphic utility of *Kolpochoerus* is currently debated (Sahnouni *et al.* 2009; Raynal *et al.* 2001). The large giraffid *Sivatherium maurusium* is known from a variety of localities and does not provide solid biostratigraphic indications. Currently it is best known from Olduvai Bed IV and several North African localities that pre-date the Brunhes-Matuyama boundary, suggesting an age of older than 780 ka for the 0209 locality. The similarities between the faunal suite recovered at Cornelia and those found at 0209 may suggest relative contemporaneity for these sites. Our research team is currently involved in a multi-technique geochronological effort and further analysis will provide a better estimate of the ages of the different areas of dunefield area. However, current preliminary data provides an estimate of the general geochronology of the region. Paleomagnetic analysis of deposits from West Coast paleontological localities in South Africa are generally limited by the lack of suitable lithologies that record a geologically stable magnetic remanence. Most deposits record a secondary chemical remanence rather than a primary depositional magnetic remanence formed at the time the sediments were deposited. Our preliminary study of the calcretes and sandstones from Elandsfontein indicates that they hold a complex, but stable series of magnetic remanences. Currently samples from the eastern part of the dunefield record reversed polarity which we are currently attributing to the Matuyama chron.

Conclusion

The locality of Elandsfontein has long held a prominent place in the description of Acheulean hominin behavior in southern Africa, yet interpretations derived from this site are hindered by problems associated with the integrity of the assemblages collected from this area. Here we describe a new excavation (0209) where numerous geoarchaeological lines of evidence suggest it may be possible to understand the site formation process associated with the discard of artefacts at this locality. The presence of an abundance of small flakes, cut marked bones, articulated skeletal elements, as well as fabric analysis of the artifacts and fossils suggest this locality has a higher spatial and temporal integrity than other assemblages reported from the Elandsfontein area. If this is the case it finally may be possible to investigate early Pleistocene technological responses to the ecology of the Western Cape.

Models of human uniqueness suggest that the suite of characteristics that define humanity is relatively recent and originates in Africa (Hill *et al.* 2009). This is supported by archaeological evidence for late Pleistocene populations in Africa with increasingly sophisticated behavioral adaptations (Backwell *et al.* 2008; Brown *et al.* 2009; Shea 2007), the appearance of which is overwhelmingly African in origin (Henshilwood & Marean 2003; McBrearty & Brooks 2000). However, information on the behavior of populations that preceded these behavioral changes is rare throughout the Old World (Goren-Inbar 2011; Goren-Inbar & Speth 2004) and particularly sparse in southern Africa (Kuman 2003). Our excavations at Elandsfontein promise to generate behavioral information that defines Acheulean behavior in multiple environmental contexts within the winter rainfall zone of South Africa. Despite the primacy of this biome in debates surrounding human origins, relatively little is known about the ecological place of humans in this ecosystem through time.

Understanding the processes that have driven human behavioral evolution in the Middle Pleistocene will require an examination of the diversity of relatively synchronous traces of Acheulean hominin behavior at several localities (Potts *et al.* 1999). Here we provide some of the first indications that areas within the Elandsfontein region records discrete instances of hominin behavior in *in situ* contexts. Thus Elandsfontein may provide one of the only examples of landscape scale distribution of artefacts reflecting hominin behavior in the Middle Pleistocene of the West Coast of South Africa. The Elandsfontein record of hominin behavior is not without its complexities. Complex geomorphological processes require intense scrutiny of the geological context of sites before interpretations of behavior can be developed. However, localities such as 0209East appear to represent instances where hominins produced stone artefacts and used them to gain access to the flesh of large mammals. Future work will investigate the differential patterns of artefacts discard at these localities as well as aspects of the paleoecology of this and similar localities.

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References

- Archer, W. & Braun, D.R. 2010. Variability in bifacial technology at Elandsfontein, Western cape, South Africa: a geometric morphometric approach. *Journal of Archaeological Science* 37: 201–209.
- Avery, G. 1989. Some features distinguishing various types of occurrence at Elandsfontein, Cape Province, South Africa. *Palaentologica Africana* 19, 213–220.
- Backwell, L., d'Errico, F. & Wadley, L. 2008. Middle Stone Age bone tools from the Howiesons Poort Layers, Sibudu Cave, South Africa. *Journal of Archaeological Science* 35: 1566–1580.
- Braun, D.R., Archer, W. & Walker, S.J. 2008. Variability in Acheulian technology at Elandsfontein, South Africa. *PaleoAnthropology* 8: A7.
- Brown, K.S., Marean, C.W., Herries, A.I.R., Jacobs, Z., Tribolo, C., Braun, D., Roberts, D. L., Meyer, M.C. & Bernatchez, J. 2009. Fire as an Engineering Tool of Early Modern Humans. *Science* 325: 859–862.
- Butzer, K.W. 1973. Re-evaluation of the geology of the Elandsfontein (Hopefield) site, south-western Cape, South Africa. *South African Journal of Science* 69: 234–238.
- Butzer, K.W. 2004. Coastal eolian sands, paleosols, and Pleistocene geoarchaeology of the Southwestern Cape, South Africa. *Journal of Archaeological Science* 31: 1743–1781.
- Chazan, M., Ron, H., Matmon, A., Porat, N., Goldberg, P., Yates, R., Avery, G., Sumner, A. & Horwitz, L.K. 2008. Radiometric dating of the Earlier Stone Age sequence in Excavation I at Wonderwerk Cave, South Africa: preliminary results. *Journal of Human Evolution* 55: 1–11.
- Clark, D.J. 1970. *The Prehistory of Africa*. London, Thames and Hudson.
- Clark, D.J. 1988. The Middle Stone Age of East Africa and the Beginnings of Regional Identity. *Journal of World Prehistory* 2: 235–305.
- Conard, N. 2003. Handaxes on the Landscape and the Reconstruction of Paleolithic Settlement Patterns. In: Burdukiewicz, J.M., Fiedler, L., Heinrich, W.-D., Justus, A. & Brühl, E. (eds) *Erkenntnisjäger: Kultur und Umwelt des frühen Menschen. Festschrift für Dietrich Mania*: 123–144. Halle: Veröffentlichungen des Landesamt für Archäologie Sachsen-Anhalt.
- Cruz-Uribe, K., Klein, R.G., Avery, G., Avery, M., Halkett, D., Hart, T., Milo, R.G., Garth Sampson, C. & Volman, T.P. 2003. Excavation of Buried Late Acheulean (Mid-Quaternary) Land Surfaces at Duinefontein 2, Western Cape Province, South Africa. *Journal of Archaeological Science* 30: 559–575.
- Deacon, H. 1970. The Acheulian Occupation at Amanzi Springs Uitenhage District, Cape Province, Cape Provincial museums at the Albany Museum, Albany.
- Deacon, H. J. 1998. Elandsfontein and Klasies River Revisited. In: Ashton, N., Healy, F. & Pettitt, P.B. (eds) *Stone Age Archaeology: Essays in Honour of John Wymer*: 23–28. Oxford: Oxbow Books.
- Dominguez-Rodrigo, M., Alcalá, L. & Luque, L. (eds) 2009. *Peninj: a research project on human origins (1995–2005)*. Cambridge, Massachusetts: American School of Prehistoric Research, Harvard University.
- Drennan, M.R. 1953. The Saldanha skull and its associations. *Nature* 172: 791–793.
- Ewer, R.F. & Singer, R. 1956. Fossil carnivora from Hopefield. *Annals of the South African Museum* 42: 335–347.
- Felix-Henningsen, P., Kandel, A.W. & Conard, N.J. 2003. The significance of calcretes and paleosols on ancient dunes of the Western Cape, South Africa, as stratigraphic markers and paleoenvironmental indicators. In: Füleký, G. (ed.) *Papers of the 1st International Conference on Soils and Archaeology, Százhalombatta, Hungary, 30 May–3 June 2001*. British Archaeological Reports International Series 1163: 45–52. Oxford: Archaeopress.
- Fuchs, M., Kandel, A.W., Conard, N.J., Walker, S.J. & Felix-Henningsen, P. 2008. Geoarchaeological and chronostratigraphical investigations of open-air sites in the Geelbek Dunes, South Africa. *Geoarchaeology* 23: 425–449.
- Goren-Inbar, N. 2011. Culture and cognition in the Acheulian industry: a case study from Gesher Benot Ya aqov. *Philosophical Transactions of the Royal Society B: Biological Sciences* 366: 1038.
- Goren-Inbar, N. & Speth, J.D. (eds) 2004. *Human Paleocology in the Levantine Corridor*. Oxford: Oxbow Books.
- Hardaker, T. 2005. The Namibia Paleolithic Field Research project (Nampal) 2002. *The South African Archaeological Bulletin* 60: 20–23.
- Hendey, Q.B. 1982. *Langebaanweg: A Record of Past Life*. Cape Town: South African Museum.
- Henshilwood, C.S. & Marean, C.W. 2003. The origin of modern human behavior - Critique of the models and their test implications. *Current Anthropology* 44: 627–651.
- Herries, A.I., Brink, J.S., Bousman, B., Eisenmann, V., Gowlett, J.A.J., Grun, R., Hancox, J., Moggi-Cecchi, J. & Rossouw, L. 2009. A palaeomagnetic age of about 990,000 years for the Cornelia-Uitsoek fossil vertebrate, hominin and Acheulian site, South Africa. *American Journal of Physical Anthropology* 138: s148–s149.
- Hill, K., Barton, C.M. & Hurtado, A.M. 2009. The emergence of human uniqueness: Characters underlying behavioral modernity. *Evolutionary Anthropology* 18: 187–200.
- Hooijer, D.A. & Singer, R. 1960. Fossil rhinoceroses from Hopefield, South Africa. *Zoologische Mededelingen* 37: 113–128.
- Hooijer, D.A. & Singer, R. 1961. The fossil hippopotamus from Hopefield, South Africa. *Zoologische Mededelingen* 37: 157–165.
- Inskeep, R. & Hendey, Q. 1966. An interesting association of bones from the Elandsfontein fossil site. In: Cuscoy, L.D. (ed.) *Actes du Ve Congrès Panafricain de Préhistoire et de l'Étude du Quaternaire*: 109–124.
- Kaiser, T.M. & Franz-Odenaal, T.A. 2004. A mixed-feeding Equus species from the Middle Pleistocene of South Africa. *Quaternary Research* 62: 316–323.

- Kandel, A.W., Felix-Henningsen, P. & Conard, N. 2003. *An overview of the spatial archaeology of the Geelbek Dunes, Western Cape, South Africa*. British Archaeological Reports International Series 1163: 37–44.
- Kandel, A.W., Walker, S.J. & Conard, N.J. 2006. Near-coastal settlement dynamics at the Anyskop blowout, an archaeological locality at Langebaanweg, South Africa. *African Natural History* 2: 186–187.
- Keen, E.N. & Singer, R. 1956. Further fossil suidae from Hopefield. *Annals of the South African Museum* 42: 350–360.
- Keller, C. 1973. Montagu Cave in Prehistory: a descriptive analysis. *Anthropological Records* 28: 1–98.
- Klein, R.G. 1978. The fauna and overall interpretation of the 'Cutting 10' Acheulean site at Elandsfontein (Hopefield), southwestern Cape Province, South Africa. *Quaternary Research* 10: 69–83.
- Klein, R.G. 1983. Paleoenvironmental implications of Quaternary large mammals in the Fynbos biome. *South African National Progress Reports* 75: 116–138.
- Klein, R.G. 1988. Archaeological significance of animal bones from Acheulean sites in southern Africa. *African Archaeological Review* 6: 3–25.
- Klein, R.G. 2000a. Archeology and the evolution of human behavior. *Evolutionary Anthropology* 9: 17–36.
- Klein, R.G. 2000b. The earlier stone age of southern Africa. *South African Archaeological Bulletin* 55: 107–122.
- Klein, R.G., Avery, G., Cruz-Uribe, K., Halkett, D., Hart, T., Milo, R. & Volman, T.P. 1999. Duinefontein 2: An Acheulean Site in the Western Cape Province of South Africa. *Journal of Human Evolution* 37: 153–190.
- Klein, R.G., Avery, G., Cruz-Uribe, K. & Steele, T.E. 2007. The mammalian fauna associated with an archaic hominin skullcap and later Acheulean artifacts at Elandsfontein, Western Cape Province, South Africa. *Journal of Human Evolution* 52: 164–186.
- Klein, R.G. & Cruz-Uribe, K. 1991. The bovids from Elandsfontein, South Africa, and their implications for the age, palaeoenvironment, and origins of the site. *African Archaeological Review* 9: 21–79.
- Kleindienst, M.R. 1973. Excavations at Site JK2, Olduvai Gorge, Tanzania, 1961-1962: the geological setting. *Quaternaria* 17: 145–208.
- Kuman, K. 1994. The Archaeology of Sterkfontein - Preliminary Findings on Site Formation and Cultural-Change. *South African Journal of Science* 90: 215–219.
- Kuman, K. 2003. Site formation in the early South African Stone Age sites and its influence on the archaeological record. *South African Journal of Science* 99: 251–254.
- Luyt, J., Lee-Thorp, J. & Avery, G. 2000. New light on Middle Pleistocene westcoast environments from Elandsfontein, Western Cape, South Africa. *South African Journal of Science* 96: 399–403.
- Mabbutt, J. A. 1956. The physiography and surface geology of the Hopefield fossil site. *Transactions of Royal Society of South Africa* 35: 21–58.
- Malan, B. 1962. The stone industry of the site at Elandsfontein, Hopefield, South Africa. *Actes du IV^e Congrès Panafricain de Préhistoire et de l'étude du Quaternaire* 225–232.
- Marean, C.W. & Spencer, L.M. 1991. Impact of carnivore ravaging on zooarchaeological measures of element abundance. *American Antiquity* 56: 645–658.
- Marean, C.W., Spencer, L.M., Blumenshine, R.J. & Capaldo, S.D. 1994. Captive hyaena bone choice and destruction, the Schlepp Effect and Olduvai archaeofaunas. *Journal of Archaeological Science* 19: 101–121.
- Mason, R. 1961. The Acheulian Culture in South Africa. *The South African Archaeological Bulletin* 16: 107–110.
- McBrearty, S. & Brooks, A.S. 2000. The revolution that wasn't: a new interpretation of the origin of modern human behavior. *Journal of Human Evolution* 39: 453–563.
- McBrearty, S. & Tryon, C. 2006. From Acheulean to Middle Stone Age in the Kapthurin Formation, Kenya. In: Hovers, E. & Kuhn, S.L. (eds) *Transitions Before the Transition: Evolution and Stability in the Middle Paleolithic and Middle Stone Age*: 257–277. New York: Springer.
- McNabb, J., Binyon, F., Hazelwood, L., Machin, A., Mithen, S., Petraglia, M.D., Rolland, N., White, M. & Wynn, T. 2004. The large cutting tools from the South African Acheulean and the question of social traditions. *Current Anthropology* 45: 653–677.
- McNabb, J. & Sinclair, A. 2009. *The Cave of Hearths: Makapan middle pleistocene research project: field research by Anthony Sinclair and Patrick Quinney, 1996-2001*. Southampton: British Archaeological Reports International Series, S1940
- Mithen, S. 1996. *The Prehistory of the Mind: The cognitive origins of art and science*. London: Thames & Hudson Ltd.
- Nash, D.T. & Petraglia, M.D. (eds) 1987. *Natural Formation Processes and the Archaeological Record*. Oxford: British Archaeological Reports 352.
- Needham, H.D. 1962. Aspects of Quaternary geology of the Sandveld with particular reference to the Hopefield fossil site. Unpublished MSc dissertation. Cape Town: University of Cape Town.
- Porat, N., Chazan, M., Grün, R., Aubert, M., Eisenmann, V. & Horwitz, L.K. 2010. New radiometric ages for the Fauresmith industry from Kathu Pan, southern Africa: Implications for the Earlier to Middle Stone Age transition. *Journal of Archaeological Science* 37: 269–283.
- Potts, R., Behrensmeier, A.K. & Ditchfield, P. 1999. Paleolandscape variation and Early Pleistocene hominid activities: Members 1 and 7, Olorgesailie Formation, Kenya. *Journal of Human Evolution* 37: 747–788.
- Rabinovich, R., Gaudzinski-Windheuser, S. & Goren-Inbar, N. 2008. Systematic butchering of fallow deer (*Dama*) at the early middle Pleistocene Acheulian site

- of Gesher Benot Ya 'aqov (Israel). *Journal of Human Evolution* 54: 134–149.
- Raynal, J.P., Sbihi Alaoui, F.Z., Geraads, D., Magoga, L. & Mohi, A. 2001. The earliest occupation of North-Africa: the Moroccan perspective. *Quaternary International* 75: 65–75.
- Rick, T.C. 2002. Eolian processes, ground cover, and the archaeology of coastal dunes: A taphonomic case study from San Miguel Island, California, USA. *Geoarchaeology* 17: 811–833.
- Roberts, D. 1996. Geology of the Elandsfontyn fossil site. In: Almond, J. E. (ed.) *Excursion Guide: Fossil Sites in the Southwestern Cape*. Stellenbosch: Palaeontological Society of South Africa.
- Roberts, D.L., Bateman, M.D., Murray-Wallace, C.V., Carr, A.S. & Holmes, P.J. 2008. Last Interglacial fossil elephant trackways dated by OSL/AAR in coastal aeolianites, Still Bay, South Africa. *Palaeogeography, Palaeoclimatology, Palaeoecology* 257: 261–279.
- Roberts, D.L., Bateman, M.D., Murray-Wallace, C.V., Carr, A.S. & Holmes, P.J. 2009. West coast dune plumes: Climate driven contrasts in dunefield morphogenesis along the western and southern South African coasts. *Palaeogeography, Palaeoclimatology, Palaeoecology* 271: 24–38.
- Sahnouni, M., Van Der Made, J. & Everett, M. 2009. Early North Africa: Chronology, ecology, and hominin behavior: Insights from Ain Hanech and El-Kherba, northeastern Algeria. *Quaternary International* 223: 436–438.
- Schick, K.D. 1986. *Stone age sites in the making: experiments in the formation and transformation of archaeological occurrences*. Oxford: British Archaeological Reports 319.
- Schick, K.D. 1987. Modeling the formation of early stone age artifact concentrations. *Journal of Human Evolution* 16: 789–807.
- Schick, K.D. 1991. *On making behavioral inferences from early archaeological sites. Cultural Beginnings: Approaches to Understanding Early Hominid Lifeways in the African Savanna*. Bonn: R. Habelt.
- Shackley, M. 1980. An Acheulean industry with *Elephas recki* fauna from Namib IV, South West Africa (Namibia). *Nature* 284: 340–341.
- Shea, J.J. 2007. Behavioral differences between middle and upper paleolithic *Homo sapiens* in the east Mediterranean Levant - The roles of intraspecific competition and dispersal from Africa. *Journal of Anthropological Research* 63: 449–488.
- Singer, R. & Crawford, J.R. 1958. *The significance of the archaeological discoveries at Hopefield, South Africa*. *Journal of the Anthropological Institute of Great Britain and Ireland* 88: 11–19.
- Singer, R. & Keen, E.N. 1955. Fossil suiformes from Hopefield. *Annals of the South African Museum* 42: 169–179.
- Singer, R. & Wymer, J. 1968. Archaeological investigations at the Saldanha skull site in South Africa. *The South African Archaeological Bulletin* 23: 63–74.
- Stynder, D.D. 2009. The diets of ungulates from the hominid fossil-bearing site of Elandsfontein, Western Cape, South Africa. *Quaternary Research* 71: 62–70.
- Van Riet Lowe, C. 1927. Fresh light on the prehistoric archaeology of South Africa. *Bantu Studies* 3: 385–393.
- Van Riet Lowe, C. & Van der Elst, W. 1949. Two New African Chelles-Acheul or Stellenbosch Stage I Sites. *The South African Archaeological Bulletin* 4: 111–115.
- Volman, T. P. 1984. Early prehistory of southern Africa. In: Klein, R.G. (ed.) *Southern African prehistory and paleoenvironments*. Rotterdam: Balkema.