Comparative Studies in Landscape Archaeology

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B.4 .... Kandel 2004
B.5 .... Kandel & Conard 2005
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B.7 .... Conard & Kandel in press
B.8 .... Dietl, Kandel & Conard 2005
B.9 .... Dodonov, Kandel, Simakova, Masri & Conard in press

SUMMARY

This cumulative doctoral thesis in landscape archaeology incorporates results from ten years of research and focuses on prehistoric patterns of settlement in South Africa, Syria and southern Germany. By studying the development of the natural environment and its effect on human populations, we can observe the dynamics of change over time and space. This approach helps to explain the nature of human adaptation and settlement within an environmental context. These studies complement the field of archaeology by integrating a variety of natural scientific disciplines, including geology, pedology, geomorphology, geography, paleontology, zoology, botany and palynology. The research presented here illustrates the benefits gained by incorporating results from these fields.

The primary focus of this work has been in South Africa at 23 localities in the Geelbek Dunes and the Anyskop Blowout. These localities provide insight into the settlement patterns of the Earlier, Middle and Later Stone Age inhabitants of the coastal strandveld of the Western Cape. The research strategy employs the movement of the dunes to investigate large surface areas that have been exposed by deflation. The finds lie on the surfaces of three ancient dunes and three calcrete horizons whose ages allow the finds to be bracketed into distinct periods of time. The presence of more than 30,000 lithic artifacts, marine and terrestrial faunal remains, ornaments, pottery and stone hearth features attests to the intensity of the occupations. While Earlier and Middle Stone Age people left mostly ephemeral traces, the Later Stone Age inhabitants occupied specific parts of the landscape for longer periods. The localities of Geelbek document specific activities of its Stone Age inhabitants including hunting and retooling, flint knapping, cooking, material working and bead manufacturing.

The research also made use of a similar approach in the countryside north of Damascus, Syria. Hundreds of archaeological localities provide insight into the settlement patterns of the Lower, Middle, Upper and Epipaleolithic and Neolithic inhabitants of this arid environment on the east flanks of the Anti-Lebanon Mountains. The research strategy encompassed survey on a regional scale to investigate land surfaces that have been exposed by geological forces. Patterns of settlement indicate a varied strategy of landuse. Paleolithic inhabitants were highly mobile and used all of the landscape, while settlement during the Epipaleolithic focused on specific geographic landforms, such as water sources and cliff lines with good vantage points. During the Neolithic, settlement moved from the highlands into the desert lowlands where lakes were present. Detailed excavations at two stratified sites provided chronostratigraphic control for finds from the Epipaleolithic and Neolithic periods.

Research in Baden-Württemburg and Bavaria, Germany provided a basis for examining settlement patterns in a humid, temperate environment. Vegetation and thick layers of sediment preclude the types of surveys conducted in South Africa and Syria. Instead, research focused on further investigations near previously documented sites, as well as exposures at quarries, road cuts and river banks. While both approaches were less successful in producing new sites, the survey nonetheless resulted in the discovery of two new Middle Paleolithic sites. The first in the Upper Rhine Valley

was an ephemeral occupation in a swampy area along the Rhine River, while the other was a mammoth kill site in a ravine near the Black Forest.

These studies in landscape archaeology underscore the highly fluid and adaptive nature of Stone Age and Paleolithic hunter-gatherers and reflect their interrelationship with the environment. The data suggest that the economic activity associated with being a hunter-gatherer triggers their highly mobile and successful pattern of landuse, which in turn enables their flexible and diversified behavior.

ZUSAMMENFASSUNG

In der vorliegenden Arbeit werden die Ergebnisse von zehn Jahren Forschung auf dem Gebiet der Landschaftsarchäologie in Südafrika, Syrien und Süddeutschland zusammengefasst. Dabei liegt der Schwerpunkt auf der Untersuchung prähistorischer Besiedlungsmuster. Durch die Untersuchung der Umweltentwicklung und ihren Auswirkungen auf menschliche Populationen, kann die Dynamik der Änderung über die Zeit und den Raum betrachtet werden. Diese Vorgehensweise hilft, die Evolution menschlichen Verhaltens und die daraus resultierende Landschaftsnutzung in einem Umweltkontext zu verstehen. Diese Forschung bildet eine Ergänzung zur Archäologie durch die Hinzunahme verschiedener Naturwissenschaften, wie der Geologie, Pedologie, Geomorphologie, Geographie, Paläontologie, Zoologie, Botanik und Palynologie, und zeigt wie die Zusammenarbeit dieser Disziplinen die Möglichkeiten der Archäologie erweitert.

Das Hauptarbeitsgebiet sind 23 Lokalitäten der Geelbek-Dünen und des Anyskop Blowouts in Südafrika. Diese Lokalitäten zeigen Besiedlungsmuster menschlicher Populationen des Earlier-, Middle- und Later Stone Age des *Strandveld*-Kustengebietes in der Westkapprovinz. Es wurden Deflationstäler untersucht, die sich zwischen den Dünen befinden und die durch deren Wanderung freigelegt wurden. Die Funde lagen auf den Oberflächen von drei Altdünen und drei Calcrete-Horizonten. Die geologische Schichten ermöglichen die Ermittlung eines maximalen Alters für die Funde. Mehr als 30.000 Steinartefakte, marine und terrestrische Faunenreste, Perlen, Keramik und Feuerstellen belegen die Intensität der Besiedlung. Während Earlier- und Middle Stone Age Populationen in der Regel unstrukturierte Spuren hinterließen, zeigen Fundstellen des Later Stone Age eine gezielte Nutzung der Landschaft über längere Perioden. Die Fundstellen von Geelbek dokumentieren menschliche Aktivitäten wie Jagen, Kochen, Schmuck- und Werkzeugproduktion.

In Syrien sind ähnliche Forschungsmethoden wie in Südafrika zum Einsatz gekommen. Hier wurde die Landschaft nördlich von Damaskus untersucht. Hunderte von archäologischen Fundstellen zeugen von der Besiedlung dieses trockenen Gebietes östlich des Anti-Libanon-Gebirges während des Alt-, Mittel-, Jung-, und Epipaläolithikums, sowie des Neolithikums. Im Unterschied zu Südafrika war in Syrien ein deutlich größeres Surveygebiet notwendig, um die durch geologische Prozesse freigelegten Oberflächen zu untersuchen. Die Funde zeigen eine variierende Landschaftsnutzung. Paläolithische Populationen waren sehr mobil und nutzten die ganze Landschaft, während sich die Besiedlung im Epipaläolithikum stärker auf spezifische geographische

Zonen konzentrierte. Bevorzugt waren Plätze in der Nähe von Wasserquellen und entlang der Klifflinie mit gutem Überblick über die Landschaft. Im Neolithikum gab es eine Präferenz für tiefergelegene Gebiete, in denen sich kleine Seen befanden. Ausgrabungen an zwei gut stratifizierten Fundstellen liefern hier eine chronostratigraphische Abfolge vom Epipaläolithikum bis zum Neolithikum.

Untersuchungen in Baden-Württemberg und Bayern boten die Möglichkeit Besiedlungsmuster in einem gemäßigten Klima zu erforschen. In Vergleich zu den ariden Gebieten von Südafrika und Syrien lässt sich die Landschaft in Deutschland auf Grund von Vegetation und teils mächtigen Sedimentablagerungen nur unter erschwerten Umständen untersuchen. Stattdessen wurde bereits an bekannten Fundstellen sowie Steinbrüchen und Aufschlüssen an Strassen und Flussbänken geforscht. Obwohl die Methodik weniger Erfolg hatte, konnten dennoch zwei neue mittelpaläolithische Fundstellen entdeckt werden. Die erste liegt im oberen Rheintal und stellt eine kurzfristigen Aufenthalt in einem Sumpfgebiet des Rheintals dar, die andere ist ein Mammut-Kill-Site, in einer Schlucht im Schwarzwald.

Die landschaftsarchäologischen Untersuchungen unterstreichen die Anpassungsfähigkeit der Jäger und Sammler der Steinzeit und spiegeln das Verständnis für ihre jeweilige Umwelt wider. Die Ergebnisse verdeutlichen darüber hinaus, dass die ökonomischen Aktivitäten der Jäger und Sammler zu einer hochmobilen Lebensweise führen und damit auch eine diversifizierte Nutzung der Landschaft einhergeht.

EDUCATION

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PREFACE

This cumulative doctoral thesis provides a synopsis of several international research projects conducted between 1995 and 2005 by the Department of Early Prehistory and Quaternary Ecology at the University of Tübingen. The thesis aims to compare the results obtained from ten years of scientific investigation into the discipline of landscape archaeology. Its scope spans three continents, covering the period from the Middle Pleistocene through the Holocene, and focuses on the Stone Age of southern Africa. Additional comparisons are provided by concurrent prehistoric investigations in the Near East and Central Europe. These wide-ranging projects were conducted as part of an effort to examine the patterns of Paleolithic settlement in multiple geographic zones.

This thesis includes publications and manuscripts from research conducted in South Africa, Syria and Germany. The text is divided into four sections consisting of: 1) introduction; 2) research strategy; 3) summary of key results; and 4) conclusions. A list of all published works and manuscripts is presented in Appendix A, but only the publications submitted to fulfill the requirements of this cumulative dissertation are attached in the nine subsections of Appendix B.

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1.0 INTRODUCTION

The study of landscape archaeology incorporates a multi-disciplinary approach with the objective of reconstructing past landscapes and the environmental context of human settlement. In essence, landscape archaeology attempts to analyze the large-scale spatial and temporal patterning that resulted from the evolution of hominids and their expansion out of Africa. This analysis is accomplished by a variety of means that include documenting climatic changes with geological, geophysical and geographical techniques and analyzing the distribution of human activities using archaeological methods. This approach strives to explain how environmentally controlled processes affected the landscape and to interpret the human use of natural resources in an integrated ecological framework.

While caves and rockshelters can contribute to this research strategy, open air localities play a significant role in landscape archaeology because they offer an opportunity to study the paleoenvironment and examine prehistoric landuse on a large scale. However, this increase in spatial scale often comes at a cost, a decrease in temporal resolution. This loss of resolution applies particularly to surface finds. To compensate for this shortcoming, we can also refer to more focused types of occupation, such as those found in caves and rockshelters. These more restricted spaces offer the advantage of enhanced temporal resolution, but are clouded by frequent and intense occupations in relatively limited areas that obscure the specific nature of each occupation. To maximize our understanding of settlement, we should integrate data from many types of sites to gain a more representative picture of how humans adapt to their environment.

Since 1998 work in South Africa’s Western Cape Province has focused primarily on the analysis of the Geelbek Dunes, a mobile dune field that provides an opportunity to view the past within deflation hollows formed between transverse sand dunes. As the predominant southerly winds cause the dunes to migrate northwards, the scouring action of the wind erodes the underlying horizons of ancient dunes and calcrete. The erosional action of the wind unearths archaeological and paleontological materials that often maintain their original spatial associations despite deflation.

The field activities included survey, collection and surface excavation at localities spread across the 400 hectare dune field. During survey, the localities were ranked according to archaeological and paleontological interest. At each of the selected localities, we collected topographic and geological data to map the dune field. In all, more than 30,000 piece-plotted finds date from the Middle Stone Age to colonial times and include a wide array of lithic artifacts, faunal remains and other cultural materials, such as personal ornamentation, pottery and 49 stone hearths. These materials are not readily apparent beyond the limits of the open dune field because erosion has not removed the intervening geological materials, and visibility is poor due to the presence of thicket-like strandveld vegetation.

The research in South Africa also integrated two years of work at Anyskop, a hilltop rising along the coastal plain of the Western Cape. A blowout created by the wind has exposed a surface of calcrete that underlies a 4 m thick sand sheet. Compared to Geelbek the Anyskop Blowout represents a stable setting where the dunes are not presently mobile. The field activity included survey, collection and surface excavation within the two hectare blowout. The materials found here date from the Earlier Stone Age through colonial times and are primarily composed of lithic artifacts, with other cultural remains including two stone hearth features. Although faunal remains at Anyskop are rare and highly fragmented, they share a common signal with the fauna from the Geelbek Dunes.

Starting in 1999 the Tübingen team began a research project to examine the visibility of archaeological signatures in the arid environment of Damascus Province, Syria about 50 km north of the city of Damascus. Archaeological materials lie on surfaces exposed by a variety of geomorphological forces. The field work involved general survey and collection spread over 300 square kilometers. As a result of the survey, we initiated excavations of archaeological deposits at Baaz Rockshelter and Kaus Kozah Cave. The survey yielded lithic materials from the Lower Paleolithic through Neolithic, while the excavations thus far have produced a variety of cultural materials dating from the Epipaleolithic through Neolithic.

My investigations in southern Germany ran from 1995 to 2001 and were connected with the SFB 275 in Tübingen. The work involved identifying new, open-air, archaeological localities based on geochemical signatures and the presence of artifacts in drilled cores. The work also involved the further investigation of known archaeological localities. The research looked at regions of Baden-Württemberg and Bavaria with a focus on well-documented Middle Paleolithic sites. Investigative activities were conducted in front of well-known cave sites including Vogelherd, Hohlenstein-Stadel and Bockstein in the Lonetal and Weinberghöhle near Mauern. Important new open-air localities were discovered in Luttingen, in the Upper Rhine Valley, and in Bollschweil, southwest of Freiburg in the Black Forest region.

2.0 RESEARCH STRATEGY

This section presents an overview of the different techniques used to investigate localities at three spatial scales, macro, meso and micro, and subsequently to analyze the samples using physical and chemical methods. To make meaningful comparisons, the research was designed to use similar methodologies in each of the regions. Modifications were implemented as required, to compensate for the differing environments and to meet the specific needs of each project.

At the South African and Syrian localities the undeveloped nature of the arid landscape permitted the implementation of a consistent method of research. Visibility of geological outcrops and archaeological materials was very high, as vegetation was frequently sparse or absent. For the initial phase of survey, a Garmin GPS facilitated the plotting of each locality into a regional geographic framework on a macro-level. This macro-level served as the basis for the geographical information system (GIS) and was georeferenced to satellite and space shuttle images, topographic and geologic maps, and ortho- and aerial photographs.

In South Africa, where the area of study covered only a few hundred hectares, a total station consisting of a Leica theodolite controlled by a Husky field computer allowed for efficient surveying, collecting and piece-plotting of all data points at a meso-level scale. Consequently the total station enabled the precise measurement of archaeological finds, as well as local topography and geology. These data were in turn integrated into the GIS. However, in Syria such a use of the total station was impractical because of the complexity involved in manually surveying hundreds of square kilometers with few known benchmarks. A differential GPS would have provided an effective way of achieving the same degree of precision as in South Africa, but was not available as the project began. Furthermore, political sensitivities in Syria make the use of such a device unfeasible. As a result the strategy in Syria relied on collections of archaeological materials at points marked with the GPS. This method allowed for the speedy recovery of widespread sites and is relevant because many of these sites are being destroyed by increasing agricultural activity in the region.

On the micro-level scale, the total station served to carefully document archaeological materials and geological samples obtained from excavations in both South Africa and Syria. The end result was that all three levels of scale were joined into a unified system in which data could be easily accessed.

In Germany, the same methodology could not be readily utilized because the landscape is completely altered by human activities and the sites are deeply buried by sediment. Since the environment is temperate and humid, vegetation covers most undeveloped land surfaces. These factors limit the visibility of geological outcrops and archaeological materials, except where human or natural activities create incidental exposures of sediment, for example, at quarries, road cuts or river banks. To locate potential sites, it was first necessary to consult literature citing known geological deposits of appropriate age or previously documented archaeological localities. Once these were pinpointed, further investigation involved coring and excavating to assess the potential of the sites. The total station was again used on the micro-level to spatially document the location of the investigations in relation to known features and referenced to topographic maps.

Physical and chemical testing of the many geological and archaeological samples covered a broad spectrum of techniques employed in the natural sciences. Several types of dating were applied. Radiocarbon analyses, both conventional and AMS, were used to determine the age of archaeological and botanical specimens. Uranium series dating helped to establish the chronology of calcrete formation. Luminescence dating of ancient sand dunes (IRSL and OSL) and ESR dating of fossil teeth resulted in ages of deposition for sediments. C/N isotope testing on human remains helped to determine the proportion of marine versus terrestrial diet. Gas chromatographic analysis of potsherds for lipids helped to ascertain which fats pots contained. Standard geological analyses for grain-size distribution as well as pH, organic carbon and pedogenic oxides helped determine the physical and chemical constituents of the soils. Analysis of pollen, gastropods and other microfauna helped to constrain paleoenvironmental parameters and provide clues about their depositional environments.

3.0 KEY RESULTS

This section presents a summary of the most important results of this research. While the entire published body of work (Appendix A) encompasses a broad range of topics in landscape archaeology from varied geographic areas, I focus mainly on experiments and projects in which I generated a measurable scientific output, including conceptualization, analysis and publication. These studies mostly answer taphonomic and archaeological questions. Among the taphonomic issues, I explain how archaeological assemblages come into existence and how they are further affected by environmental processes. Among the archaeological issues, I examine the adaptations and mobility of prehistoric populations.

3.1 Evolution of the Geelbek Dunes

A paleoclimatic reconstruction of the Geelbek Dunes was synthesized based upon the geologic investigation of the alternating layers of sand and calcrete (Felix-Henningsen et al. 2003). These layers are exposed in the deflation hollows between the modern mobile dunes. The stratigraphy consists of three ancient dune horizons and at least three layers of calcrete. Each phase of ancient dune deposition and calcrete formation signifies a cycle of environmental change. During arid phases, sand dunes, similar to the modern dune field, were mobilized (Franceschini 2003, Compton & Franceschini 2005). During moister phases with rainfall ranging from about 550-800 mm/yr, stands of vegetation stabilized the calcareous sand dunes, fostering the development of weak soil profiles in the B-horizon. Leached carbonates precipitated in the C-horizon as calcrete (Netterberg 1969, de la Cruz 1978, Eitel 1994). During some of the subsequent arid phases, the overlying sand horizons were completely eroded away, exposing calcrete to atmospheric conditions. As a result, dense, laminar calcrete formed at the surface during more humid phases. Subsequent exposure to the sun cracked the laminar calcrete, allowing the action of karstification to dissect the calcrete below (Felix-Henningsen et al. 2003).

Combined with luminescence dates, the resulting landform speaks of two late humid phases at 5-6 ka (ADII) and 10-11 ka (ADI) when vegetation stabilized the landscape and weak soils formed. An early weak soil horizon (AD 0) was found between the upper two calcrete layers but could not be dated. Uranium series dates on calcrete tell of several cycles of formation around 65 ka, 125 ka and 250 ka (Kandel et al. 2003). This framework enables the indirect dating of many archaeological and paleontological finds lying on the surface of these sand and calcrete horizons. Thus, a defined period of time can be attributed to an assemblage depending on the level of the stratigraphic position of the finds.

3.2 GOME (The Geelbek Object Movement Experiment)

A major component of the work in the Geelbek Dunes involved the spatial analysis of varying classes of materials found on the different geological horizons (Kandel et al. 2003). To assess the integrity of the deflated finds, the team implemented experiments into the effects of deflation on surface finds. These experiments help to interpret the distribution of surface finds exposed by the predominant southerly winds. Thus, the purpose of GOME was to physically monitor the effect of deflation on objects of differing density, size and shape placed on three different geological substrates. The results indicated that on compact sand, little deflation occurred, and on calcrete, no deflation was recorded. However, on loose sand, most objects tended to deflate vertically and migrate downhill with gravity. Not surprisingly, lighter and flatter objects were temporarily transported by the wind, even in an uphill direction. However, once aerodynamic stability was achieved through streamlining, normal deflation continued. As a result, the groups of objects deflated downwards together as a package. This result was important because it showed that the finds in the Geelbek Dunes can be viewed as cohesive assemblages.

3.3 Measuring the Movement of Dunes

For five years, the precise location of the deflation valleys between the Geelbek Dunes was plotted with the total station (Kandel et al. 2003). By comparing the annual maps, the net movement of these transverse dunes could be reconstructed. The results show that the dunes move northerly 8-10 m/yr on average with a maximum of 25 m/yr recorded. During the austral summer, fine sand is driven by the predominant southerly wind that dries out the land surface and mobilizes sand for transport. Alternating northerly winds in winter bring most of the annual rainfall of ca. 250 mm that helps to stabilize the dunes. Thus migration to the south did not occur under the climatic regime of the period from 1998-2005. This is the first time that a total station has been used to precisely monitor the migration of mobile dunes in southern Africa.

3.4 The Effect of Bushfires on the Distribution of Tortoise Shell

At open-air sites it is often not a simple task to determine whether faunal materials accumulated as a result of natural events or human intervention (Avery et al. 2004). While lithic artifacts and other cultural materials serve as clear indicators of human activity, terrestrial faunal remains can accumulate as a result of natural death, predation by carnivores or hunting by hominids. A bushfire that burned 18,000 hectares along the West Coast of South Africa provided a perfect opportunity to test this taphonomic question. The issue of how terrestrial faunal remains accumulate at open-air sites is one of the most challenging issues that the research team addressed.

We collected data on tortoise mortality west of Elandsfontein to establish how a typical bushfire might appear in the fossil record. The intent was to compare data from the die-off with samples from open-air, archaeological localities including Elandsfontein (Klein 1978, Klein & Cruz-Uribe 1991), Duinefontein (Klein et al. 1999) and Geelbek (Conard et al. 1999). The results indicated that natural fires and archaeological accumulations have similar signals. Post-fire mortality here and at a selection of other recent fires in the Western Cape ranged up to 15 individuals/hectare, which significantly overlaps the range observed at the archaeological localities (Avery et al. 2004). Furthermore, the carapaces of tortoises killed by the fire appear unburned, while those that were already dead and exposed on the surface appeared burned after the fire. Thus, the study showed that it is difficult to determine the source of tortoise shell, burned or unburned. The geological context of the finds plays an important role in interpreting open-air sites.

3.5 Environmental Response After a Bushfire

The occasion of the bushfire also provided an excellent opportunity to observe how the environment responded in its aftermath. For the first few weeks, small sand dunes up to 2 m high began to accumulate as a result of the strong southeasterly winds of summer. However, within three months, as the summer winds dissipated and the rainy season commenced, the growth of new vegetation began to re-stabilize the land surface. After two years, the path of the fire was still visible, but after five years it could no longer be discerned. Thus, even an event of this magnitude did not initiate dune activity, despite the prior presence of active dune fields, adequate sand supply and favorable climatic conditions (Avery et al. 2004).

3.6 Carnivore Experiment on Ostrich Eggs

The presence of many finds of modified pieces of ostrich eggshell (OES) at Geelbek, some dated to more than 40,000 years old, precipitated an experiment to examine what other factors besides human impact might induce the conchoidal pattern of perforation observed at several of the archaeological localities at Geelbek (Kandel 2004). Perforated OES is common at Later Stone Age sites (e.g., Rudner 1971, Sandelowsky 1971, Humphreys, 1974, Henderson 2002). However, those described from Middle Stone Age sites are rare and include fragments from Diepkloof near Elands Bay (Poggenpoel pers. comm.) and Apollo 11 in Namibia (Vogelsang 1998). Researchers usually interpret these perforated fragments of OES as indicators that prehistoric people used OES containers for storage. Therefore the presence of containers implies that prehistoric people planned the storage of water, as well as other materials. Ethnographic records support this conclusion (e.g., Schapera 1930, Marshall 1976, Silberbauer 1981).

This experiment involved feeding whole eggs to hyenas and other carnivores to observe the resulting patterns of breakage. The ensuing analysis clearly demonstrated that carnivore damage mimics human breakage. Therefore, the previous conception that all perforated pieces of ostrich eggshell resulted from human activity was overthrown. Instead, a cautious approach was recommended so that anthropogenically modified pieces could be discerned from those eaten by carnivores. Only engraved or clearly used fragments should serve as evidence for water storage (Kandel 2004).

3.7 Production of Ostrich Eggshell Beads

Based on an analysis of many sites in the Western Cape, Smith et al. (1991) hypothesized that hunter-gatherers and herders left behind different archaeological signatures as evidence for their use of the landscape. At sites occupied by hunter-gatherers, they observed that small game predominates, pottery is absent and the lithic inventory consists of a higher percentage of formal tools made mainly on silcrete. At pastoralist sites, they noted that domesticated stock predominates, pottery is common and formal tools are infrequent, with a predominance of shattered quartz. In addition to these characteristics, they attribute variability in the sizes of OES beads to the economic differences between hunter-gatherers and herders. Small beads less than 5 mm were associated with sites occupied by hunter-gatherers, whereas large beads greater than 5 mm were associated with the pastoralists that migrated into the region about 2000 years ago. Sadr (2004) proposes an alternate model of diffusion for pastoralism, in opposition to Smith et al.'s (1991) theory of migration.

The study of over 1000 OES beads showed that hunter-gatherers were the primary producer at Geelbek. The OES beads were found in various stages of completion, and this led to the development of an analytical method to systematize the stages of bead production (Kandel & Conard 2005). In fact, the application of this method can be used on any assemblage of beads from any location. By assigning heuristic values to each stage of bead manufacture, the calculated production value ascribed the degree to which a bead reached its final state of use and ultimate discard. Our production value facilitates the interpretation and analysis of site utilization by prehistoric groups, as originally conceived by Jacobson (1987). It also allows for an estimate of the length and intensity of occupation. For example, the scatter of beads at the locality *Pottery* indicated that a small family group occupied the site for a relatively long period, perhaps a few weeks, before discarding many complete and almost complete beads. In contrast, the locality *Nora* represents a place where the production value indicates a brief occupation with a more inconsistent approach to bead manufacturing. Finally, the predominance of burned beads and their presence in all stages of production established that burning was intentional and therefore of an aesthetic nature (Kandel & Conard 2005).

3.8 Scavenging of Whale Meat and Blubber

In an average year, a whale will probably not be stranded along the sandy portions of coastline in South Africa. However, over the course of many decades, single and group strandings are well documented (Best & Ross 1989, Smith 1993). Thus, whale meat and blubber represent a readily available marine resource. Smith & Kinahan (1984) considered whale to be an invisible resource because its large size prohibited people from moving the faunal remains away from the shore. The edible meat and blubber could easily be transported to inland locations but left no discernible traces of their use. However, whale barnacles, which attach themselves only to living whales, offer a proxy to detect the use of whale at archaeological sites (Jerardino & Parkington 1993).

For example, at Geelbek the direct association of a stone feature consisting of burned calcrete blocks surrounded by a circular concentration of whale barnacles provided evidence that prehistoric people scavenged whale from a beach at least 5 km away (Kandel & Conard 2003). They brought the meat and blubber back to the Geelbek locality *Pottery* where they roasted it on a hearth constructed for that purpose, discarding the remains of the whale barnacles around the fireplace. Other associated archaeological materials dated between 2950 and 2500 BP (Kandel & Conard 2003), while the whale barnacle itself ultimately yielded an AMS date of 2900 BP (Woodborne pers. comm.). This is the oldest evidence for such behavior in southern Africa and the earliest date associated with such a hearth.

3.9 Later Stone Age Settlement at Geelbek

The settlement of the Geelbek Dunes intensified during the first millennium BC, with most archaeological remains dating to this time (Conard & Kandel in press). The period was characterized by prehistoric people who optimized their hunting and foraging strategies to exploit both marine and terrestrial resources. Marine foods included a wide variety of shellfish, crayfish, penguin, seal and whale (Kandel & Conard 2003). People utilized terrestrial resources but focused on small game, such as steenbok, tortoise, dune mole rat and hare. Occasionally they hunted or scavenged large mammals, including eland, rhino, and elephant. The inhabitants of Geelbek procured raw materials to make stone artifacts from a variety of sources located within a radius of about 20-30 km. These prehistoric groups preferred silcrete and crypto-crystalline siliceous material to manufacture formal tools for hunting, scraping and drilling. Coarser-grained igneous and metamorphic rocks provided the raw material for hammering, grinding and digging tools. The manufacture of small beads from ostrich eggshell was common, and scraping tools made from white mussel shell were frequent. In summary, the cultural remains from this period suggest that hunter-gatherers made use of a diversified strategy that was well adapted to exploit their natural environment. This view parallels the economic signals observed by Smith et al. (1991) for hunter-gatherers.

Remains from later settlements include large ostrich eggshell beads, fragmented pots and rare bones of sheep and cattle (Conard & Kandel in press). These people also left behind bone tools, sometimes decorated, used for hunting and gathering. While the cultural signature of these later occupants is different from the previous millennia, the pattern of resource exploitation seems to have remained constant, suggesting that hunter-gatherers and not herders dominated the landscape. In this scenario, these new technologies were assimilated by the indigenous population, a view which leans towards Sadr’s (2004) proposal of diffusion. Finally, colonial remains from the contact period indicate the establishment of trade in this region (Kügler 2002).

3.10 Raw Material Procurement and Landscape Use

Prehistoric people at Geelbek and Anyskop adopted a selective procurement strategy to obtain lithic raw materials (Dietl et al. 2005). This selectivity involved a temporal component and was based on the quality of the raw material, as well as the distance to its source. During the older periods of the Earlier and Middle Stone Age, the scattered nature of the lithic artifacts demonstrates an ephemeral use of the entire landscape with no clear encampments and implies a high degree of mobility. Rather the artifacts, such as points and backed segments, attest mainly to hunting activities over broad areas of the terrain. During the younger period of the Later Stone Age, the artifacts indicate a more intensive use of the landscape, with a greater variety of activities documented (Conard & Kandel in press). As before, hunting and retooling are present, as shown by numerous backed pieces. In addition, evidence abounds for domestic activities, with the presence of adzes and scrapers for wood working and hide processing. Ground stone tools indicate grinding of food and probably ochre. The wide array of artifacts shows that settlement had intensified and implies an increase in population.

Less common, fine-grained stones such as silcrete and crypto-crystalline siliceous material, obtained from 20-30 km away, were often chosen to make scrapers and backed tools, such as segments and backed points. Parallel, inclined and platform cores (Conard et al. 2004) made of these materials demonstrate a concerted effort to economize its use. While fine-grained quartz, available from 5-10 km away, dominates most of the assemblages, fewer formal tools are made from this material. Instead an analysis of the cores and flakes indicates that utilization of the more expedient bipolar technique generated adequate cutting edges despite the less systematic method. Coarse-grained materials such as granite, quartz porphyry and metamorphosed greywacke, procured from 5-10 km away, were also used as instruments of percussion and abrasion. Stones for hammering and grinding were used repeatedly, indicating a high degree of curation. Some were even bored through to create digging stick weights. When ground stone tools broke, they were often recycled, to be further reduced as cores, providing flakes with irregular cutting surfaces, or cursorily retouched.

3.11 Large-Scale Settlement Patterns in Syria

Geoarchaeological survey in Damascus Province on a transect from the eastern slopes of the Anti-Lebanon Mountains to the plains of the Syrian Desert indicates variable patterns of landuse over long periods of time (Dodonov et al. in press). This macro-scale survey incorporated geological, geomorphological, archaeological and palynological aspects with a focus on the development of landforms and changing environmental conditions. Intrinsic to the project was the designation of seven geomorphological zones defined by landforms and constrained by elevation, which influenced the pattern of prehistoric settlement.

The scattered distribution of handaxes in the open-air suggest that Lower Paleolithic settlement in the Ma'aloula region was sparse. However, the lithic artifacts from the Middle and Upper Paleolithic periods show that the Ma'aloula region was used extensively by its prehistoric inhabitants. Settlement was widespread but ephemeral, focusing on the highlands and lowlands. The Middle Paleolithic occupation, dominated by Levallois cores and debitage, is most widespread and best represented. The Upper Paleolithic represents a shorter span of time and is characterized by the production of blades.

With the advent of the Epipaleolithic, as indicated by microlithic technology, the settlement system begins to change significantly. Epipaleolithic people were widely distributed from the mountains to the lowlands, but seem to be associated with specific landforms, such as springs, drainage systems and cliff lines. Epipaleolithic people focused on elevated places that offered shelter and vantage onto the surrounding landscape. The subsequent Neolithic with ceramics is poorly represented in the highlands and suggests a general depopulation of the higher elevations. The concurrent shift to lower elevations is evident by the tell on the west shore of the dry lake bed near Jeiroud. Thus, the establishment of a more complex settlement pattern and an agriculturally based economy is demonstrated here.

The survey resulted in the discovery and subsequent excavation of two stratified cave deposits spanning the Late Pleistocene to Holocene transition from the Epipaleolithic to Neolithic periods.

These sites document human adaptation to changing conditions at the end of the last glaciation. The Epipaleolithic occupation of these sites is most remarkable, because it precedes the advent of agriculture and a more sedentary lifestyle. Epipaleolithic people collected wild grain and crushed it with pestles in mortars that were ground into the bedrock, or even into intentionally placed boulders and small, portable cobbles. They resided in round rock structures. The Neolithic deposits are marked by the presence of pottery and domesticated animals. The analysis of the deposits from Baaz Rockshelter and Kaus Kozah Cave continues.

4.0 CONCLUSIONS

The results of these studies, and others that are still underway, represent a broad cross-section through the field of landscape archaeology. In conclusion, this research strives to answer questions using a natural scientific approach to understand what archaeological and paleontological remains tell us about ancient environments. While this approach may seem simplistic, it should be evident from this collected body of research, that interesting and often unexpected results emerge from these projects.

Some of the results seek to test field observations through experimental or replication studies. The Geelbek Object Movement Experiment showed how the integrity of assemblages remained intact despite the effects of deflation. The carnivore experiment employed hyenas to replicate damage to ostrich eggs that were at first thought to represent water containers. The tortoise project tried to establish how the distribution of dead tortoises would appear in the landscape. Other forthcoming studies will examine the effects of burning on marine shell and ostrich eggshell.

Some of the results provide a cautionary tone, in that natural solutions are favored over archaeologically oriented ones. For example, the study of carnivore damage on ostrich eggshell and the aftermath of a natural fire suggest that at open-air sites, care must be taken to fully understand the taphonomic issues before one jumps to a conclusion about the nature of settlement.

Some of the results aim to resolve specific issues about occupation. Whale barnacles around a fireplace serve as a proxy for documenting the use of whale meat. The analysis of beads provides information not only about the individuals who made the beads and their stylistic choices, but also reflects the duration and intensity of their stay. In this regard, a further examination of the nature of the stone hearths is underway and may shed light on what function these features served.

Often it is the simpler questions that yield the most exciting answers. For example, an ongoing study about the mineralized fauna from Geelbek (which was presented at two international conferences) suggests that fragile, spongy bone survives weathering better in environments where cycles of heating and cooling and wetting and drying are frequent. In fact the spongy bone survives better than robust, compact bone, an observation, borne out by laboratory experiments, that opposes the present understanding about bone preservation and taphonomy.

The various studies of lithic artifacts suggest that hominins of the Earlier and Middle Stone Ages of southern Africa were highly mobile and made use of the entire landscape. This trend parallels that seen in the Lower and Middle Paleolithic of the Near East and central Europe. By the advent of the Upper Paleolithic, changes in technology and settlement can be discerned at the Eurasian sites, as prehistoric people sought out specific niches in response to changes in their environment. The hunter-gatherers of the Later Stone Age of southern Africa, also experienced changes in their technology and began using coastal resources more intensively. Thus, the highly fluid and adaptive nature of hunter-gatherers reflects their interrelationship with the environment and suggests that the economic activity associated with being a hunter-gatherer triggers their highly mobile and successful pattern of landuse, which in turn enables their flexible and diversified behavior.

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APPENDIX A

LIST OF PUBLICATIONS

Numbers in parenthesis represent percentage of own contribution:
(original idea/data collection and analysis/writing and publication)

PUBLISHED WORKS

11. Dietl, H., **Kandel**, A.W. & Conard N.J. (2005) Middle Stone Age settlement and land use at the open-air sites of Geelbek and Anyskop, South Africa. *Journal of African Archaeology* 3, 233-244. (10/30/20)

10. **Kandel**, A.W. & Conard N.J. (2005) Production sequences of ostrich eggshell beads and settlement dynamics in the Geelbek Dunes of the Western Cape, South Africa. *Journal of Archaeological Science* 32, 1711-1721. (70/80/90)

9. Avery, G., **Kandel**, A.W., Klein, R.G., Conard, N.J. & Cruz-Uribe, K. (2004) Tortoises as food and taphonomic elements in palaeo « landscapes ». In: J.-P. Brugal & J. Desse (Eds.) *Petits Animaux et Sociétés Humaines. Du Complément Alimentaire aux Ressources Utilitaires: XXIVe rencontres internationales d'archéologie et d'histoire d'Antibes*. Editions APDCA: Antibes, pp. 147-161. (30/30/30)

9. Conard, N.J., **Kandel**, A.W., Dodonov, A.E. & Masri, M. (2004.) Middle Paleolithic Settlement in the Ma'aloula region of then Damascus Province, Syria. In: N.J. Conard (Ed.) *Settlement Dynamics of the Middle Paleolithic and Middle Stone Age*, Vol. II. Kerns Verlag: Tübingen, pp. 65-87. (20/30/40)

8. **Kandel**, A.W. (2004) Modification of ostrich eggs by carnivores and its bearing on the interpretation of archaeological and paleontological finds. *Journal of Archaeological Science* 31, 377-391.

7. 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: G. Füleky (Ed.) *Papers of the 1st International Conference on Soils and Archaeology, Százhalombatta, Hungary, 30 May - 3 June 2001.* BAR International Series 1163, pp. 45-52. (20/20/20)

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4. Rink, W.J., **Kandel**, A.W. & Conard, N.J. (2002) The ESR geochronology and geology of the open-air Palaeolithic deposits in Bollschweil, Germany. *Archaeometry* 44: 635-650. (20/20/30)

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1. Conard, N.J., Prindiville, T.J. & **Kandel**, A.W. (1999) The Stone Age Archaeology and Ecology of the Geelbek Dunes, West Coast National Park, South Africa. *South African Field Archaeology* 8: 35-45. (10/30/20)

Numbers in parenthesis represent percentage of own contribution:
(original idea/data collection and analysis/writing and publication)

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10. Conard, N.J., Dietl, H., Dodonov, A.E., Drechsler, P., **Kandel**, A.W. & Masri, M. (In prep.) Results from the 2004 TDASP Survey. In: N. J. Conard (Ed.) *The 5 Year Research Report of the Tübingen-Damaskus Ausgrabungs- und Survey Projekt*. (10/10/30)

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7. Conard, N.J., **Kandel**, A.W. & Abdulrachman, A. (In prep.) The 2000 excavation at Baaz Rockshelter. In: N. J. Conard (Ed.) *The 5 Year Research Report of the Tübingen-Damaskus Ausgrabungs- und Survey Projekt*. (20/40/20)

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1. Dodonov, A.E, **Kandel**, A.W., Simakova, A.N., Masri, M. & Conard, N.J.(In press) Geoarchaeological characteristics of open-air Paleolithic sites in the Ma'aloula region, Damascus Province, Syria. Manuscript accepted for publication in *Geoarchaeology*. (20/20/50)

EDITED VOLUMES

2. Conard, N.J. & **Kandel**, A.W. (Eds.) (1997) Reports for the Second Wallertheim Workshop. 23-25 March 1997.Department of Early Prehistory, University of Tübingen: Tübingen.

1. Stellrecht, I. (1995) Project Summary: A Chronicle of Change. Culture Area Karakorum. A.W. **Kandel** (Ed.). Pak-German Research Project: Islamabad.

APPENDIX B

PUBLICATIONS SUBMITTED IN FULFILLMENT OF THE REQUIREMENTS OF THIS CUMULATIVE DISSERTATION

Appendix B.1

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: G. Füleky (Ed.) *Papers of the 1st International Conference on Soils and Archaeology, Százhalombatta, Hungary, 30 May - 3 June 2001*. BAR International Series 1163, pp. 45-52.

In: 2003. G. Füleky (Ed.) *Papers of the 1st International Conference on Archaeology and Soils.*
BAR International S1163, pp. 45-52.

THE SIGNIFICANCE OF CALCRETES AND PALEOSOLS ON ANCIENT DUNES OF THE WESTERN CAPE, SOUTH AFRICA, AS STRATIGRAPHIC MARKERS AND PALEO-ENVIRONMENTAL INDICATORS

Peter Felix-Henningsen, Andrew W. Kandel and Nicholas J. Conard

Summary

Two types of geological strata are exposed within the interdunal deflation bays of Geelbek in the Western Cape of South Africa: 1) Multiple layers of hardpan calcrete date to the Pleistocene, and 2) Several ancient dunes show the development of paleosols dating to the Late Pleistocene and Holocene. The unvegetated mobile dune fields of Geelbek are situated within a landscape of vegetated fossil dunes and open windows into the paleoclimate, landscape history and prehistoric settlement of the West Coast region. All of the former land surfaces are associated with Stone Age artifacts and appear to have been occupied under more humid conditions than today. While the exposed calcrete layers reflect complex cycles of soil formation, erosion and karstification under changing climatic regimes, the paleosols of the overlying ancient dunes reflect formation under a different set of climatic conditions and varying time spans. The unique characteristics of these soil horizons make them useful as stratigraphic markers.

Key Words

Paleoecology, paleopedology, coastal dunes, South Africa, Pleistocene, Holocene

1.0 Introduction

Paleosols associated with ancient dunes represent past cycles of alternating arid and humid climates. The paleosols indicate climatic change on both regional and global scales and are useful in reconstructing the paleoecological development of a landscape and its potential for human occupation. In the Western Cape of South Africa between Cape Town and the Olifants River vegetated paleodunes and active coastal dunes are subdivided by a sequence of paleosols that are associated with calcretes.

While ancient strata are inaccessible in densely vegetated areas, several plumes of longitudinal and transversal dunes create deflation hollows that serve as windows into the past and offer access to information about former climates and human behavior. The paleosols are associated with cultural layers of the Stone Age and indicate that several phases of humidity higher than today existed during the late Middle and Upper Quaternary. Paleopedological investigations at Geelbek, about 90 km north of Cape Town, accompanied archaeological investigations (Kandel *et al.*, 2003) and focus on the genesis, stratigraphy and paleoclimatic importance of calcretes and paleosols in ancient dunes. This paper presents the initial results of the paleopedological investigations.

One aim of the paleopedological investigation is to develop a chronology of the paleosols and calcretes and thereby shed light on the archaeological significance of artifacts which are found within and on these paleosol horizons. The origin of stone artifacts and faunal remains found embedded within a specific horizon is relatively straightforward. However, deflation by wind and other erosional processes has often projected artifacts from several different paleosols onto a single surface, resulting in superimposed scatters of artifacts from multiple periods of occupation that have nonetheless retained their basic spatial integrity. The paleopedological results presented here offer the best possibility to unravel the nature and sequence of the former landscapes in which humans lived.

2.0 Study Area and Methods

The mobile, inland dune plume at Geelbek (about 33°10' S; 18°09'E, location see Fig. 1 in Kandel et al., this volume) is situated near the Atlantic Ocean within the West Coast National Park and covers an area of about 4 km². The climate today is semiarid Mediterranean with predominant winter precipitation of about 270 mm per year. Predominant summer winds from the south-southwest (Flemming, 1977) create both transverse and barchanoid peaks up to 40 m in height and interspersed valleys which are oriented perpendicular to the main wind direction (Tinley, 1985). Multiple measurements of the borders of several deflation hollows in the Geelbek Dunes have documented dune movement of up to 25 meters per annum over the *sandveld*, with an estimated mean of 10 meters per year (Kandel *et al.* 2003). Franceschini (2003) correlates the departure of the dunes from the coast with the mid-Holocene marine transgression, a well-documented high sea level at approximately 6 ka BP (Miller, 1993). This interpretation stands in contrast to more traditional interpretations that generally correlate coastal dune formation with drops in sea level, such as during the last glacial maximum. At this time vast sand flats on the broad continental shelf along the Southern African coast laid exposed, providing parent material for the dunes (Deacon, 1983; Tinley, 1985; Lancaster, 1987).

Table 1. Geelbek. Range of texture (soil samples free of carbonate) and carbonate content of mobile dunes.

	% Medium Sand 630 – 200 µm	% Fine Sand 200 – 63 µm	% Fines < 63 µm	Carbonate mass %
Yellowish white dunes (Mobile dune a)	12 - 23	57 - 96	4 - 8	23 - 36
Dark yellow dunes (Mobile dune b)	22 - 37	61 - 77	1 - 2	8 - 13

Mobile dune a: average of 6 samples
Mobile dune b: average of 3 samples

The texture of the mobile dunes is dominated by medium and fine sand (Table 1). Mineralogically, the dunes consist mainly of quartz with a relatively high percentage of calcium carbonate (8–36 mass %.) The carbonates occur as sand-sized fragments of shells and older calcretes, the latter having been reworked by abrasion of submarine outcrops and erosion at cliffs. The content of carbonate correlates with the color of the mobile dunes. The longitudinal dunes in the eastern and central part of the dune plume of Geelbek display a yellowish-white color and higher concentrations of calcium carbonate (23–36 mass %), while the dunes at the western margin of the plume show a brownish-yellow color and a lower carbonate content (8–13 mass %). The darker dunes are colored by aeolian sand that deflated from the erosion of the adjacent, vegetated, ancient dunes, for example, after an extensive bush fire. The electrical conductivity and the amount of water-soluble salts in the mobile dunes are low (100–150 mg kg^{-1}). Among the water-soluble ions extracted from the mobile dune sand, Cl^-, SO_4^{2-}, Na^+ and Mg^{2+} show the highest concentrations, indicating a marine source for the sand, as seawater has the highest concentration of these ions.

The inland dune plume of Geelbek is situated in a 3–4 km wide belt of older coastal dunes (de la Cruz, 1978) extending along the Atlantic Coast from Cape Town in the south to the Olifants River in the north. In contrast to the mobile dune field of Geelbek, which forms a 'local desert,' the ancient dunes are densely vegetated by shrubby fynbos (fine bush) vegetation. The natural shrub vegetation is restricted to the protected area of the West Coast National Park. Outside the National Park grazing and agriculture have destroyed most of the natural vegetation. The relief of the ancient dunes undulates with an elevation difference of between 50 and 100 m separating the peaks and troughs. Coastal cliffs along Langebaan Lagoon expose a vertical sequence of ancient dunes, which are subdivided by several horizons of calcrete (Knox, 1977; Theron et al., 1992). Near the modern land surface the ancient coastal dunes are capped by a fragmented bank of calcrete that follows the hilly relief of the dunes. The calcrete is covered by a younger aeolian sand sheet and shallow dunes on which a weak Cambic Arenosol developed under recent climatic conditions.

A calcrete layer also forms the base of the mobile dune field at Geelbek and outcrops in the interdunal deflation bays. An ancient dune, in which a Cambic Arenosol is developed, underlies the basal calcrete. The ancient dune with the paleosol is exposed in profiles of karst basins which frequently dissect the calcrete bank (Fig. 1). The calcrete is covered by a sequence of two immobile ancient dunes with paleosols and the recent mobile dunes. The paleosols of the ancient dunes are the primary focus of this paleopedological study.

After detailed survey and profile investigations, representative samples were taken from each soil horizon. Particle-size distribution was determined by sieving after the dissolution of carbonates with HCl and the fine fraction (< 63 µm) was calculated by mass difference. Chemical analysis of pH, EC, C_{org} and pedogenic oxides (Fe, Mn, Si, Al) followed the procedures of Schlichting et al. (1995). Soil classification and designation of soil horizons is based on the FAO-legend (FAO-UNESCO 1989).

3.0 Results and Discussion

3.1 Calcrete

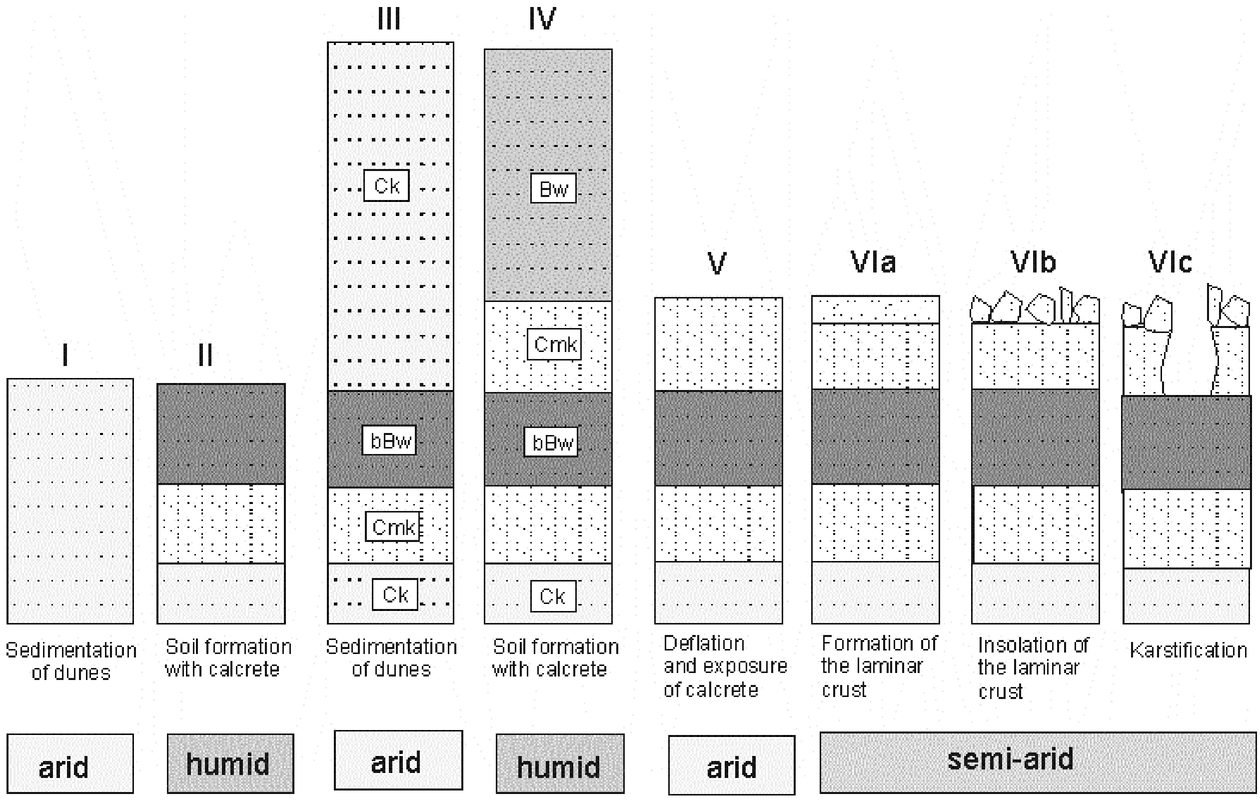

Fig. 1. Geelbek. Stages of calcrete development.

Hardpan calcrete forms the basis of the interdunal deflation bays of Geelbek. The macro- and micromorphological characteristics of the hardpan calcretes of the study area and the adjacent coastal region as the basis for a genetic interpretation were intensively studied by Netterberg (1969) and Knox (1977). The morphological characteristics and the genesis of calcretes in Namibia were also investigated in detail by Eitel (1994). The results from Geelbek show that calcrete displays a sequence of horizons with typical characteristics due to its polygenetic development. These characteristics are also revealed by calcrete that is exposed within the interdunal deflation bays (Fig. 1). Calcrete developed as a subsoil horizon of a paleosol. A semi-humid to semi-arid climate caused decalcification of the dune sand during the wet season and re-precipitation of carbonates within the deeper parts of the sediment during the dry season. Over the course of soil formation the growth of vegetation and an increased weathering of silicates led to the formation of fines that in turn impeded the leaching of bicarbonate to deeper parts of the dune. Continuous enrichment of calcium carbonate led to cementation of the upper part of the horizon (Fig. 1, stages I and II). A rapid climatic change to more arid conditions could have caused the sedimentation of younger calcareous dunes, which covered the paleosol before it was destroyed by deflation or erosion. A new cycle of calcrete formation could begin during a subsequent period with more humid conditions (Fig. 1, stages III and IV).

In the case of slowly increasing aridity and/or limited availability of aeolian sand, the paleosol surface remained exposed for a long period. The calcrete was subsequently exposed by deflation or erosion of the decalcified, and thus less stable, soil material (Fig. 1, stage V). During long periods at the surface the exposed calcrete dissolved during rainy periods and was re-precipitated as carbonate during dry periods. This alternating cycle resulted in the formation of a very hard, dense, laminar 'upper crust' (Cmk1 horizon) of yellowish-gray color at the exposed calcrete surface (cf. Eitel, 1994; Fig. 1, stage VIa), which in Geelbek is up to 10 cm thick.

Below the laminar upper crust, a hard, white, massive 'lower crust' (Cmk2 horizon) displays the coherent structure of the original calcrete. This horizon is frequently dissected by vertical cracks and root channels, partly filled with coarse crystalline secondary carbonates, that could have precipitated during the formation of the upper crust by deep infiltration of dissolved bicarbonates. In Geelbek the total thickness of the upper and lower crust, which together form the hardpan calcrete (de la Cruz 1978), varies between 40 and 80 cm. As the concentration of calcium carbonate decreases with increasing depth, the hardpan calcrete gradually changes into a soft, white carbonate enrichment horizon. The thickness of this 'powder calcrete' (de la Cruz 1978) varies from 30 cm to more than 1 m. In places hard, thick, vertically orientated rhizo-concretions composed of carbonate, some with diameters up to 5 cm and more, extend from the hard crust down into the soft enrichment horizon. These concretions indicate that during the formation of the calcretes, the soil surface was vegetated by trees or shrubs and that the calcrete originally developed within the rooted zone.

The vegetation assisted in the formation of calcrete. Due to acidification which resulted from the formation of organic acids and the respiration of roots and microorganisms, carbonates dissolved in the upper soil horizons. Leaching of dissolved bicarbonates was, however, hampered by interception and transpiration, which limited the amount of gravitational water. A specific depth of accumulation cannot, however, be estimated because shrubs and trees in a semi-arid climate develop a deep reaching root system.

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Table 2. Geelbek. Mass balances of calcium carbonate accumulation in calcretes, standardized to a total profile thickness of 1 m and thickness of the related decalcified zone which must have existed in the overlying dune sand.

Profile	Horizon	Depth (cm)	Bulk density (g cm^{-3})	Carbonate content (mass %)	Carbonate mass (kg m^{-3})	Carbonate accumulation, based on carbonate content of dune a (kg m^{-3})	Carbonate accumulation, based on carbonate content of dune b (kg m^{-3})	Thickness (m) of the decalcified zone, based on carbonate content of dune a	Thickness (m) of the decalcified zone, based on carbonate content of dune b
GC 1	Cmk1	0 - 5	2.21	63.1	1,275	795	1,115	1.66	6.97
	Cmk2	- 20	2.47	70.3					
	Ck	-100	2.11	56.1					
GC 3	Cmk1	0 - 8	2.46	71.6	1,020	540	860	1.13	5.38
	Cmk2	- 50	2.09	49.1					
	Ck	-100	1.93	46.3					
GP 7	Cmk1	0 - 10	2.34	63.3	1,236	756	1,076	1.58	6.73
	Cmk2	- 40	2.30	46.4					
	Ck	- 100	2.39	53.5					
Mobile dune a)	C	0 - 100	1.60	30.0	480				
Mobile dune b)	C	0 - 100	1.60	10.0	160				

Location of the profiles:
GC1: Road bank at the road from Geelbek to the south coast of Langebaan Lagoon (33° 13' 22.6" S; 18° 6' 46.9" E)
GC3: Geelbek, deflation bay "Rhino" (33° 10' 43.3" S, 18° 09' 08.5" E)
GP 7: Geelbek, interdunal deflation bay "Stone Ring" (33° 10' 46.6" S, 18° 09' 30.3" E)
Mobile dune a: average of 6 samples from the yellowish white dunes, 23 – 36 mass% $CaCO_3$
Mobile dune b: average of 3 samples from the dark yellow dunes, 8 – 12 mass% $CaCO_3$
Calcrete horizons: Cmk1: laminar upper crust; Cmk2: coherent massive lower crust; Ck: soft carbonate enrichment horizons

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Based on the analytical data from three selected calcrete profiles, mass balances of the calcium carbonate accumulation were calculated, taking into account the carbonate content and bulk densities of the calcareous mobile dunes and the calcrete horizons (Table 2). Standardized to the uppermost meter of calcrete, the bulk masses of accumulated calcium carbonate are similar at differing locations in the Geelbek area. According to the variation of the primary $CaCO_3$ content of the mobile dunes between 8 and 36 mass %, the thickness of the decalcified zone may have varied between one and several meters.

Stone Age artifacts and animal bones embedded in calcrete were either projected from the former land surface onto the calcrete surface during the course of erosion of the former paleosol, deposited directly on the bare calcrete surface during the beginning of karstification or were present in the sand before soil development began at the depth of precipitation of calcium carbonate.

Further physical weathering by insolation frequently caused fragmentation of the upper part of the calcrete (Fig. 1, stage VI b) which assisted infiltration of rainwater through the resultant cracks. Continuous dissolution of the bare calcrete along the cracks caused the formation of extensive karst basins that dissected the calcrete and in some places exposed the underlying ancient dune with a bBw horizon of a fossil Cambic Arenosol (Fig. 1, stage VI c).

Some of the presently exposed calcretes contain coarse fragments of an older calcrete, an indication of the complex history of the landscape. This phenomenon can be explained by repeating cycles of sand deposition, soil and calcrete formation, soil erosion, karstification, redistribution of calcrete fragments and renewed dune deposition.

The occurrence of calcrete at different elevations, as well as the variance in composition, color and intensity of karstification, indicates that calcretes of differing age form the foundation of the deflation bays. The absolute dating of samples of the hardpan calcrete confirms these different ages. The vegetated, ancient, coastal dunes outside the mobile dune field of Geelbek consist of several ancient dune complexes of possibly Middle Pleistocene age, which are subdivided by hardpan calcrete horizons. These became dissected by broad valleys following erosion by runoff water. Thus, calcretes of dissimilar age were exposed at different elevations along the slopes of the valleys. Finally the younger Late Pleistocene and Holocene ancient dunes (AD I and AD II, see below) and the modern dune field were deposited on top of the exposed calcretes of the older dunes, which again became exposed in the young deflation valleys.

Netterberg (1978) and Eitel (1994) discuss the possibilities and difficulties of absolute dating of calcretes. Difficulties in obtaining dates arise from the fact that the unweathered dune sand of Geelbek contains sand-sized fragments of older calcrete. Furthermore, the dissolution and re-precipitation of carbonates that affected the hardpan calcrete after its exposure caused formation of secondary carbonates of indeterminate age. Absolute dating therefore is only successful if micromorphological investigations can prove that the samples are free of older calcrete fragments and secondary carbonates.

The dates for each sample gained by the application of two independent dating methods indicate separate phases of calcrete formation at ca. 250, 150 and 65 ka BP. These preliminary data from Stephan Woodborne of the CSIR in Pretoria result from both IRSL dating of the sand matrix of the calcrete and U-series dating of the calcium carbonate. Until more precise chronological control is established for the Geelbek Dunes, the assumption that the hardpan calcrete is of Pleistocene age seems justified.

Netterberg (1969) and de la Cruz (1978) discuss the paleoclimatic significance of calcrete. The formation of calcrete is very sensitive to climatic conditions such as the amount of rainfall, the rate of evapo-transpiration and wind speed. Netterberg (1969) suggests that calcrete occurring in South Africa in areas receiving less than 500 mm of annual rainfall, such as Geelbek, can be considered fossil. According to the distribution of calcareous soils in South Africa, the occurrence of hardpan calcrete is restricted to warm, semiarid areas that receive less than 550 mm of annual rainfall.

3.2 Pleistocene and Holocene Ancient Dunes and Paleosols

The karstified basal calcrete is overlain by two ancient dunes (AD) of Upper Pleistocene (AD I) and Holocene (AD II) age in which paleosols have developed in the absence of calcrete formation. Profiles in karst depressions of the basal calcrete show that in some places the calcrete covers an older ancient dune of Middle Pleistocene age (AD 0, Figs. 1 and 2). The ancient dunes illustrate characteristics of paleosol formation that allow their use as stratigraphic markers. Furthermore they can be interpreted according to the paleoclimatic conditions during the period of soil formation.

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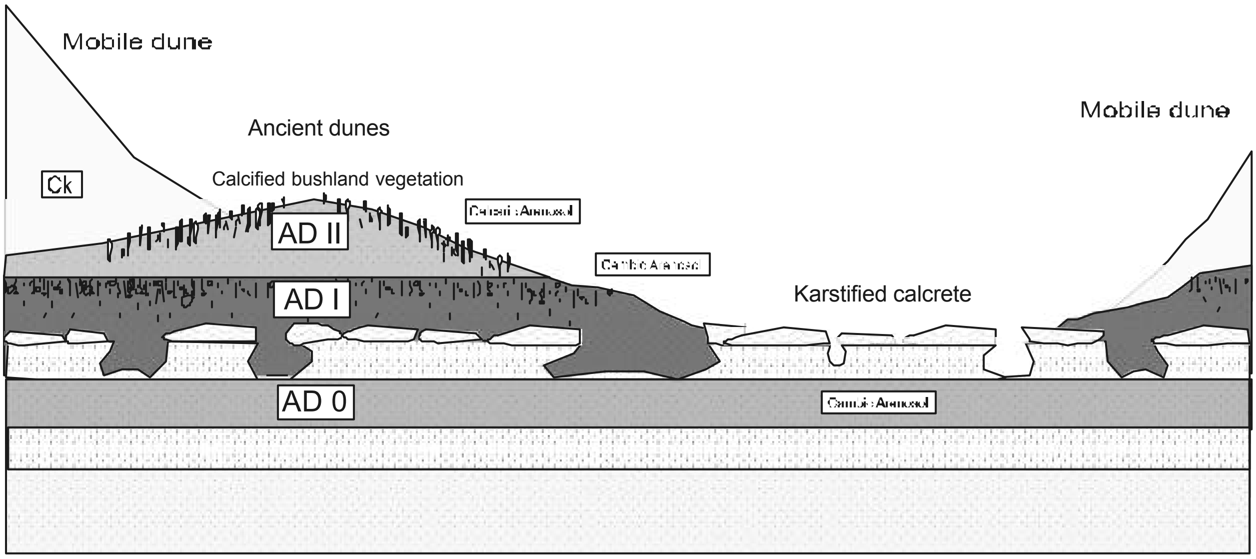

Fig. 2. Geelbek. Cross section of a deflation bay in the dune field. The basal karstified calcrete is covered by two different ancient dunes with paleosols and mobile longitudinal dunes.
AD 0: Pleistocene ancient dune older than the basal calcrete. In some places a brown Bwk horizon of a fossil Cambic Arenosol is developed directly underneath the calcrete, which shows an irregular accumulation of secondary carbonate due to the infiltration of bicarbonate from the calcrete above.
AD I: Pleistocene ancient dune above the basal calcrete, with an up to 2 m thick decalcified, brown (7.5YR 6/4) bBw horizon of a fossil Cambic Arenosol
AD II: Holocene ancient dune with a weakly weathered, brownish yellow (10YR 7/4) bBwk horizon of a fossil Cambi-calcaric Arenosol, which is strongly enriched by secondary carbonates, filling insect burrows and root channels. Former roots of bushes, which pass through the paleosol, and fragments of stems and branches, which cover the soil surface, are partly or completely calcified.
Ck: Mobile dunes: Light yellow, calcareous fine sand

3.2.1 Paleosol in the ancient dune, AD 0

The paleosol AD 0 in the ancient dune below the basal calcrete consists of a ca 1 m thick, brown (10YR 6/3) bBw horizon that was infiltrated by secondary carbonates from the overlying hardpan calcrete. The decreasing concentration of $CaCO_3$ with depth from the upper boundary of the paleosol and the formation of pedogenic Fe and Mn-oxides and amorphous silica prove that the bBw horizon was originally decalcified by the leaching of carbonates, which caused the weathering of silicates (Fig. 3). Decalcification of the topsoil and subsoil horizons led to the formation of an enrichment horizon of calcium carbonate below the bBw horizon (Fig. 3) which gradually developed into a lower hardpan calcrete (Figs. 1 and 2). The paleosol represents a long period of semi-arid conditions in which the depth of decalcification was restricted by the low amount of rainfall. Nonetheless, the length of the period of soil formation sufficed to cause intensive weathering of silicates in the decalcified topsoil and subsoil horizons.

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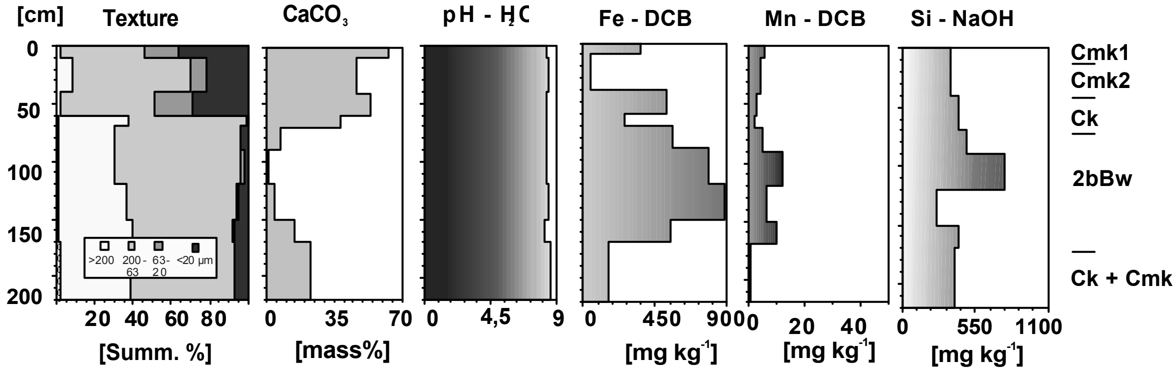

Fig. 3. Geelbek. Physical and chemical characteristics of the fossil Cambic Arenosol developed in AD 0. (Stratigraphic position shown in Figs. 1 and 2.)

3.2.2 Paleosol in the ancient dune, AD I

The paleosol in AD I is a strongly weathered Cambic Arenosol up to 2 meters thick. The soil horizons are free of carbonates, and weathering of silicates has brought about the dark brown (7.5YR 5/4) color. The analytical data presented in Fig. 4 show that the amount of fines (< 63 µm) is very low and ranges from 3–5 mass % in all horizons. Although all paleosol horizons are free of calcium carbonate, the soil horizons display pH values around 8, which result from a low concentration of soluble salts (< 100–200 mg kg^{-1}, mainly Na salts) in combination with a low buffer capacity. Sea spray and deposition by rain are assumed to be the source of the salts. The pedogenic iron and manganese oxides and amorphous silica (Fig. 4) which were formed by weathering of silicates in an acid environment indicate that the soil formation occurred under rather humid climatic conditions, causing decalcification and acidification of the ancient dune. The depth of decalcification exceeds 2 m in the investigated profiles down to the base of the dune. Therefore, the formation of an enrichment horizon of calcium carbonate and the formation of a hardpan calcrete below the bBw horizon was not possible. According to Netterberg (1969) hardpan calcretes occur in areas that receive less than 550 mm annual precipitation and calcification is generally absent in areas with an annual rainfall of more than 800 mm (de la Cruz, 1978). Therefore the decalcified, comparatively strongly weathered paleosol developed on AD I represents a long period of semi-humid to humid climate.

Unfortunately an IRSL date of the ancient dune, which could delimit the period of soil formation, is not available. But in some localities the paleosol surface of AD I is characterized by an associated, brown-stained, sub-fossil, faunal assemblage and a Later Stone Age lithic assemblage (Kandel et al. this volume).

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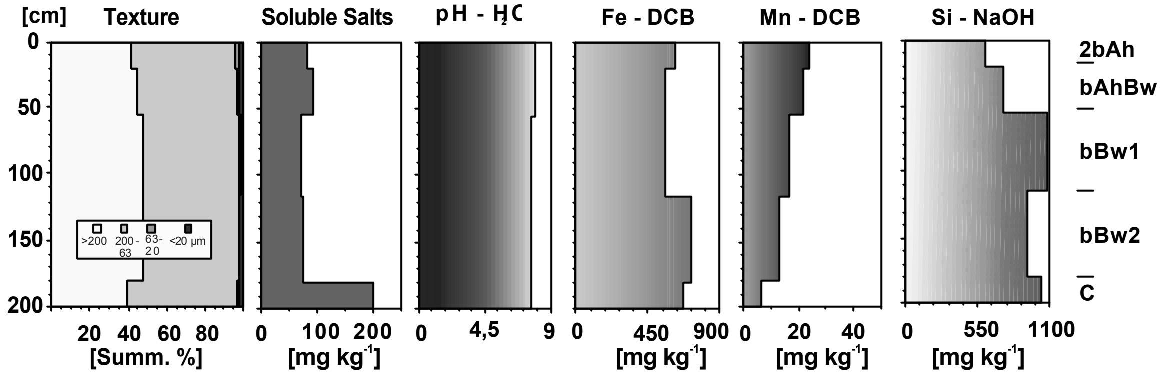

Fig. 4. Geelbek. Physical and chemical characteristics of the fossil Cambic Arenosol developed in AD I. (Stratigraphic position shown in Figs. 1 and 2.)

3.2.3 Paleosol in the ancient dune, AD II

The paleosol in ADI is overlain by the younger ancient dune (AD II), on which a fossil Calcaric Arenosol has formed. Both the bAh horizon and the underlying, weakly weathered bBw-Ck horizon of light orange (10YR 7/4) color contain carbonates, mainly in the form of calcified roots and small nodules. The carbonate content (about 2 mass %, Fig. 5) of the soil horizons is distinctively lower than the carbonate content of the recent mobile dunes (8–36 mass %). Based on the weak weathering of silicates, the initial stage of a bBw horizon indicates a rather short period in which the subsoil must have been free of carbonates. The concentration of carbonates in insect burrows and pores indicates that the major part of the carbonates accumulated by re-calcification. Furthermore, a diagenetic transformation of the former dune vegetation into calcified wood (roots and lower part of stems) is a unique characteristic of AD II. The presence of calcified wood shows that the leaching of bicarbonate from the recent, mobile dunes must have caused both the fossilization of the wood and the secondary enrichment of the paleosol horizons with calcium carbonate. Therefore, the paleosol of AD II indicates a short period of humidity higher than today but distinctively lower than the humid period during which the Cambic Arenosol developed on AD I.

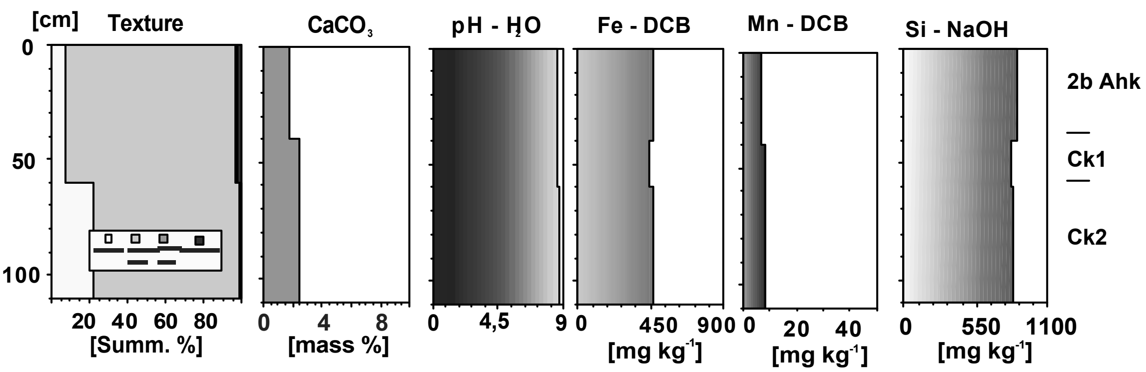

Fig. 5. Geelbek. Physical and chemical characteristics of the fossil Cambi-calcaric Arenosol developed in AD II. (Stratigraphic position shown in Figs. 1 and 2.)

Prehistoric ceramics have been documented on AD II, thus providing a maximum age of 1900 BP, the time when ceramics first occur in the southwestern Cape (Deacon and Deacon 1999.) Preliminary IRSL dates of 5 to 6 ka appear to be reliable for the deposition of the sand in AD II. This shows, that the recent mobile dunes, which cover AD II to a thickness of 10–30 meters approached the study area after 1900 BP.

4.0 Conclusions

The preliminary results of paleopedologic analyses used in conjunction with archaeological data have been successfully applied to reconstruct patterns of ancient geological processes, paleoenvironments and the history of archaeological settlement in the Geelbek region. The calcretes and Arenosols that developed on ancient dunes at Geelbek have unique characteristics and can be used as both stratigraphic marker horizons and paleoclimatic indicators. Stratigraphically the paleosols indicate phases in which deposition of aeolian sand and migration of the dunes was not possible because a cover of dense vegetation anchored the dunes. The shift to more arid climatic conditions caused the beginning of another phase of dune sedimentation and migration.

The degree to which the availability of aeolian sand at the coast, affected marine streams, transgression and regression phases, influenced the inland migration of the dunes apart from the paleoclimate is not yet clear. But since the dunes remain mobile under modern climatic conditions, the paleosols indicate phases of higher annual precipitation than today. Apart from the intensity of decalcification and weathering of silicates due to the degree of humidity, the period of soil formation also must be taken into account. A short period with high humidity may yield the same soil characteristics as a long period of arid climatic conditions. A more detailed interpretation will only be possible in future investigations when the further application of dating methods for soil components and sediments allows a limitation of the absolute ages of the paleosols.

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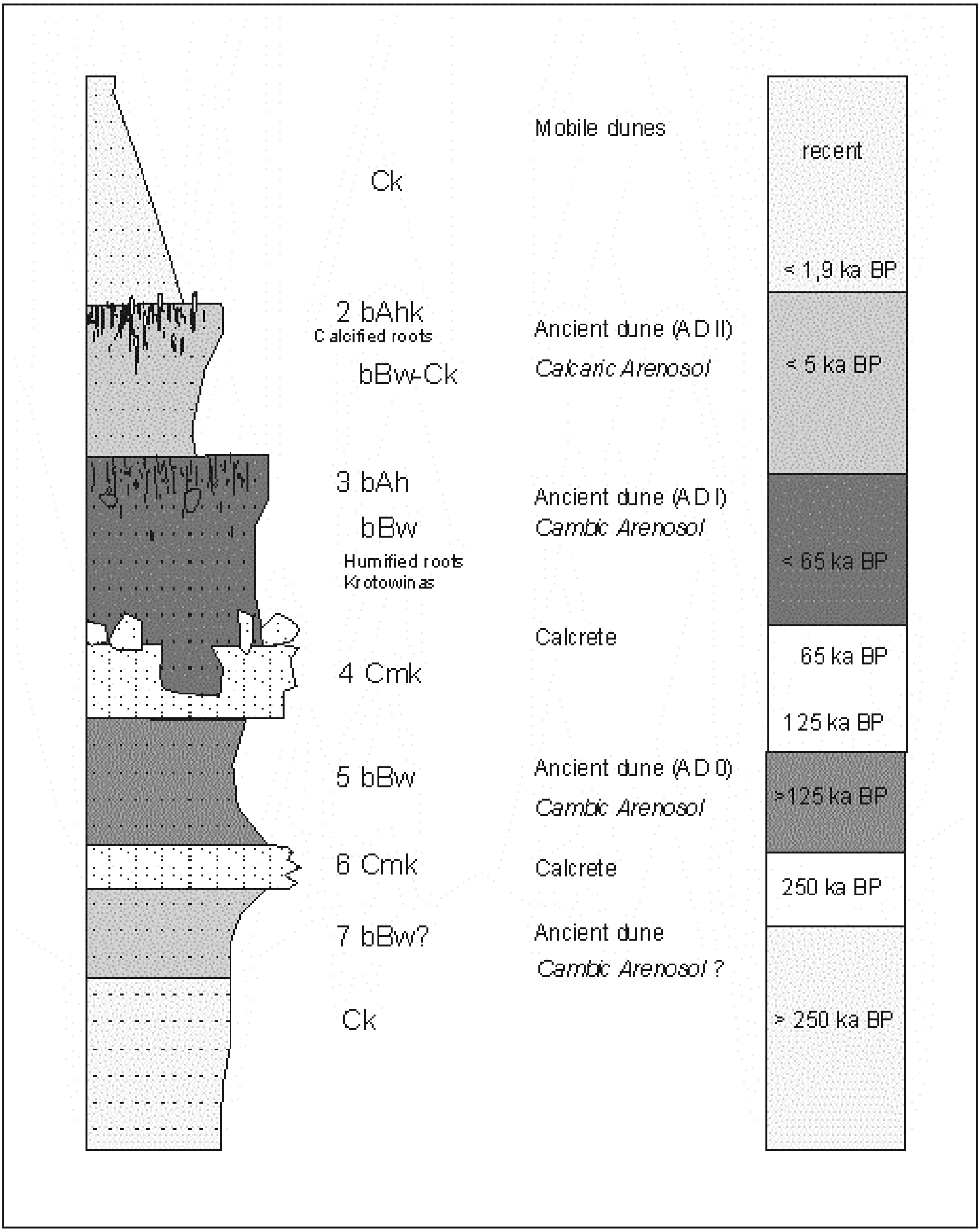

Fig. 6 Geelbek. Idealized stratigraphic sequence of ancient dunes, calcretes and paleosols with an estimation of the absolute ages of the calcretes and ancient dunes based on preliminary dating results.

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Appendix B.2

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AN OVERVIEW OF THE SPATIAL ARCHAEOLOGY OF THE GEELBEK DUNES, WESTERN CAPE, SOUTH AFRICA

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INTRODUCTION

The Geelbek Dunes of the Western Cape Province (South Africa) cover an area of approximately 4 km^2 situated 90 km north of Cape Town in the West Coast National Park (Fig. 1). The deflation hollows located between the wind-blown, mobile sand dunes have long been recognized as a source of mammalian fossils and Stone Age artifacts. In 1998 a team from the Department of Early Prehistory and Quaternary Ecology of the University of Tübingen began fieldwork to systematically study archaeological occurrences in this active dune system (Conard et al. 1999). Over the course of the following field seasons from 1998 through 2001, the team spent over seven months in the field surveying the dunes, collecting samples of the faunal and artifactual remains, and excavating large areas. The team studied the geology and geomorphology of the dunes by excavating test pits, obtaining soil and organic samples for dating and other physical testing, measuring movement of the dunes, and setting up experiments to monitor the movement of objects placed in the dune system.

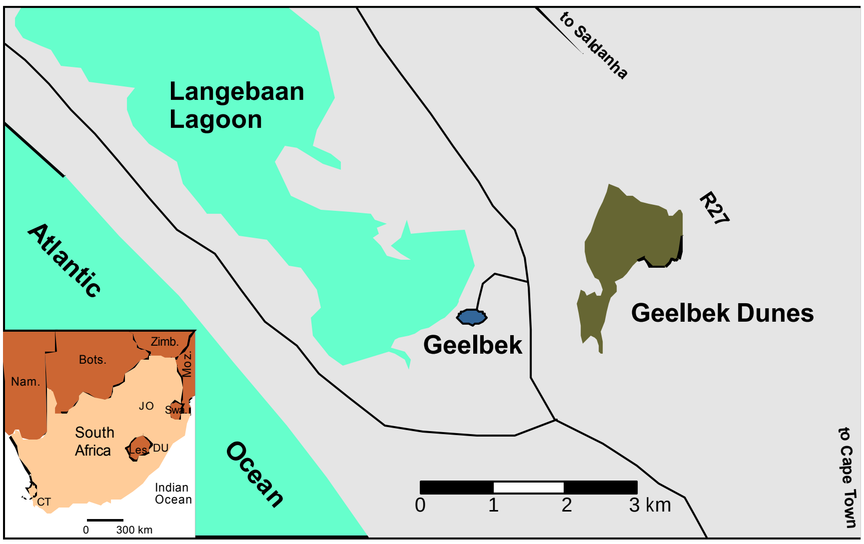

Figure 1. Geelbek. General site location map.

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Archaeological research has typically favored well-stratified deposits at cave sites and rock shelter over poorly stratified, open-air sites. Thus, cave sites and rock shelters comprise a large portion of the archaeological record currently available from the Stone Age in South Africa. The differential preservation of archaeological remains further skews this perspective. Although it cannot be denied that cave sites and rock shelters represent key sources of archaeological data, they also present a somewhat biased image of the past. First, the location of these sites does not represent the actual distribution of hominid activities in ancient landscapes. Second, the internal spatial distribution of finds at these sites offers limited information, in that multiple occupations are preserved over a relatively small area. These two factors render the interpretation of the finds and features difficult.

The actual size of most Stone Age archaeological excavations in rock shelters or caves is much smaller than the area necessary to detect spatial patterning in open-air settlements of recent hunter-gatherer, according to ethnoarchaeological sources (Bartram et al. 1991, O'Connell 1987, Yellen 1977). At Geelbek, the detailed piece-plotting and refitting of finds recovered from surfaces in excess of 5000 m^2 has allowed us to address issues such as site type, spatial organization, subsistence dynamics and camp structure in open-air contexts from the Stone Age. These new data augment the existing datasets which often come from cave sites and rock shelters. In this paper, we describe the contribution of some of these open-air localities to the understanding of the paleoecology and archaeology of the Western Cape.

METHODS

Over the course of the systematic survey, 114 deflation hollows in the Geelbek Dunes were visited, their geological and archaeological characteristics described, and their locations measured with a GPS receiver. On the basis of these observations, 22 deflation hollows were chosen for further, more detailed investigation (Fig. 2). The selection of which localities to evaluate was based on several factors. Localities that were judged to be interesting from a specific archaeological or paleontological viewpoint were given higher preference over those less notable. Localities within a variety of geological contexts were chosen to obtain a sample of the different environments exposed between the dunes. Spatial distribution of the localities was considered in order to achieve a sample over the entire area of the dunes. Some localities with low find densities were purposely evaluated to gather as wide a spectrum as possible of the different situations. Finally, the time available for conducting the fieldwork was considered.

Within the 22 localities investigated, a Total Station efficiently and accurately piece-plotted and stored data on almost 30,000 individual finds. The Total Station consisted of a Leica laser theodolite used in conjunction with a Husky field computer and an operating program which was developed by Dibble and McPherron (1996). In addition to individual finds, the Total Station mapped the borders of geological units and measured the local and regional topography.

The majority of finds were found exposed on the surface, either deposited there or, more likely, projected onto that surface by deflation of the overlying strata. Only where geological conditions were favorable was it possible to unearth *in situ* archaeological materials. Systematic excavation was conducted in areas of high surface find densities in order to evaluate the efficiency of the recovery methods, to investigate the local geology and to improve the representation of smaller finds. Some lower density areas were also excavated for comparison.

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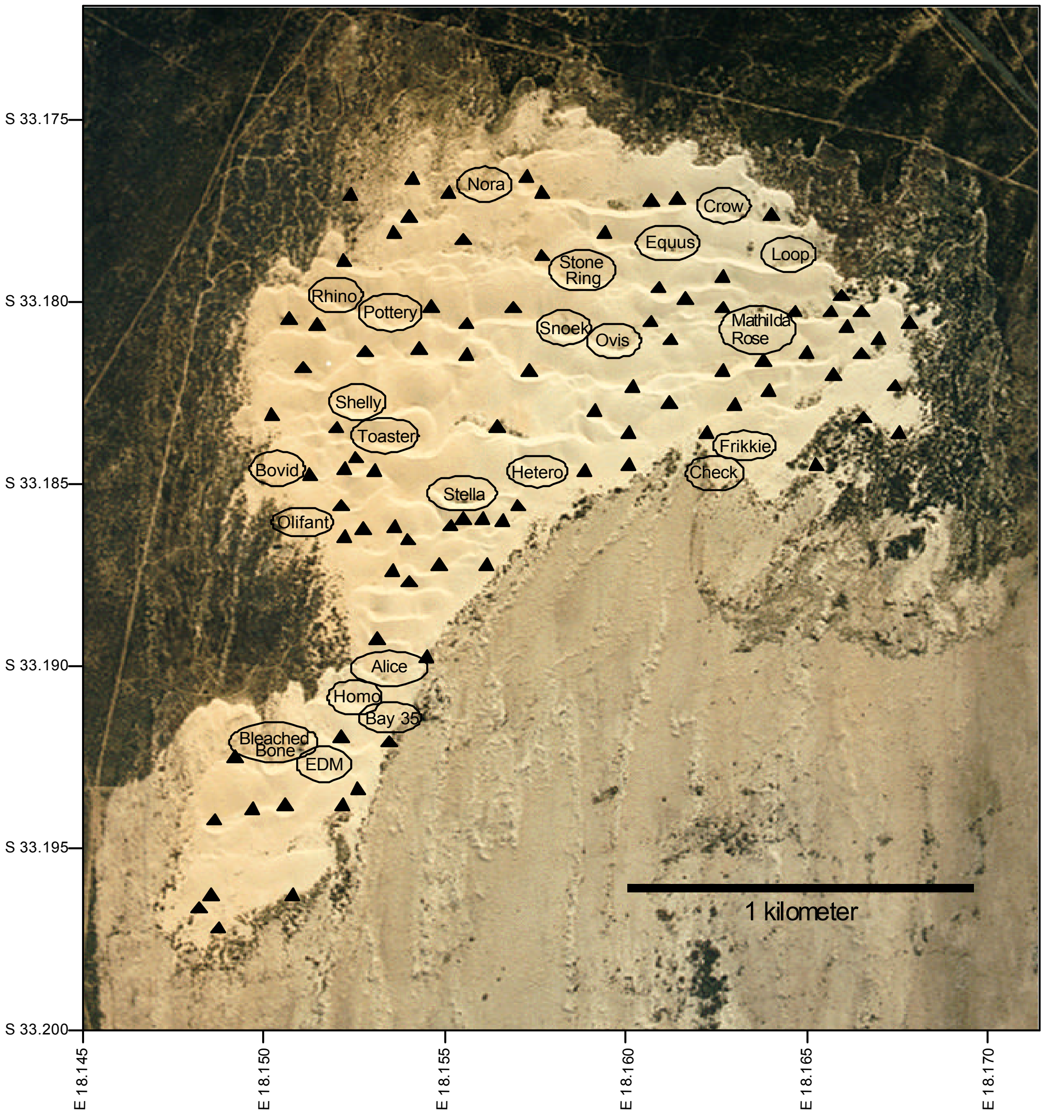

Figure 2. Geelbek. Map of the dunes showing the 22 localities investigated. The other 92 deflation hollows are marked by triangles.

GEOLOGY

Studying the geology of the Geelbek Dunes has been one of the key focal points of this project. Only through the detailed evaluation of the different paleoenvironmental settings of the past 200,000 years can the archaeological finds be placed in a meaningful context. Since a detailed account of the geological results is presented as an accompanying paper (Felix-Henningsen et al., 2002), they are summarized briefly here and in Figure 3.

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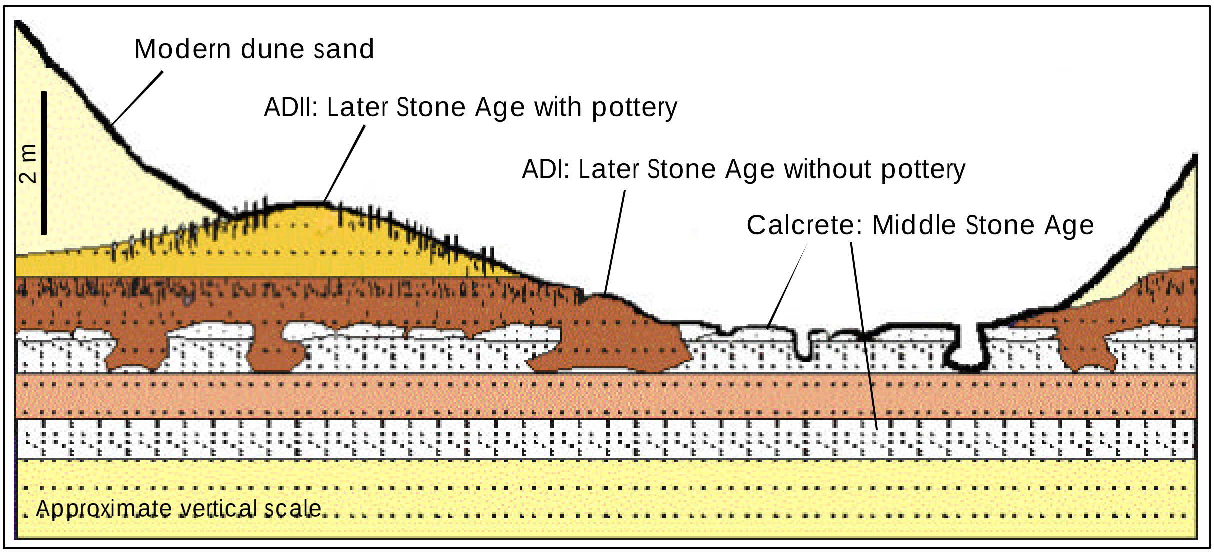

Figure 3. Geelbek. Geological cross-section of the stratigraphy of the dunes, depicting layers of calcrete, ADI, ADII and modern dune sand.

A calcrete substrate is found underlying the entire dune area and is exposed in most of the deflation bays throughout the dunes. Multiple layers of calcrete have been observed at localities such as Stella, Equus, Stone Ring and Rhino. These layers stem mostly from the Middle Stone Age, with U-series dates ranging between 200 and 22 ka BP. A layer of consolidated, dark brown sand overlies the calcrete layers, as seen at localities Nora, Snoek, Homo and Crow. This substrate, known as Ancient Dune I (ADI), formed during the pre-pottery Later Stone Age and has produced IRSL dates between 22 and 2 ka BP. Above the dark brown sand is a layer of yellow sand with calcareous rhizoliths (root casts) called Ancient Dune II (ADII), as seen at Bleached Bone, Pottery, Alice and Stone Ring. This layer is from the Later Stone Age with pottery and yielded IRSL dates from 2 ka BP to present. Finally, loose, wind-blown sand covers the entire sequence of deposits, offering changeable windows into the past.

ARCHAEOLOGICAL RESULTS

The Middle Stone Age

Absolute dates on calcrete from the localities Stella and Rhino provide evidence for the first securely dated archaeological and geological strata at Geelbek at about 150 and 65 ka BP (IRSL & U-Series). At these localities, occasional artifacts and scatters of numerous fossilized animal remains associated with calcrete are attributed to the MSA. Comparisons of finds and exposed geological units from these localities with those of other investigated deflation hollows in the dune field suggest that the MSA has a low-density, widespread distribution both inside and outside the dune field.

MSA peoples at Geelbek selected locally available, lithic raw materials for manufacturing artifacts. Little evidence for clear lithic scatters at MSA occurrences exists, which suggests that primary lithic reduction rarely occurred in the dunes. Rather, tools, cores and blanks were produced elsewhere and transported to Geelbek. Occurring in low density, ephemeral scatters, the finds from the MSA indicate a minimal pattern of activity or a low population density for this period.

Preliminary results of faunal and taphonomic analyses indicate the presence among the fossilized remains of several large mammalian species which became extinct at the end of the Pleistocene. These include the "giant" Cape zebra (*Equus capensis*), the long-horned buffalo (*Pelorovis antiquus*) and the "giant alcelaphine" (*Megalotragus priscus*). These and other species, such as eland (*Taurotragus oryx*), greater kudu (*Tragelaphus strepsiceros*), black hartebeest (*Connochaetes gnou*), black rhino (*Diceros bicornis*), African elephant (*Loxodonta africana*) and blue antelope (*Hippotragus leucophaeus*), are useful in reconstructing the environment at the time of deposition. The presence of these species suggests that grass played a more significant role in the regional vegetation than it does today. During this period when sea level was lower, the distance to the ocean was greater and grasslands covered the resulting coastal plain (Deacon 1982).

While concentrations of artifacts are rare, several concentrations containing the well-mineralized remains of large herbivores, some semi-articulated, have been documented from freshly weathered exposures in Rhino, Stella and Alice. Axial elements, particularly vertebrae, are the most common skeletal elements among the fossil assemblage. Poor surface preservation of the bones precludes the secure identification of cut marks, but other anthropogenic modifications, such as impact fracturing, do occur. Bones that have been chewed by carnivores, gnawed by rodents or burrowed by insects occur frequently.

At locality Equus,1268 fragments of ostrich eggshell (OES) greater than 15 mm were collected from an area of several hundred square meters. The total weight of the OES suggests that this scatter represents at least seven ostrich eggs. Forty-nine of the finds show evidence of human modification in the form of intentional percussion to create a single, rounded opening, some of which are of small diameter and others, large. One piece even preserves two separate, rounded openings. The bimodal distribution of small and large holes and the presence of one OES fragment with two holes suggest that the finds as a whole stem from two-holed water bottles. Preliminary results for a composite sample of the OES resulted in a 14C date in excess of 44 ka BP, placing these finds within the MSA. These data indicate that a cache of two-holed OES water containers was stored at this locality where MSA people probably camped for short periods.

The MSA of Southern Africa represents a period in prehistory in which anatomically modern humans evolved (Deacon & Deacon 1999). During the MSA, people obtained many behaviorally modern traits and likely represent the populations which left the African continent and moved into Asia, Europe and eventually the New World (McBrearty and Brooks 2000). Hominids at this time lived as hunter-gatherers in competition with other carnivores for both game and scavenging opportunities. During the MSA at Geelbek, when sea level was up to 100 meters lower than today (Deacon & Deacon 1999, Shackleton and Opdike 1973), the resulting broad coastal plain appears to represent a location from which mammalian resources were removed by carnivores and hominids and to which lithic resources were brought. Water was cached in OES water bottles for use during local forays. These observations indicate that the archaeological sites at Geelbek were part of a larger cultural landscape.

The pre-pottery Later Stone Age

Finds attributable to the LSA are more numerous than those from the MSA. Stone and bone tools, faunal remains with indications of human modification and bottles made from ostrich eggshell occur more frequently on ADI, although they are also documented on calcrete surfaces alongside MSA assemblages,. The low frequency of diagnostic stone tools makes it more difficult to correlate these LSA occurrences to established chronologies from local cave and rock shelter sites. However, IRSL dates of the dark brown sand (ADI) suggest an age of 10 to 11 ka BP. Thus, a Terminal Pleistocene/Early Holocene age of the finds is also plausible, corresponding to the Albany Industry of Deacon (1982) and Deacon & Deacon (1999).

Several concentrations of stone tool debris have been documented. These are mostly fabricated on local raw materials, but also occasionally on imported, exotic raw materials. Core reduction methods during this period are dependent on the material used. Bladelets and their cores are common on fine-grained silcrete. Silcrete and quartz were used for the production of backed microliths. Scatters of coarser lithic material, such as quartzite and granitic rocks, indicate an expedient and opportunistic strategy for core reduction.

Faunal analyses are not yet complete for the LSA of ADI, but preliminary results indicate a faunal character similar to that of today. The LSA of Geelbek contains examples of distinct site types. LSA kill/butchery sites can be found at Geelbek, for example at Snoek where the mineralized remains of a butchered eland preserve cut-marks. These remains are spatially associated with over 30 backed microlithic tools and a scatter consisting of several, two-holed, water containers made from ostrich eggshell. At Crow, several bone link-shafts, which are used in composite arrows, have been recovered, thus establishing an association with hunting activities. Other localities preserve hearth features, which indicate places where people lived.

The LSA prior to the introduction of pottery was a period in which anatomically and behaviorally modern humans lived as hunters-gatherers. These populations are seen as direct descendents of the San (Bushmen) of Southern Africa. At Geelbek, hunting activities and occupation sites have been documented, suggesting that this area of the coastal plain played an important role in resource acquisition and was a place where hunter-gatherers lived.

The Later Stone Age with pottery

About 2000 years ago, pastoralists or herders called the Khoekhoen introduced both domestic stock and pottery into the Cape from the north and east. Interaction with existing hunter-gatherers took place, and this is reflected in the artifacts at these sites. At Geelbek, the numerous localities in which pre-pottery LSA sites are preserved differ from LSA occurrences with pottery in the abundance of the different classes of artifacts. In addition to LSA cultural debris, the LSA sites of the Geelbek Dunes with pottery also contain ostrich eggshell beads in all stages of production, concentrations of burned and unburned calcrete blocks, marine shell refuse and shell artifacts. These sites are documented in clear concentrations on ADII, and the spatial information from these sites suggests that these scatters preserve the remains of domestic camps.

As is typical in the dunes, the majority of raw materials are local: quartz and quartz porphyry debitage predominate and indicate the primary, on-site production of stone tools. Lesser amounts of silcrete and quartzite flakes and tools had been made elsewhere and imported to Geelbek. On the basis of raw material composition and tool frequency, the pottery LSA of the dunes shares similarities with the numerous, coastal shell middens (Robertshaw 1979). Among the formal tools, scrapers are the most common, with grinding stones, occasional bored stones and backed microliths present in many of the assemblages. These tools suggest not only that hunting took place here, but also domestic activities in which wood, plant and other organic materials were processed.

Preliminary analyses indicate that much of the fauna may be attributed to natural deaths and kills by small carnivores. The identified faunal remains include steenbok (*Raphicerus campestris*), Cape grysbok (*R. melanotis*), gray duiker (*Sylvicapra grimmia*), tortoise (*Chersina angulata*) and Cape hare (*Lepus capensis*). Many remains of small bovids carry traces of damage induced by non-human carnivores, and anthropogenic modifications are rare. However, it cannot be ruled out that carnivores, which further modified the assemblages, visited abandoned campsites. The absence of remains of domesticated animals at these sites suggests that hunter-gatherers, and not pastoralists, occupied the dunes.

The use of marine resources is clearly documented at Geelbek and establishes a clear link to both the lagoon and seashore. Marine shell is present at most of the localities, most notably Shelly, Check and Pottery. The black mussel (*Choromytilus meridionalis*) dominates the marine assemblages, followed by the white sand mussel (*Donax serra)* and limpets (*Patella* sp.) At Shelly and Toaster broken valves of *D. serra* have been consistently chipped along the broken edge to form simple scrapers. The remains of fish are less common. Of the analyzed fish remains, only 2 finds of the white sea catfish (*Galeichthys feliceps)* have been identified from Matilda Rose.

The presence of pottery at many localities reflects occupation by hunter-gatherers, pastoralists, or a combination of both. Fragments of pottery vessels are abundant at localities such as Toaster, Pottery, Stone Ring and Nora. Entire vessels from both Pottery and Stone Ring have been reconstructed. Pottery, or at least the ability to make it, was probably obtained from the pastoralists (Yates & Smith 1993). Thus, the trade of material goods and cultural exchange between the two groups were probably common.

Beads made from OES occur frequently at several localities in the dunes, for example Nora, Pottery and Toaster. Smaller, thin-walled beads overwhelmingly predominate over the larger variety. The size of ostrich eggshell beads has been used elsewhere to differentiate between hunter-gatherers and pastoralists (Yates 1995). The smaller bead size at Geelbek suggests that hunter-gatherers produced them. The production of both natural and blackened beads can be demonstrated at localities such as Nora and Pottery, where all stages from OES blanks to fully fashioned beads are present. This observation indicates that people lived at these places for longer durations.

Localities such as Pottery, Toaster and Equus preserve hearth features composed of concentrations of blackened blocks of calcrete. The concentric blackened calcrete is mostly fragmented into pieces under 10 cm with the largest individual blocks ranging up to 30 cm. This type of feature is interpreted as a roasting pit or platform (Avery 1974, Robertshaw 1979) and also supports that these localities served as places where people lived for longer durations.

At three localities, Homo, Hetero and Loop, small scatters of human remains have been identified. Current AMS 14C dates of these specimens give rough ages in the LSA with pottery. The bones appear to represent the remains of three disturbed burials of individuals who were probably interred near their area of discovery.

The pottery LSA on ADII represents a period in Southern Cape prehistory in which two populations of indigenous Africans, the San and Khoekhoen co-existed in the Cape. Finally,

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historic artifacts attributable to the European settlers are present in small numbers on ADII and demonstrate that colonists also visited the dunes after they reached the Cape in 1652. For example, the provenience of three clay pipes was traced back to their European roots, glazed pottery sherds and glass fragments were examined, and metallic artifacts such as horseshoes and shell casings were collected in the dunes.

ASSOCIATED STUDIES

In additional to the archaeological field work, several associated studies were initiated in the fields of geology, experimental archaeology and geography. The geological investigation, including physical dating, clearly plays a crucial role in understanding the evolution of the Geelbek dune field. The results are summarized in this paper and presented in greater detail in an accompanying paper in this volume (Felix-Henningsen 2002).

Studies in experimental archaeology sought to duplicate the conditions necessary to recreate some of the various find types that were observed in the dunes. For example, fragments of ostrich eggshell were burned to achieve the different coloration of the OES beads by controlling the level of oxygen and organic materials present. Another experiment sought to fabricate OES beads in order to qualify which methods were most effective in making these ornaments. Calcrete was also burned in an attempt to duplicate the conditions necessary to blacken the blocks frequently observed in large concentrations in the field.

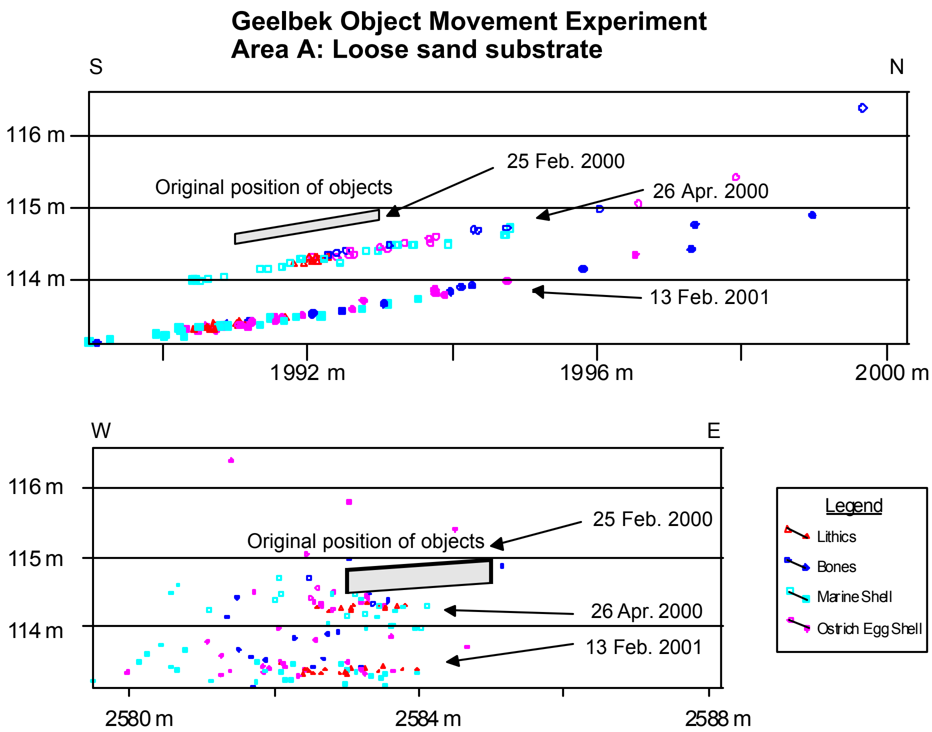

Figure 4. Geelbek. The cross-section of GOME, Area A shows that vertical deflation of approximately 1.5 m has occurred in just one year.

Another project in experimental archaeology, dubbed GOME (Geelbek Object Movement Experiment), involved placing several categories and shapes of objects on the different geological strata to monitor their subsequent movement over time. On 25 February, 2000, One hundred objects each were placed in 2m grids on loose sand, compact dark brown sand

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(ADI) and on exposed calcrete. GOME has continued for 2 years with the results shedding insight into the way in which large-scale dune movements affect the taphonomy of these objects. The results confirm that deflation in these dunes occurs rapidly with the loss of 1.5 meters of dune sand documented in the first year (Fig. 4). Objects scatter not only in the predominant wind direction but are also strongly affected by the slope and stability of the surface on which they lay (Fig. 5). The shape and density of objects also plays a significant role in how far they move.

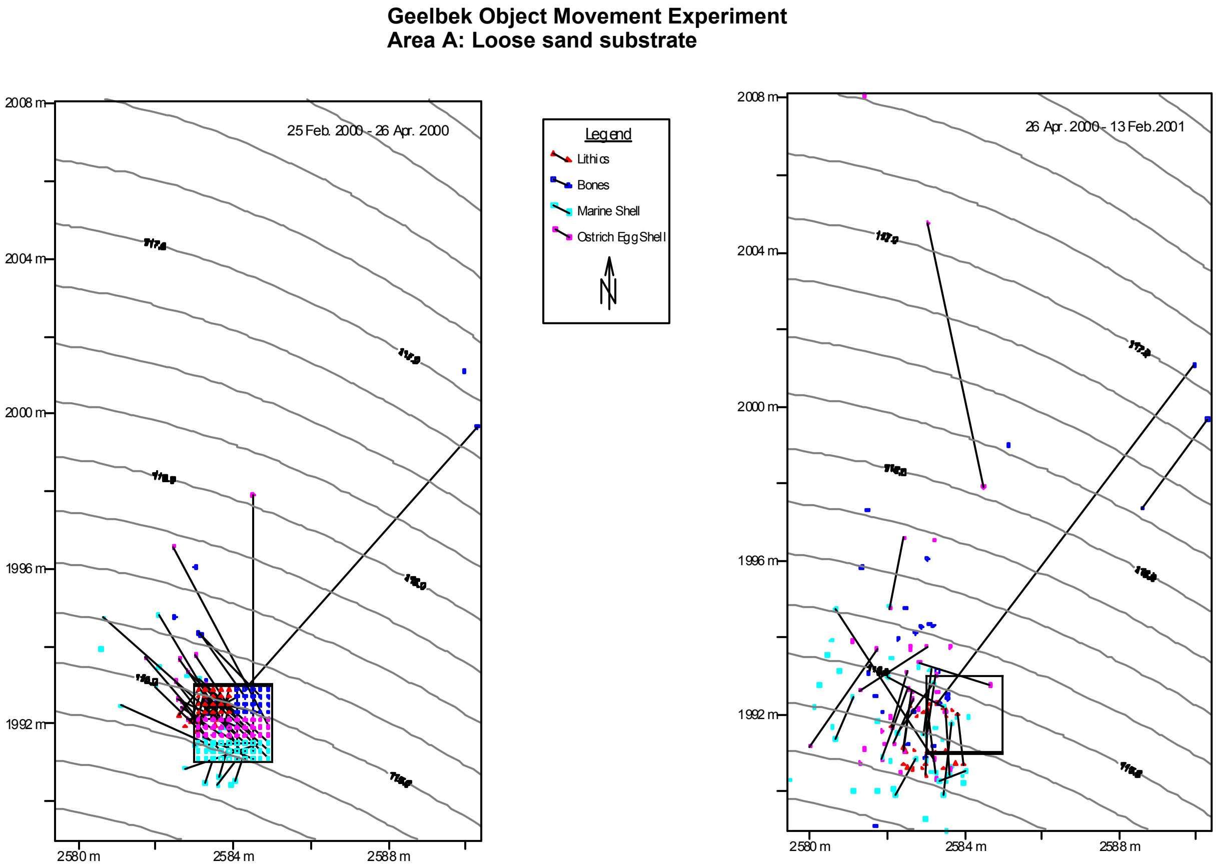

Figure 5. Geelbek. The plan of GOME, Area A demonstrates how artifacts generally moved downhill (westwards and southwards), despite the prevailing wind direction from the south.

In a geographical experiment to monitor large-scale movement of the dunes, the outlines of several of the deflation hollows were measured annually. In this way, the track of the dunes has been monitored. The rate in which the dunes migrate and expose new surfaces in the Geelbek system is not uniform and varies greatly depending on the specific setting Over the course of the project some of the deflation hollows in the Geelbek Dunes have been observed to move a maximum of 25 meters in one year, with an estimated average of about 10 meters per year (Fig. 6).

While the deflation bays moved northwards, the external boundaries remained stable over the course of the project. At the edge of the dune field, vegetation hindered the movement of the dunes, and the basic topographic structures remained fixed. Sand tended to accumulate slowly, as evinced by the gradual burial of fixed measuring stakes.

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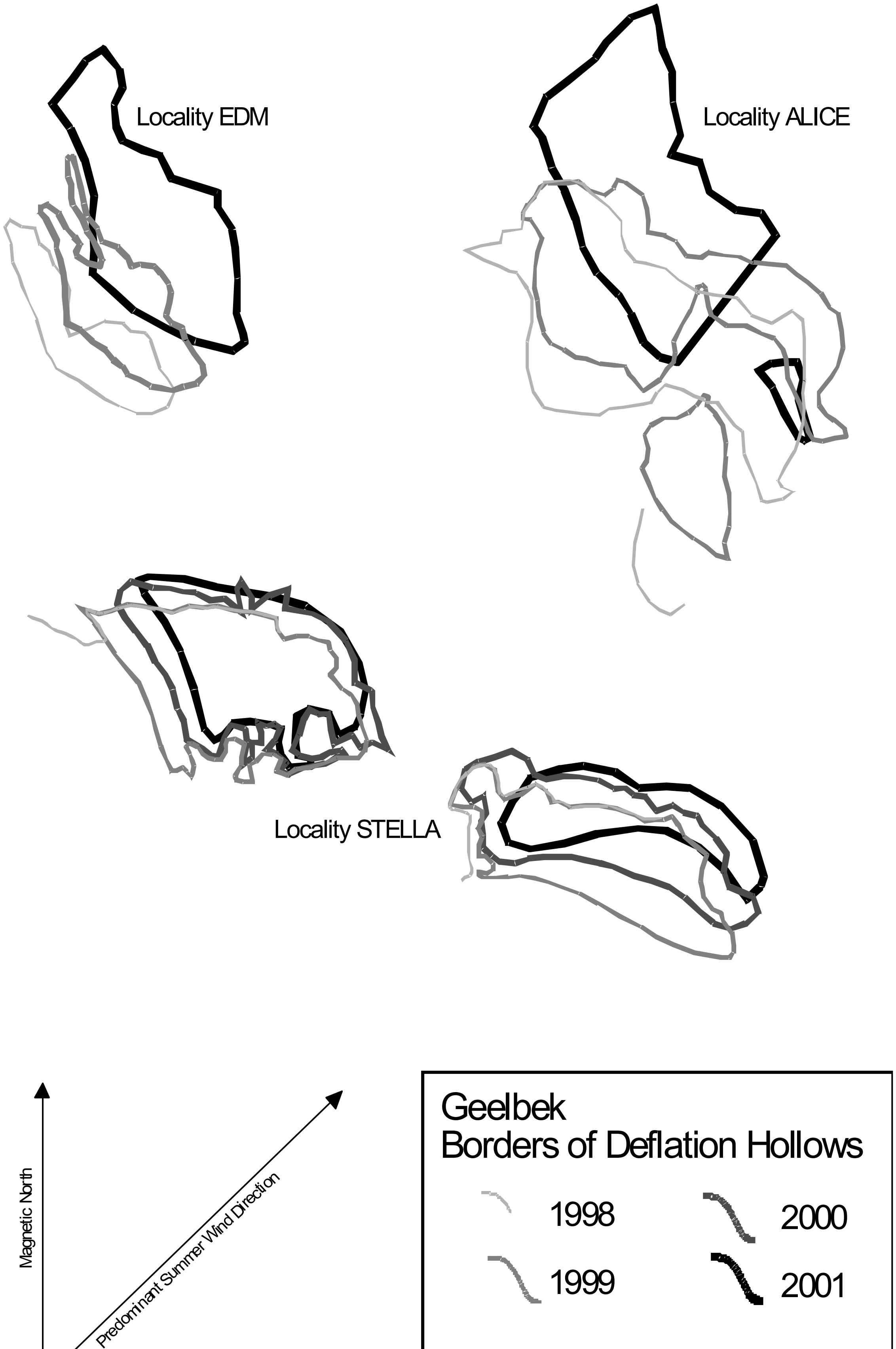

Figure 6. Geelbek. Schematized plan of localities EDM, Alice and Stella, showing relative movement of the dunes from 1998 through 2001.

CONCLUSIONS

Fieldwork and analyses of finds from Geelbek show the critical link between archaeology and soil science in prehistoric research. Open-air localities provide an important, source of information on paleoecology, Stone Age behavior, settlement, and landscape use when studied using interdisciplinary methods. Data from archaeological and pedological work at Geelbek contribute to the archaeological and ecological record of the region and allow us to correlate locally observed phenomena with the broader regional history. Differences in find frequencies and distributions are the result of geological, as well as cultural processes. Thus, this information represents a significant resource regarding prehistoric site formation and taphonomy and provides new insight into diverse aspects of past behavior including subsistence practices, raw material economy and landscape use.

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Appendix B.3

Avery, G., Kandel, A.W., Klein, R.G., Conard, N.J. & Cruz-Uribe, K. (2004) Tortoises as food and taphonomic elements in palaeo « landscapes ». In: J.-P. Brugal & J. Desse (Eds.) *Petits Animaux et Sociétés Humaines. Du Complément Alimentaire aux Ressources Utilitaires: XXIVe rencontres internationales d'archéologie et d'histoire d'Antibes*. Editions APDCA: Antibes, pp. 147-161.

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Tortoises as food and taphonomic elements in palaeo « landscapes »

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Résumé
Les tortues se trouvent fréquemment dans le régime et la culture matérielle des chasseurs et des bergers sud-africains. Ici on examine les sites du Pléistocène et de l'Holocène où les gens, les charognards, les rapaces et les processus naturels auraient pu contribuer aux assemblages. Dans les sites les plus anciens, sauf peut-être Duinefontein 2, l'effet des feux de brousse masque l'utilisation des tortues par les hommes. En conséquence de ces feux on peut trouver des quantités considérables d'os de tortues dans le paysage. D'autre part, dans le site plus récent de Geelbek, la fréquence des os brûlés près des foyers indiquent l'activité humaine.

Abstract
Tortoises are common elements in hunter-gatherer and pastoralist diets and play an important role in their material culture in South Africa. At Middle and Late Pleistocene and Holocene localities in the Western Cape, people, scavengers, raptors and natural processes have contributed to assemblages of tortoises at several open-air sites. With the possible exception of Duinefontein 2, human use of tortoises in the earlier occurrences is masked by the effect of bush fires. As documented in a field study on the farm Elandsfontein Wes, bush fires introduce significant amounts of tortoise bone into the taphonomic stream. At Geelbek, the incidence of burnt bones near Later Stone Age fire places implies human activity.

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Terrestrial angulate tortoises *Chersina angulata* are an important faunal element of the Fynbos Biome, which is focused within the Western Cape Province, and provide food for humans, raptors and predators. Tortoises are utilized by modern hunter-gatherers and their remains are common in Holocene and Pleistocene archaeological occurrences on the coast and inland ; they were mostly eaten, but smoothed and ground carapaces formed bowls and fragments were made into ornamentation (Silberbauer, 1965 ; Schweitzer, 1979 ; Schweitzer, Wilson, 1982 ; Brooks, 1984 ; Klein, Cruz-Uribe, 1983, 1987, 2000 ; Parkington *et al.*, 1992 ; Halkett *et al.*, 2003). Klein, Cruz-Uribe (2000) have demonstrated that the average size of tortoises taken by Late Acheulian and Middle Stone Age (MSA) people was significantly larger than during the Later Stone Age (LSA), probably because human populations were small and predation levels were lower during the MSA. Tortoise size varied during the LSA, but the smallest occur after the arrival of Khoekhoe pastoralists 2000 years ago. This difference was shown to be independent of change in other faunal elements and even climate (Klein, Cruz-Uribe, 1983).

Angulate tortoises are extremely common in the Western Cape coastal region, which comprises the study area. Tortoises would therefore have been readily available to hunter-gatherers and herders. At the time of the early European settlement at the Cape, Khoekhoe herders traded tortoises with the settlers, provided them cooked to slaves, and it is noted that Khoekhoe and San people ate them (Moodie, 1950 ; Raven-Hart, 1971). Deacon (1976) suggested that deliberate veld burning as a grazing and geophyte management tool had an early history, possibly amongst hunter-gatherers as well as herders, and may have been a seasonal practice related to transhumance. Records from the journal of Van Riebeeck indicate that the Khoekhoe managed grazing with fire and that timing was related to transhumance (Thom, 1952). Deacon also cites ethnographic evidence (Bleek, 1928 ; Schapera, 1930) that this was a traditional practice. Schapera noted the use of fire to enhance grazing and to kill off undesirable animals such as snakes (regularly found in archaeological samples, *e.g.*, Byneskranskop) and scorpions (Schapera, 1930), which would undoubtedly have also killed numbers of tortoises. He also notes that Naron women collect tortoises amongst other small animals for food. Silberbauer notes that one G/wi (San) band in Botswana killed a total of 440 tortoises in a year, with zero taken between May and October, presumably since they are less evident during winter (hibernation), and that numbers and resources used reflected availability (Silberbauer, 1965).

Various taphonomic issues need consideration. It may be possible to distinguish human from other agents in more recent archaeological contexts where people are the major contributors. Yet this is not obvious at some sites where tortoise bones are numerous, particularly open-air occurrences in the vicinity of water bodies to which a wide range of animals, and sometimes people, were attracted. Tortoises can be prey of large eagles, *e.g.*, black eagles *Aquila verreauxii* (Boshoff *et al.*, 1991), which deposit them at cliff breeding sites where they could be incorporated into archaeological deposits (Avery, 1984 ; Sampson, 2000). However, eagles are an unlikely factor in the assemblages under discussion since suitable roosting/breeding sites did not exist. Brown hyaenas *Parahyaena brunnea* eat tortoises (Avery, Scott, in prep.), but are unlikely to have contributed significantly since nursery dens were elsewhere. Crows may be a minor factor and kelp gulls *Larus dominicanus* (J. Cooper, University of Cape Town, pers. comm.) are also known to eat tortoises. However, with the exception of people, none is likely to have been a key factor.

After a 1986 bush fire in the Cape of Good Hope section of the Cape Peninsula National Park the taphonomic potential of post-fire tortoise mortality became clear based on an unpublished survey by GA and published observations on this fire (Wright, 1988) and one at Pearly Beach (Stuart, Meakin, 1981). After a major fire on the west coast in 2000 GA and AWK conducted a survey on the farm Elandsfontein Wes to test the hypothesis that bush fires are a significant taphonomic factor in shaping fossil and archaeological assemblages in the open landscape and, secondly, may periodically have provided opportunities for intensive exploitation of tortoises by people. This paper provides a preliminary comparison of post-fire tortoise mortality from a modern bush fire with archaeological observations from three Western Cape sites : Elandsfontein, Duinefontein 2 and Geelbek (fig. 1).

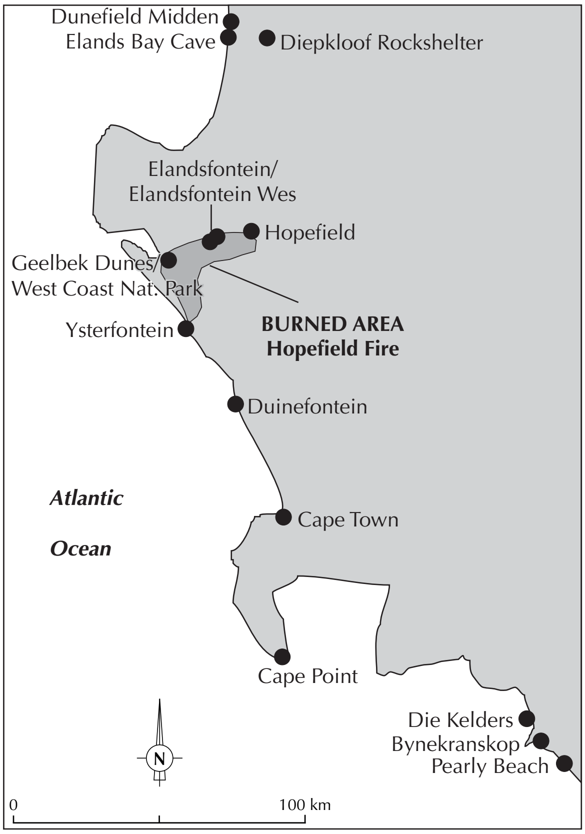

Fig. 1. *Distribution of tortoise and other remains on the « Pylon » (Elandsfontein Wes) survey area.*

Observations after the January 2000 fire

In January 2000 a bush fire swept through 18 400 ha of strandveld and coastal fynbos between Ysterfontein and Hopefield. Extensive field observation estimated that between 90 000 and 280 000 (from 6 to 15 per hectare) tortoises had been killed (E. Baard, Cape Nature Conservation and M. D. Hofmeyr, University of the Western Cape, pers. comm.).

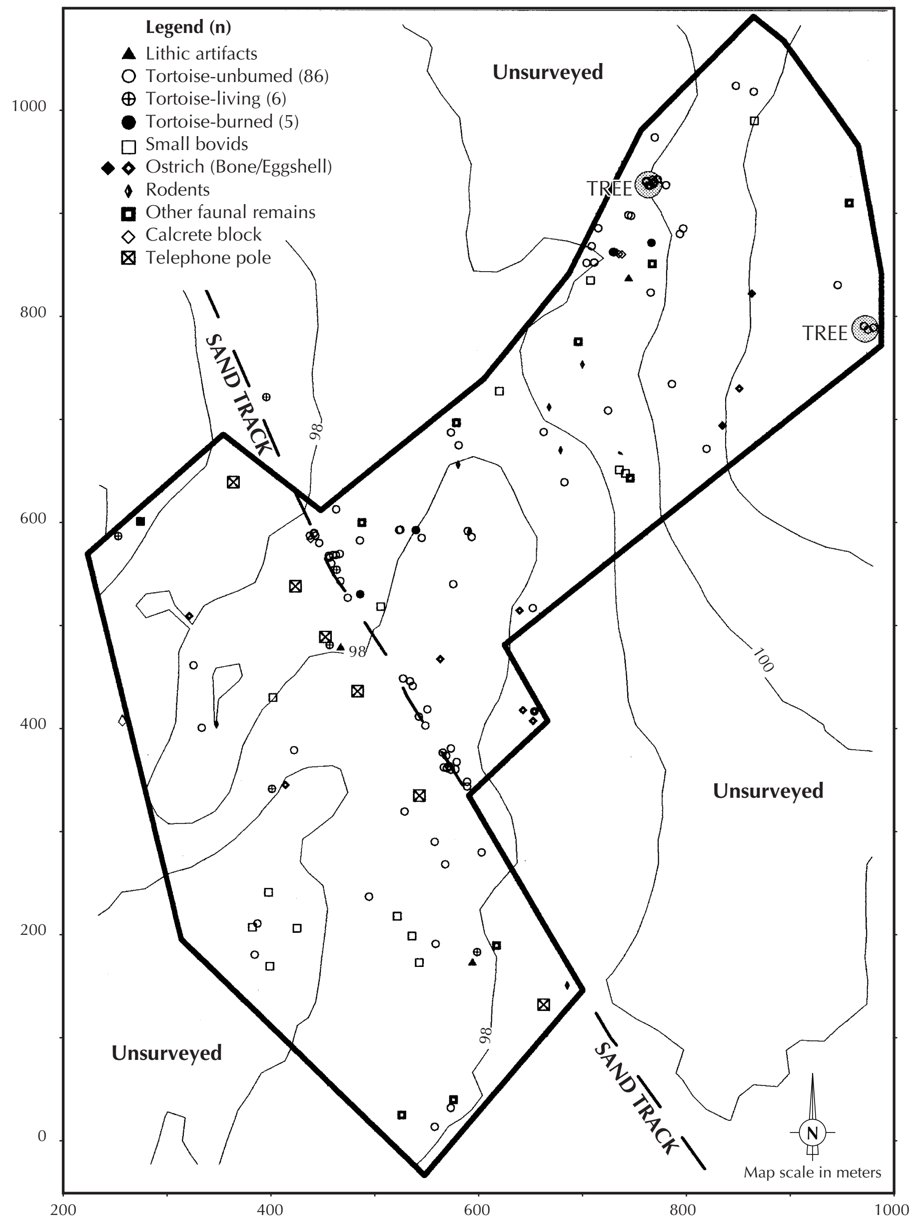

Fig. 2. *Distribution of tortoise and other remains on the « Pylon » (Elandsfontein Wes) survey area.*

Two weeks after the fire GA and AWK, accompanied by University of Tübingen students, reconnoitred the area, and then on 18 and 19 April 2000 and 2 March 2001 conducted a topographical survey and collection from a relatively flat 36,3 ha sandy area named « Pylon » on Elandsfontein Wes to obtain comparative observations on distributions of tortoises and other fauna. Results are shown on the topo-survey (fig. 2, and fig. 5). Eighty-six (NISP) complete or partial tortoises were recovered from the surveyed area. Of a MNI of 64, 59 (based on the presence of > 50 % of an individual, since remains of some had been fragmented and dispersed) were recently dead and five had probably perished in a previous fire. There were also five live individuals re-colonizing the area. Remains of snakes, Squamata, ostrich, *Struthio camelus* (eggshells and bones), mouse, Muridae, Cape dune molerat, *Bathyergus suillus,* cat, Felidae, common duiker, *Sylvicapra grimmia,* steenbok, *Raphicerus campestris* and cattle, *Bos taurus* were also recovered. The density of dead tortoises at « Pylon » was 1,6 per hectare, which is lower than that recorded elsewhere, possibly due to variation in substrate, topography and vegetation (coastal fynbos not strandveld) suited to tortoises. Accepting the variability and that some individuals probably escaped, these values, nevertheless, provide close approximations of the « natural » densities present in that locality before the fire.

The moisture content of tortoises and speed of the wind-driven fire (14 km/h at times, K. Moore, West Coast National Park, pers. comm.) were such that, while there was superficial burning and some charring of scutes and exposed limb extremities of most individuals, this virtually never extended to more than slight browning of the underlying bone of carapaces (fig. 3). In a rapidly moving fire, asphyxiation rather than burning may have been the main cause of death (M.D. Hofmeyr, University of the Western Cape, pers. comm.). But dried bones from a previous fire were charred and calcined, clearly distinguishing them from recently dead individuals. It can be inferred that badly weathered and/or small bones exposed to a subsequent fire or fires would be destroyed.

Distribution of carcasses on the study site was patchy, but shows a clear linear concentration along the track and other localized patches, presumably where vegetation suited to tortoises was more readily accessible than in dense scrub, shrubs or thickets (similar to observations at Cape Point, GA, pers. obs.), or possibly because they moved to less-densely vegetated areas to avoid burning ; this still needs to be demonstrated. Several individuals were often found together (fig. 3). Two small groups around trees, including an individual wedged between branches, were attributed to the activities of crows. These were juvenile individuals and may indicate that the crows were not capable of removing adults to feeding perches. There is, thus, a strong possibility that part of the post-fire mortality profile was removed, although few juveniles were found the day after the Cape Point fire (Wright, 1988) ; this will be assessed at a future date. By the time we conducted the survey, some individuals had been overturned and broken, and bones were being dispersed.

Western Cape fires vary in intensity, and the amount of burning on shells, heads, tails and limb extremities should co-vary with this. The Hopefield fire moved rapidly through vegetation of relatively low density with minimal litter and other organic matter that would sustain burning. At Cape Point, the fire was much hotter. Fires exposed the sandy substrate and calcrete ridges to strong

Fig. 3. *« Pylon » carcasses showing lack of burning on bone, dispersal of small elements and proximity of individuals.*

prevailing summer south-easterly winds and it was evident during the 2000 survey that sand was moving and mini-dunes (< 0,6 m) forming in some areas. In some instances carcasses were already being covered, although such areas extended for tens rather than hundreds of metres. No sand movement was evident on the calcrete ridges, which are stabilised by the fragmented substrate, but high tortoise mortality was often associated with them. The coastal fynbos vegetation of the study area varied from sparse to woody thickets and the relative woodiness of vegetation on the ridges may have caused hotter and longer burning. At Cape Point, sandstone outcrops, which were largely clear of vegetation, served as refuges where numbers of live tortoises were recorded after the fire. Although in a different « rocky » substrate, the Hopefield fire observations may support the suggestion that tortoises instinctively move to rocky structure in order to escape fire (Wright, 1988).

Archaeological and fossil localities

Elandsfontein (EFT : Late Acheulian-400 ky to 700 ky)

At Elandsfontein (Avery, 1989 ; Inskeep, Hendey, 1966 ; Klein, 1978 ; Klein, Cruz-Uribe, 1991 ; Singer, Wymer, 1968) prevailing winds have exposed mineralized fossil bones and artefacts within a 150 ha dunefield. Animals and people were probably attracted by the presence of water. Some systematic collections were made, but excavation has been limited and the site is not as well resolved as

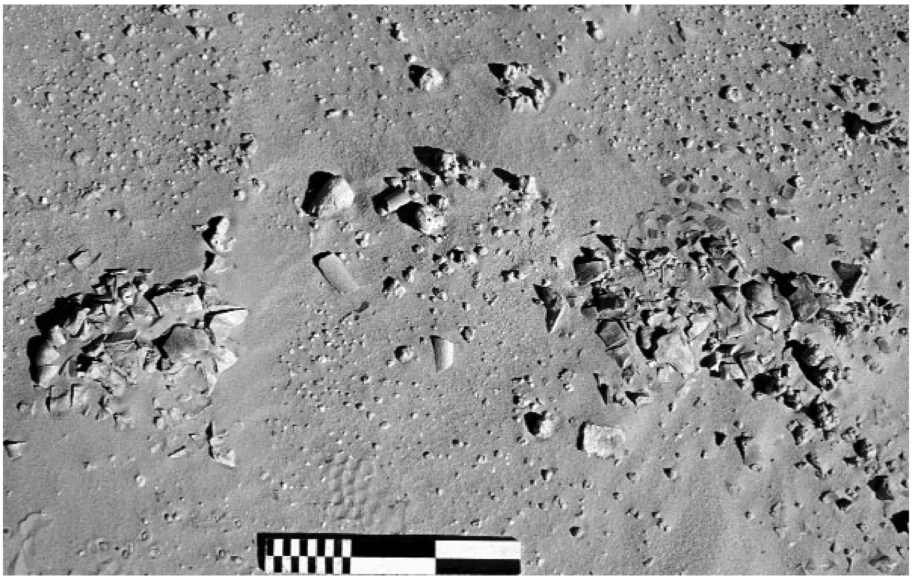

Fig. 4. *Two tortoises on the Elandsfontein palaeo-land surface, which probably died in a bush fire.*

Duinefontein 2 or Geelbek. Tortoise bones are mostly in the form of disarticulated skeletal elements of shells and limbs, and screening reveals abundant < 1 cm fragments scattered over the surfaces that have been investigated. An occurrence of two « complete » individuals is illustrated (fig. 4). The faunal assemblage includes the calvarium of an archaic *Homo sapiens* and a range of large and small taxa, of which bovids are abundant. Human contribution to the assemblage was probably very small.

Duinefontein 2 (DFT2 : Late Acheulian-300 kyto 400 ky)

Duinefontein 2 (Cruz-Uribe *et al.*, 2003 ; Klein *et al.*, 1999 ; Sampson, 2003) is in a large dunefield. Excavation of 750 m^2 of *in situ* sediment revealed two palaeosurfaces, which are thought to have been in close proximity to a water body, as evidenced by abundant frog bones and some water birds. Mineralized bones of a range of mammals dominated by bovids and some reptiles and ESA stone artefacts were also present. Bones (> 1 cm) were piece plotted. Smaller fragments were recovered from individual squares at 5 cm intervals. Bones of tortoises ranging from near-complete to < 1 cm fragments were abundant. These formed two vertically and spatially defined 150 mm to 200 mm « bands or clouds » (Horizons 1 and 2), paralleling the distribution of other fossils and artefacts and approximating the trampling zone of the sloping land surface in each case (Cruz-Uribe *et al.*, 2003 ; Klein *et al.*, 1999). Figure 5, which plots all bones > 1 cm, provides an indication of this. Very few bones with signs of burning were recovered.

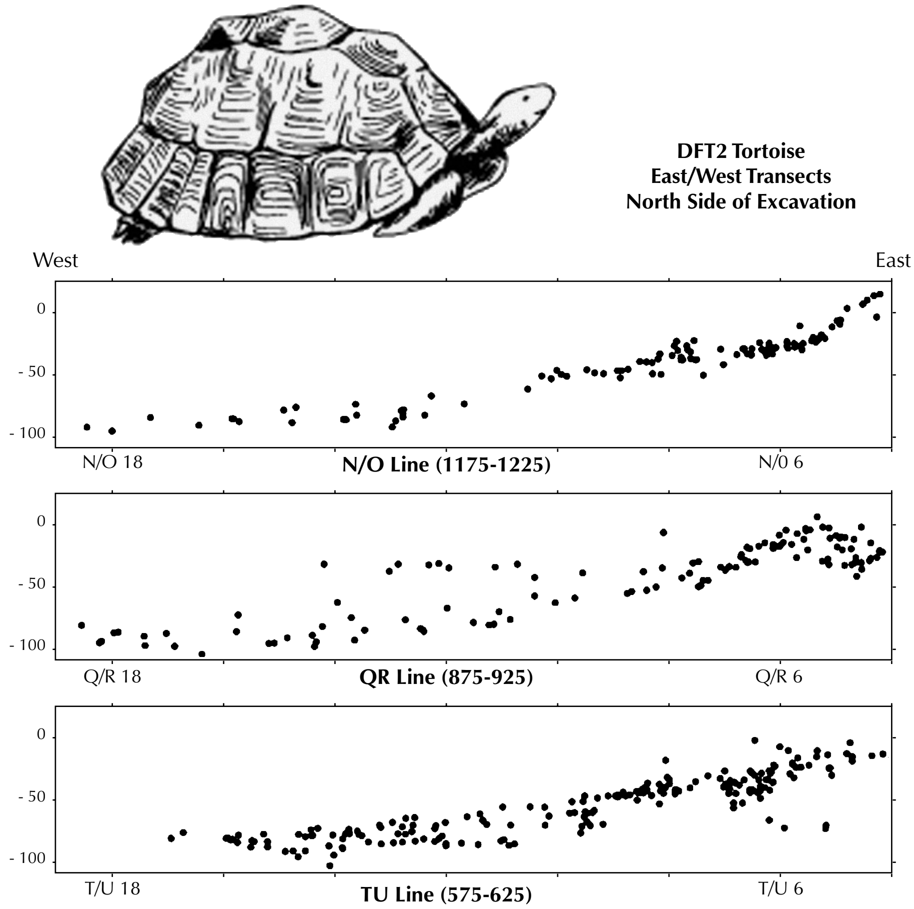

Fig. 5. *Vertical distribution of tortoise bones within a « band or cloud » representing one of the Duinefontein 2 palaeo-land surfaces (Klein* et al.*, 1999).*

Geelbek (Middle Stone Age-250 ky to 60 ky ; Later Stone Age - < 10000 BP)

Geelbek (Conard *et al.*, 1999 ; Kandel *et al.*, 2003) comprises 23 documented localities in deflation hollows within a ca. 400 ha dunefield, the northward migration of which exposes and then reburies archaeological occurrences. The finds are exposed on a variety of palaeo-surfaces comprising Holocene and Pleistocene dunes and several generations of weathered Middle Pleistocene calcrete surfaces. The Middle Pleistocene fossils are mineralised. All faunal remains > 2 cm were piece plotted, while smaller fragments were collected by dry sieving of the excavated units. Tortoise fragments were present at all localities (*e.g.*, fig. 6). While some tortoise fragments are clearly associated with features such as stone fire places, others are distributed more evenly over the landscape. Although quantification needs refinement, burned carapace and plastron fragments were relatively

Site, Authors	Area ha	MNI	Mortality/ha	Live density/ha	% Burnt
Modern post-fire mortality					
Pearly Beach (Stuart & Meakin, 1981)	4.6		5.2	ca 6.68	--
*Cape Point (Wright, 1988)	--	11.8% (rocky)	2-6 (6-year veg.)	--	
		86.3% (plain)	0-1 (2-year veg.)		
Cape Point (G. Avery, 1988, unpublished)	15		1.4	--	--
West Coast 2000 (Baard & Hofmeyr, pers. comm.)	18400		4-15	--	--
Elandsfontein Wes ("Pylon") 2000	36.3	59	1.6	--	
Eastern Cape (Branch, 1984)	--		--	38	--
Archaeological					
Geelbek (Equus MSA)	1.15	2	1.7	--	
Geelbek (Rhino MSA)	0.99	1	1	--	
Geelbek (Equus LSA)	1.15	2	1.7	--	
Geelbek (Rhino LSA)	0.99	9	9.1	--	42.6
Geelbek (Pottery LSA)	0.71	8	11.3	--	24.2
Geelbek (Nora LSA)	0.23	4	17.4	--	32.5

Fig. 6. *Densities of live and dead angulate tortoises per hectare compared with those from sites at Geelbek. *No data for area sampled or number of individuals burnt was published by Wright (1988), so the per cent mortality and live densities given are not directly comparable with the other modern samples.*

common in the larger LSA samples (fig. 7). It is also not yet possible to be sure that tortoise remains on the MSA archaeological surfaces are associated directly with the cultural remains. However, the degree of burning and densities (MNI/ha) for the Geelbek LSA occurrences are suggestive of human involvement. Analysis of the faunal samples from Geelbek localities is still in progress and the relative proportions of tortoises versus other faunal elements remains to be established.

Eland's Bay Cave (EBC : Later Stone Age-20 ky to 400 BP)

Elands Bay Cave is a finely stratified Table Mountain Sandstone Cave on the coast. Careful separation of depositional units was undertaken during the excavation and all material was passed through a 3 mm screen. All bone was retained. Marine elements are very common from 6000 BP. Tortoises are present throughout the sequence, but two units in particular were almost totally comprised of tortoise bones (Klein, Cruz-Uribe, 1987 ; Parkington, 1980).

Byneskranskop Cave 1 (BNK1 : Later Stone Age-12 500 BP to 200 BP)

Byneskranskop is a finely stratified limestone cave about 7 km inland. Careful separation of depositional units was undertaken during the excavation and all material was passed through a 3 mm screen. All bone was retained. Marine elements are common from 6000 BP. Tortoises are present throughout the sequence, but one unit in particular was almost totally comprised of tortoise bones (Schweitzer, Wilson, 1982).

Discussion

Mortality varied, with factors such as sandy plain (high mortality) and rocky (low mortality) substrate and vegetation cover contributing to this (fig. 6). Pearly Beach post-fire mortality was 5,2 per ha (Stuart, Meakin, 1981). At Cape Point live densities on vegetated plains varied from zero to one per hectare in two-year vegetation and two to six per hectare in six-year vegetation. Post-fire mortality expressed as a percentage was 11,8 % on rocky substrates, where fire avoidance played a role, and 86,3 % on the plain (Wright, 1988). The observations of Baard and Hofmeyr (pers. comm.) indicate a wide range over a considerable area, which included strandveld and coastal fynbos on sandy plains and calcrete ridges. The higher values appear to be associated with strandveld (Baard and Hofmeyr, pers. comm.), whereas the lower value obtained for « Pylon » was from a sandy plain in coastal fynbos. In the Eastern Cape 1000 km away a high live density (38 per ha) was recorded in coastal dune thicket (Branch, 1984).

Archaeological observations

At the Dunefield Midden (Parkington *et al.*, 1992), a well-preserved hunter-gatherer camp site, tortoise bones were dispersed and often burnt ; plastron and limb fragments tended to be focused in the domestic area amongst the fire places, probably where they were consumed, whereas carapace fragments tended to be in the dump ; and tortoise bones were not ravaged by dogs or jackals. The association of bones and fire places has also been documented at Geelbek (fig. 7).

Foragers would encounter many tortoises, but bush fires result in high mortality, making large numbers of carcasses readily accessible and visible. These constitute a significant potential food resource and it can be postulated that people in the vicinity of (or drawn to) a fire, would have taken advantage of the opportunity. This was probably not intensive during the Late Acheulian, given the inferred low human densities at EFT and DFT2. By MSA times, however, there is no doubt that MSA people collected tortoises for food, as evidenced by abundant remains at Die Kelders Cave (Klein, Cruz-Uribe, 2000), Blombos Cave (Henshilwood *et al.*, 2001), Diepkloof Rock Shelter (RGK, pers. comm.) and the Ysterfontein Rock Shelter (Halkett *et al.*, 2003).

Exploitation by Holocene people of tortoise carcasses after bush fires is probably indicated at Eland's Bay Cave (10700 BP to 9600 BP) and Byneskranskop Cave 1 (9760 BP), where some units have dense concentrations of tortoise bones (Klein, Cruz-Uribe, 1983, 1987). Micromammalian evidence from Byneskranskop

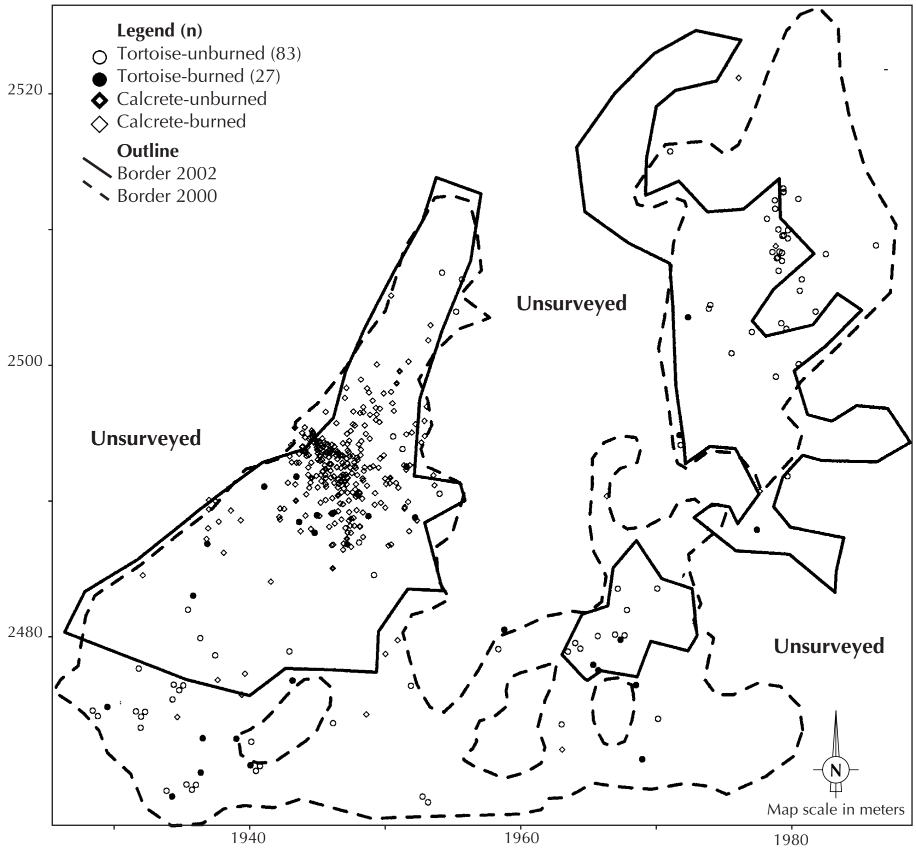

Fig. 7. *Geelbek locality Nora showing distribution of burnt and unburnt tortoise bones around burnt calcrete representing at least one fire place.*

Cave 1 (Avery, 1983) suggested that the environmental conditions under which the « tortoise midden » accumulated were wetter with pans and more closed grass on the flats and some low scrub, which differs from the drier environment with more open grass that developed after 6500 BP. Either environment would have favoured tortoises. The micromammalian evidence at Eland's Bay Cave (Avery, 1983) indicated very little difference between the period concerned and the past 1000 years, which supports the expectation that tortoise populations around each site would have been relatively similar during the Early Holocene. Furthermore, archaeological resolution not withstanding, the units appear to represent brief periods of accumulation, possibly single episodes. Although disarticulated when recovered, complete tortoises were brought to the caves. The inference is that the temporally isolated instances of very high frequencies of tortoises in some units at Byneskranskop Cave 1 and Eland's Bay Cave were independent of environmental factors and represent post-fire assemblages exploited by hunter-gatherers.

Khoekhoe use of fire to manage grazing is well known historically (Thom, 1952) and would undoubtedly have opened larger areas suited to tortoises. Use of fire may have led to indirect « management » of tortoises as a food resource with concomitant reduction in the achievable natural tortoise size due to exploitation pressure, as previously suggested (Klein, Cruz-Uribe, 1983).

The strong association of tortoise bones with fire places, the high incidence of burning, distribution of mostly-complete elements of disarticulated shells and the high densities of tortoise bones on some Geelbek LSA localities suggest that people were responsible for their presence there. Cut marks are absent. Modern reports indicate that whole tortoises would have been thrown on the fire and cooked (Raven-Hart, 1971), there being no need to cut them into portions thereafter since a carcass was small and could easily have been torn apart once the shell had been broken open.

Landscape observations

After a fire carcasses not removed by people or other animals would have been assimilated into surface sediments. Natural fynbos regeneration requires burning intervals of between 4 and 60 years. This process has been repeated, as a mosaic, over the landscape over short intervals of tens rather than hundreds of years, and the potential input of tortoise bones over time would be considerable.

Mini-dune formation and sand movement as a result of fire and disturbance by other animals covers carcasses, which creates opportunities for preservation. Areas like water bodies attract game regularly, and also open the way for trampling by large ungulates and the abrasion and comminution of bones. Since animals would regularly come to drink, such areas would be heavily grazed thereby maintaining open areas with vegetation suitable for tortoises.

The expected result would be that, particularly in areas attractive to tortoises over a period of relative stability, the proportion of preserved bones within the surface disturbance zone would be high. It is evident from the condition of the Middle Pleistocene fossils that they were preserved relatively well following episodes of deposition and trampling until mineralization took place.

Conclusion

It is concluded that bush fires are significant taphonomic factors that shape Western Cape archaeological and palaeontological faunal assemblages, particularly with respect to sand movement and the predominant occurrence of a high degree of fragmentation of scattered individual bone elements, with a few complete or near complete individuals on palaeo-landscapes. In the localities examined tortoise bones also indicate the trampling zone of ancient landscapes. Rapid covering of bones is probable, but the likelihood that re-exposure to fire would destroy badly weathered and/or small bones still on the surface can also be inferred.

There is strong archaeological evidence to suggest that at least two incidences of very high frequencies of tortoises during the early Holocene, at Byneskranskop Cave 1 and Elands Bay Cave, were the direct result of hunter-gatherer exploitation after a fire.

It is also likely that fire management of grazing by pastoralists in the past 2000 years, and increased human population density, increased natural pressures on tortoises, which led to higher mortality and a reduction in their attainable size (Klein, Cruz-Uribe, 1987, 2000).

It has not yet been possible to establish whether late Acheulian people at Elandsfontein and Duinefontein 2 were exploiting tortoises. This is part of ongoing research to which this project has contributed. It has also not been possible to establish conclusively whether the observations on post-fire mortality can provide independent support that the Geelbek MSA people used tortoises at the Middle Pleistocene occurrences. On the other hand we believe that the Geelbek LSA localities, Nora in particular, which include a relatively high proportion of burnt bones and densities at the high range or in excess of the observed modern variation, were collected by people, but not as the result of a fire.

Acknowledgements

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Appendix B.4

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Modification of ostrich eggs by carnivores and its bearing on the interpretation of archaeological and paleontological finds

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Abstract

This paper presents the results of experiments designed to interpret the significance of scatters of modified ostrich eggshell dating to the Middle Stone Age. The eggshell pieces were recovered from an open-air, archaeological context in the Geelbek Dunes of the Western Cape, South Africa and exhibited conchoidal fractures on their inside surfaces. These finds resemble the openings of ostrich eggshell water flasks described from many southern African sites. The experiments examined the processes necessary to create such openings, focusing on the experimental feeding of ostrich eggs to carnivores at the Tygerberg Zoo near Cape Town, as well as the systematic comparison of data from archaeological, ethnographic and other experimental contexts. The results demonstrate that all of the categories of data overlap significantly. This insight complicates the positive identification of ostrich eggshell water flasks when only fragmentary evidence is preserved. Thus, criteria to differentiate between ostrich eggshell flasks and the case of carnivore feeding are offered.

Keywords: Middle Stone Age; Geelbek; Deflation hollows; Ostrich eggshell; Water containers; Brown hyena

1. Introduction

During five field seasons from 1998–2002, a team from the University of Tübingen documented archaeological and paleontological remains found in deflation hollows of the Geelbek Dunes in South Africa's West Coast National Park (Fig. 1). In addition to recording more than 27,000 in situ faunal, lithic and other cultural remains in the 4 km^2 mobile dune field [5,6,18,28], the team piece-plotted almost 3000 finds of ostrich (*Struthio camelus*) eggshell (OES) and retrieved several thousand more OES fragments through dry-sieving.

The inside surfaces of 113 OES fragments exhibit conchoidal fractures characteristic of rim fragments of OES flasks. Due to this similarity, these finds were initially interpreted as caches of OES flasks. However, none of the pieces bears modifications, such as engravings or traces of pigment that would readily confirm an anthropogenic link.

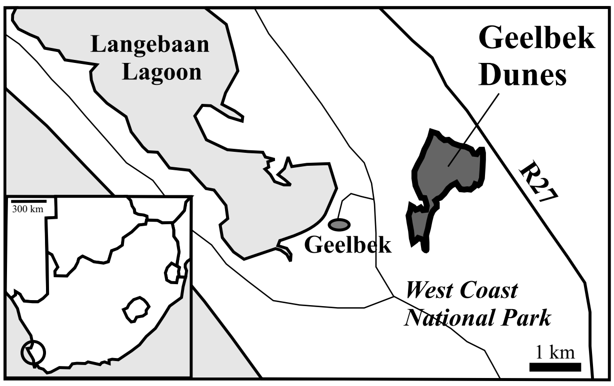

Fig. 1. Geelbek. Map showing the location of the Geelbek Dunes about 90 km north of Cape Town.

The largest, single scatter of OES, situated in the locality *Equus*, consists of 1299 piece-plotted fragments (Fig. 2). Their weight totals 1986 g and represents the equivalent of at least eight empty eggs. The OES scatter coincides with the distribution of highly mineralized faunal remains, while the lithic artifacts, including

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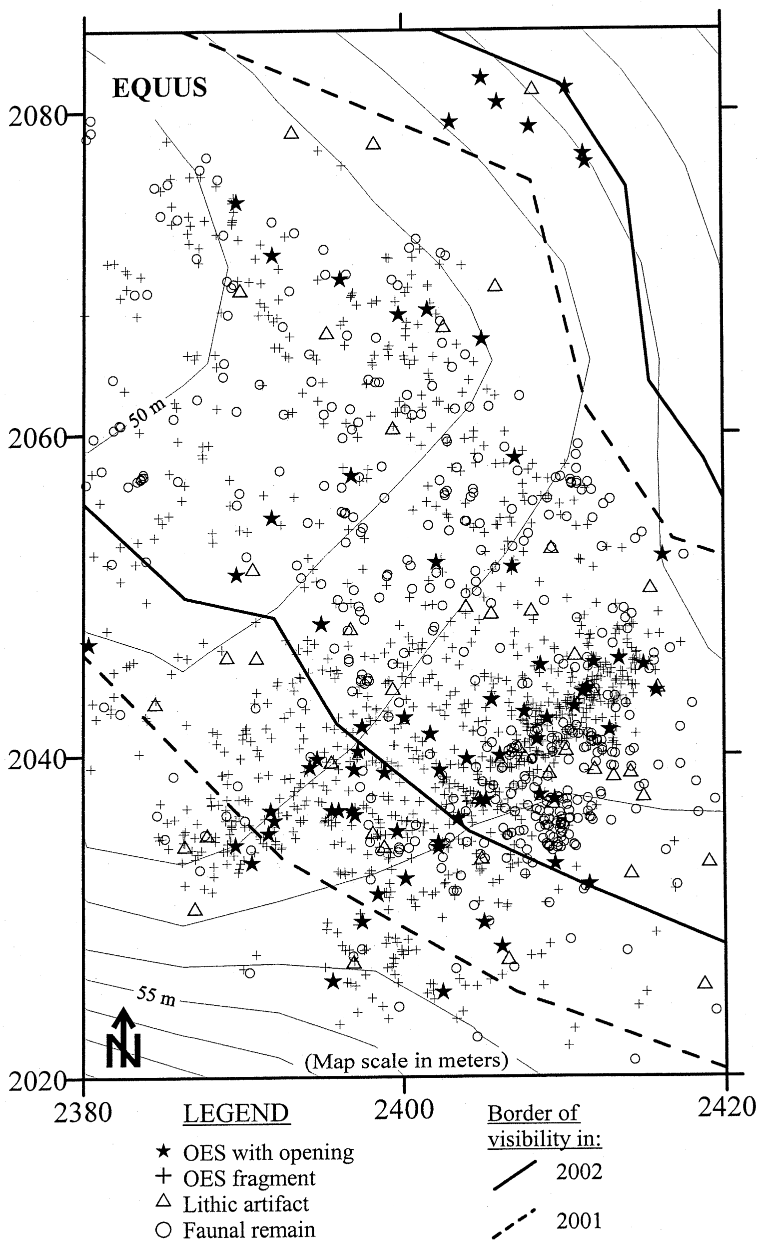

Fig. 2. Geelbek. Distribution of OES, lithic artifacts and faunal remains at the locality *Equus*. (Contour interval=1 m.)

several pieces typical of the Middle Stone Age (MSA), appear as a constant, low-density signature across the landscape.

At *Equus*, 65 single-holed OES fragments exhibit conchoidal fracturing on the inside surface (Fig. 3a–c), while two pieces display two adjacent holes (Fig. 3d). Some of the pieces show multiple generations of conchoidal fracturing, evidence for repeated blows (Fig. 3c and Fig. 4a–d). The rounded edges of the OES fragments thwarted attempts at refitting (Fig. 3e). Some of the fragments retain calcrete on their surfaces, indicating that they were once embedded within this geological formation (Fig. 3f). While the average diameter of the 46 measurable apertures was 11.0 mm, the diameters of the best-fitting arcs describe a bimodal distribution peaking at 6 and 17 mm (Fig. 5). Thus, about half of the apertures overlap the reported range of OES flasks described in the archaeological literature (cf. [25,29,30]).

AMS-dating of a fragment with an 18-mm aperture (Fig. 4a) yielded a result of 37,050 ± 310 BP (GrA-19666). Several unmodified OES fragments from the same scatter date to 44,600+3500/−2400 BP (Pta-8382) using conventional ^{14}C-dating. Woodborne [42] interprets these results as minimum ages, placing the pieces within the context of the MSA.

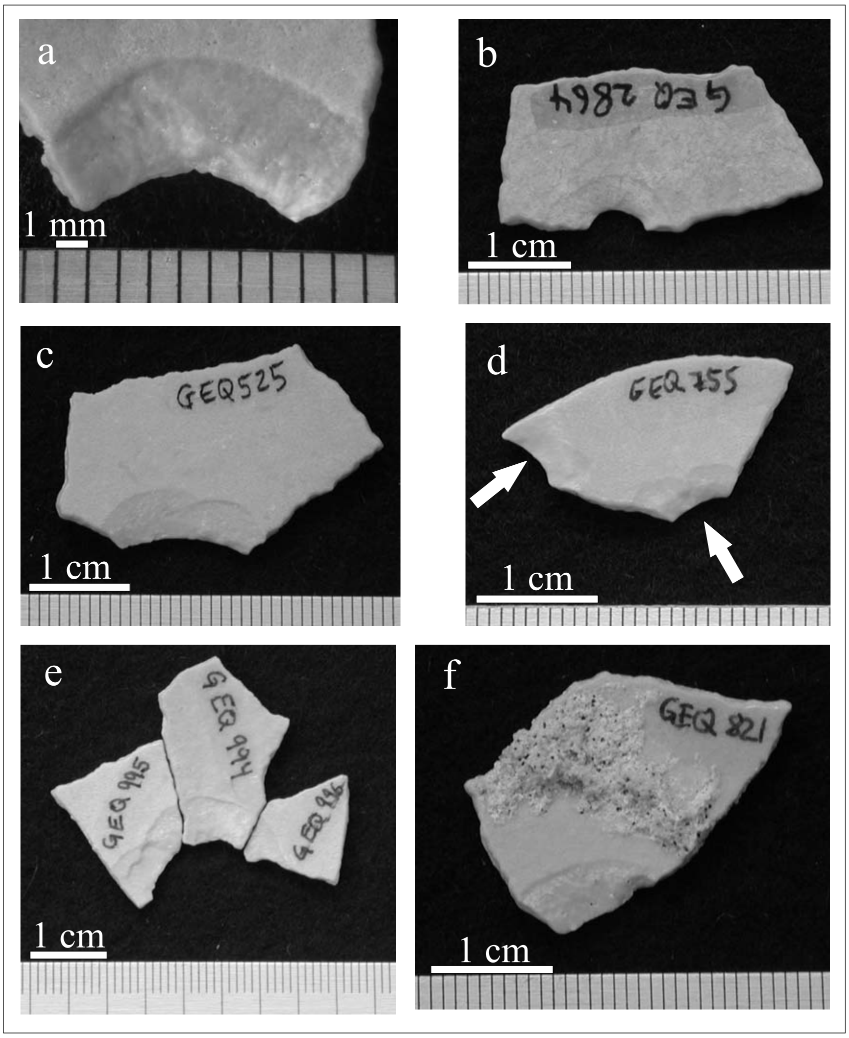

Fig. 3. Geelbek. Finds of OES from the locality *Equus* showing rounding along the edges and clear conchoidal fractures: Single-holed fragments, (a) EQ-2982; (b) EQ-2864; (c) EQ-525 dates to 37,050 ± 310 BP (GrA-19666) using AMS; (d) a two-holed OES fragment, EQ-755, with apertures on adjacent sides. The reconstructed holes measure 9 and 12 mm in diameter and are separated by 20 mm; (e) Three possibly refitting fragments, EQ-994, 995, and 996; and, (f) EQ-821 with remnants of calcrete adhering to the inner surface.

In contrast, the 180 OES fragments collected from the locality *Snoek* were grouped in a tight scatter that separates an area of lithic artifacts to the south from an area of cut-marked eland remains to the north (Fig. 6). The OES from *Snoek* weighs 263 g, the equivalent of at least one ostrich egg, and includes 11 pieces with conchoidal fractures on the inside surface. The 10 measurable apertures average 8.4 mm and describe a unimodal distribution (Fig. 5).

The OES fragments from *Snoek* preserve fresh edges, so that 76 pieces could be reassembled into 10 separate refit groups. When the 12 pieces comprising the largest refit group were assembled, the reconstruction contained two holes of 7 and 14-mm diameter whose centers were separated by 34 mm (Fig. 7). AMS-dating of one of these fragments yielded a result of 775 ± 40 BP (KIA-17759), while three other refitting fragments (Fig. 4d)

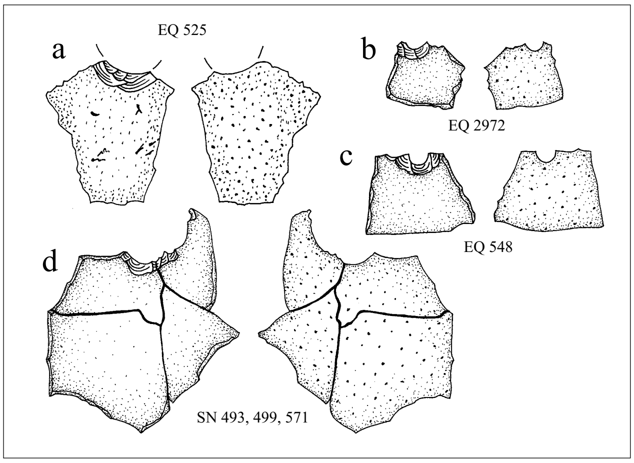

Fig. 4. Geelbek. Drawings of OES from: (a–c) *Equus;* and, (d) *Snoek*. The successive conchoidal fractures in all four illustrations show evidence for multiple blows. Scale 1:2. (Drawings (b–d) S. Feine.)

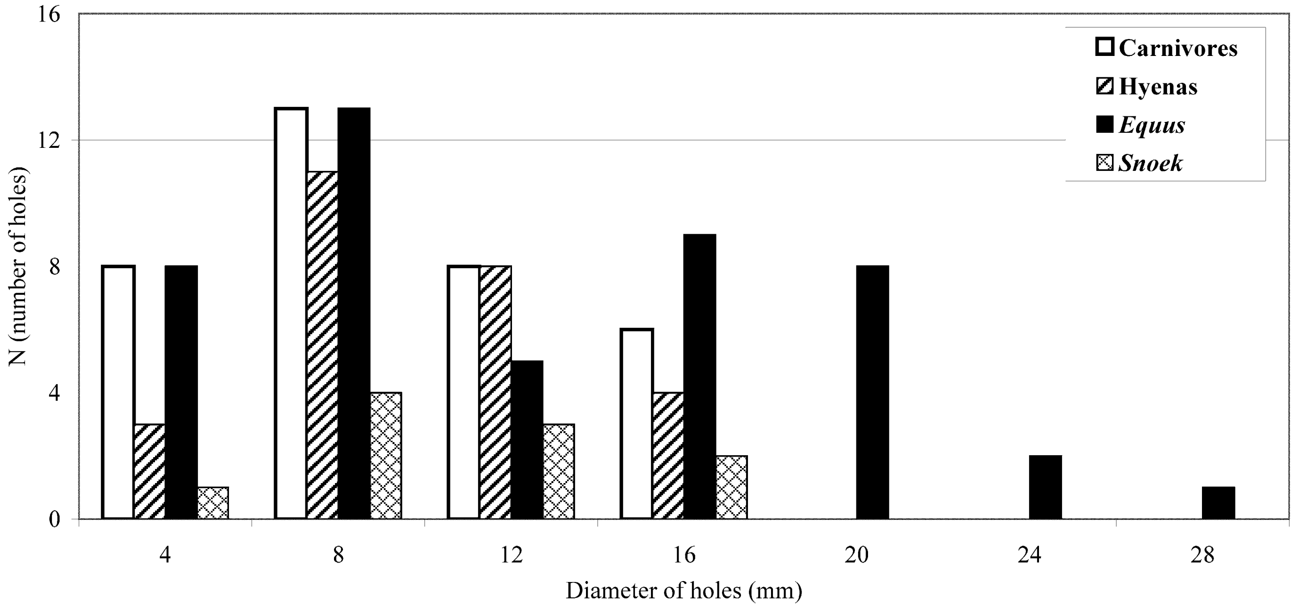

Fig. 5. Geelbek. Distribution of the aperture diameters from *Equus* (N=46) and *Snoek* (N=10) compared to the data from the carnivore experiment at the Tygerberg Zoo (N=35) and, from the same experiment, hyenas only (N=26).

dated to 890 ± 20 BP (KIA-17762). Thus, the two-holed refit group stems from a Later Stone Age (LSA) context.

While single-holed, OES flasks from the LSA are well represented in southern Africa (cf. [12,25,26,30]), double-holed flasks are virtually undocumented [29] and MSA flasks are rare [14,40]; Poggenpoel, pers. comm.). Since evidence for two-holed OES flasks from archaeological or ethnographical sources was limited, a search began for other interpretations to account for similar patterns of breakage. Damage from carnivores seemed most plausible, prompting the author to experiment with ostrich eggs. Alternatively, a concentration of OES could represent the natural remnants of a hatched brood of ostriches, or a scatter could delimit an area where eggshells were broken geologically.

2. Carnivore experiment

The experiment took place from 21–22 May 2002 at Tygerberg Zoo located 40 km east of Cape Town. A late autumn overcast prolonged both dawn and dusk, with the weather remaining cool and damp. The experiment included two brown hyenas (*Hyaena brunnea*), two lions (*Panthera leo*), a tiger (*P. tigris*) and two wild dogs (*Lycaon pictus*). Both hyenas were born in the wild but had lived in captivity since 1995. Since the animals had not been fed for two days prior to the experiment, they should have been hungry. Fresh and rotten eggs were used in the experiment, although their condition was not evident until after they had ruptured. All of the eggs had been inadvertently doused with a coating of two rotten eggs that shattered during transport.

The 9-year-old female hyena responded to the experimental conditions. On the first morning she emerged 46 min after five eggs (1–5) had been placed in a 2-m cluster in front of the earthen den dug into the center of her enclosure (Fig. 8). Within 2 min she sniffed, scratched and bit the eggs. Four min after her emergence she began to carry the eggs to the fence-line of the enclosure in her mouth. After 7 min, she cracked open one egg but did not eat it. After 9 min she began to eat her first egg. Using her mouth and her front paws to stabilize the egg against the ground, she carefully pried opened the egg with her teeth. She than lapped up its contents without completely destroying the egg. She left the remains of the crushed eggshell in an area about 1 m in diameter (Fig. 9).

During the next hour, the female moved the eggs several times in her enclosure, often taking only a portion of an eggshell with her. She frequently paused to sniff or bite the eggs, crack them open and eat from them. The order appeared somewhat arbitrary as she moved among the eggs, but the net effect was a radial distribution of eggs toward the enclosure's periphery (Fig. 10). The female favored the rear fence-line, where viewing was poorest, but when viewers approached, she stopped eating and moved away. Two hours later when she returned to her den, the experimenters entered the enclosure to collect the four eaten eggs. Since the fifth egg was scratched, but not punctured, it was left in place; however, its remains were collected later that day before additional eggs were set out.

In the late afternoon, five more eggs (11–15) were placed in the female's enclosure. Although she

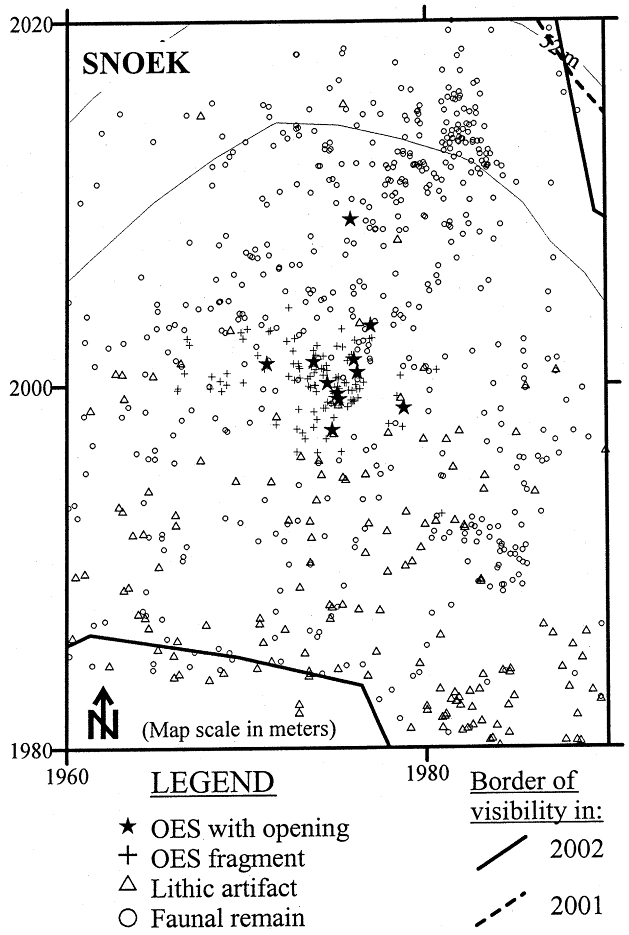

Fig. 6. Geelbek. Fig. 2. Geelbek. Plot showing spatial distribution of OES, lithic artifacts and faunal remains at the locality *Snoek*. (Contour interval=1 m.)

occasionally emerged from her den to sniff and bite the eggs, she did not eat them during daylight. Observation was discontinued after 80 min due to darkness, but by the next morning she had consumed all of the eggs. A radial pattern of distribution was again apparent, with the eggs scattered outwards, towards the perimeter of the enclosure. In addition to the five main eggshell scatters, five smaller scatters (A–E) were recovered, representing portions of eggshells that the hyena had redistributed. Over the course of 24 h, the female consumed the contents of ten ostrich eggs.

Although the 16-year-old male hyena first appeared interested in the eggs (6–10), he mostly sniffed, growled and remained in the brick den at the end of his enclosure. After two periods of observation, all five of the eggs remained uneaten. One egg (6) was retrieved for use in another experiment. By the next morning, three of the eggs (7–9) had been eaten, while one egg (10) remained whole.

Three eggs (16–18) were placed in the common enclosure of a 2-year-old male lion, a 2-year-old female lion and a 2-year-old male tiger. Within 30 s, each animal had taken control of one egg. The male tiger quickly broke open an egg (17) that was already cracked and devoured the contents, while the female and male lions appeared to play with their eggs. The male tiger then began to bat another egg (16) about, running it backwards until it hit a stone retaining wall and cracked open. All three animals ate from it. After rolling the last egg (18) about, the female lion bit down until it broke open. After she and the male lion had eaten from it, she proceeded to crunch it into smaller bits. Based on their playfulness and curiosity, these animals seemed to welcome the experiment as a diversion.

The egg (6) removed from the enclosure of the male hyena was placed in the common enclosure of a pair of 4-year-old male wild dogs. The dogs immediately began to bat the egg about. One of the dogs took control and rolled on to its back on top of the egg. This behavior did not seem intended to break the egg, but rather to mark it or possibly cover the scent of the male hyena (Fourie, pers. comm.). The next morning the egg lay undamaged at the side fence-line.

After the eggs were retrieved from the enclosures, they were collected in plastic bags, labeled and returned to the South African Museum for washing and air-drying. The subsequent analysis of the eggs included weighing the remains, identifying and refitting the aperture pieces, measuring the diameter of the apertures and describing the pattern of breakage.

2.1. Results

A summary of the results is presented in Tables 1 and 2 and discussed in more detail in the following paragraphs. The results show that these carnivores produce both single and multiple openings during feeding, mostly along the sides of the eggs. From inside the shell, the apertures reveal conchoidal fracture, whereas the outside often appears ground, chipped or beveled (Fig. 11a–d).

Using an average empty OES weight of 238 g (this study), the results in Table 1 underscore that recovery of the eggshell fragments was complete. The possibility that some of the eggs were mixed by the hyena is unlikely because refitting did not indicate the presence of any switching. None the less, a small amount of eggshell could have been ingested, hidden in the den or simply not found.

Of the eggs fed to the hyenas, the average diameter of the openings was 9.0 mm with a noticeable difference observed in the apertures made by the male (11.4 mm) versus the female (8.4 mm). Compared to the data from Geelbek, the resulting unimodal distribution (Fig. 5) parallels that from *Snoek* but stands in contrast to the bimodal distribution from *Equus*. The diameters created by the felines (5.9 mm) are smaller than those made by

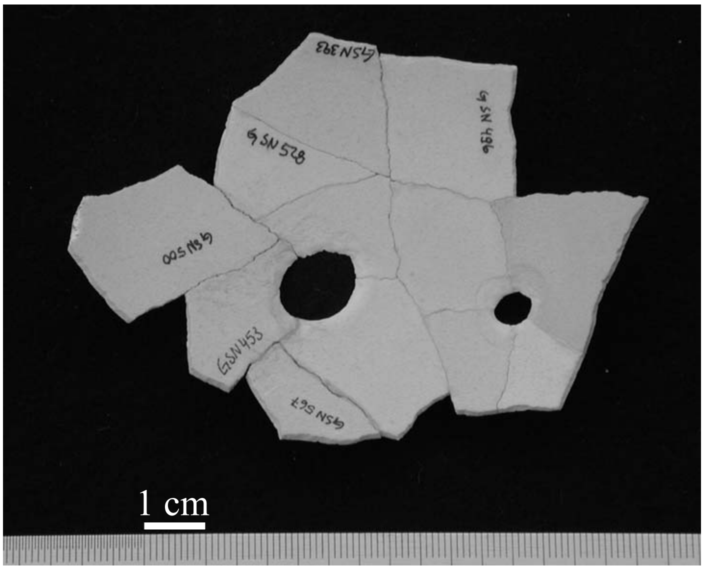

Fig. 7. Geelbek. The 12 refitted OES fragments from Refit Group 1 in the locality *Snoek* represent two complete, adjacent holes, 7 and 14 mm in diameter and located 34 mm apart. One piece from the reconstruction, SN-500, dated to 775 ± 40 BP (KIA-17759) using conventional ^{14}C dating.

Fig. 8. The female hyena, upper left, approaches five eggs (11–15) at the Tygerberg Zoo on 21 May 2002.

the hyenas. Although most of the apertures are smaller than those of OES flasks described in the literature (Table 2), about 40% of the holes occur within the hypothetical range of a flask. In fact, of the four eggs with only one hole present, three of the apertures fall within the anticipated range of OES flasks.

The eggs eaten by hyenas average 2.0 holes per egg with a slight difference observed between the male and the female (Table 2). For the felines, twice as many holes were observed per egg. These data differ significantly from the OES flasks described in the literature, which, with few exceptions, exhibit one hole per egg. None the less, four of the 16 eggs strongly resemble OES flasks in that they exhibit just one hole (Fig. 12).

3. Flask manufacturing experiment

To differentiate between damage caused by carnivores and intentionally made flasks, the author conducted another experiment to examine patterns of breakage resulting from the manufacture of OES flasks. The methods and results of this experiment are discussed in the following paragraphs.

Fig. 9. Geelbek. Typical scatter of OES (17) after a carnivore devoured it, in this case, a male tiger.

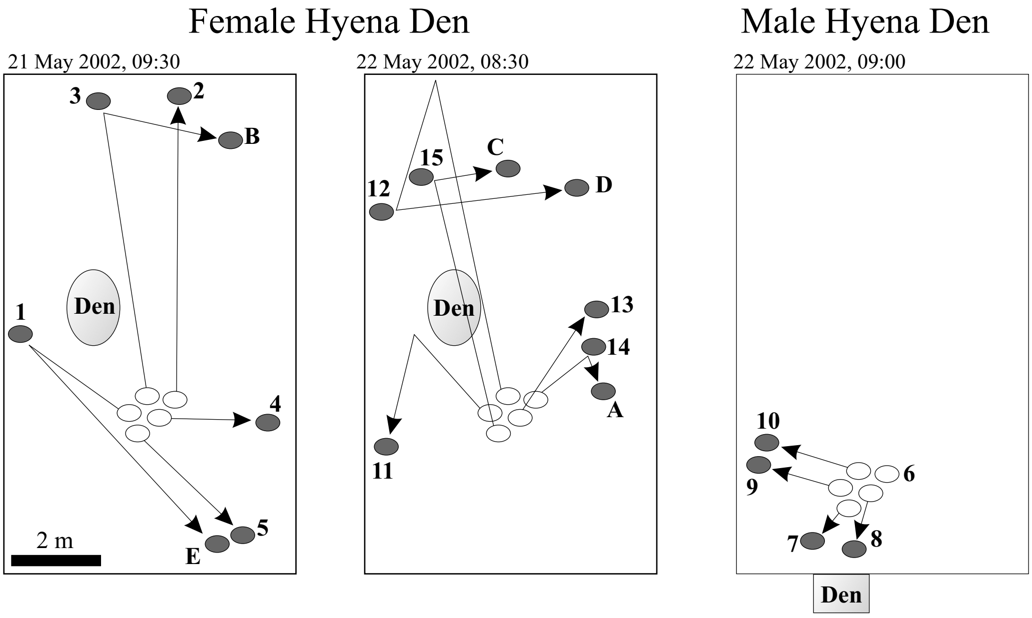

Fig. 10. Geelbek. Schematic diagram showing the start and end positions, indicated by open and shaded eggs, respectively, of the 15 ostrich eggs placed in the female and male hyena enclosures at the Tygerberg Zoo.

Based on observations made at the West Coast Ostrich Ranch, where hundreds of single-holed OES flasks are made with the rounded side of an ordinary tablespoon, the author subjected fresh ostrich eggs to both direct percussion and drilling with the intent of creating OES containers. Holding the egg upright on a grassy surface with one hand and a lithic artifact in the other, the experimenter gently tapped or drilled the narrow end of an egg (Fig. 13).

The implements included hammerstones, a pointed flake and a tablespoon. In the case of tapping, rounded objects were used until the eggs just gave way, usually after three or four blows. In the case of drilling, one of the chosen artifacts shattered, so the technique was altered to pecking with a pointed flake. An attempt to create a second, adjacent hole was conducted on two of the emptied eggs. However, the successive blows on a hollow egg cracked it. A similar experiment on two full eggs produced the same result, so that no successful two-holed containers could be produced.

Finally, a reed was utilized to round out the aperture and mix up the egg (Fig. 14). The contents were

Table 1
Geelbek. Summary of the OES used during the carnivore experiments at the Tygerberg Zoo. Completeness compares the recovered weight to an average of 238 g, as presented in this paper. Two unrecovered eggs (6 and 10) are excluded from the average. Letters A–E denote parts of eggshells that were separated from their original egg, but refit on to that egg.

Animal	OES number	Weight of OES (g)	Completeness (%)
Female hyena	1+E	297.8	125
Female hyena	2	241.0	101
Female hyena	3+B	209.3	88
Female hyena	4	259.4	109
Female hyena	5	242.3	102
Male hyena	6	0.0	0
Male hyena	7	262.9	110
Male hyena	8	259.4	109
Male hyena	9	207.5	87
Male hyena	10	0.0	0
Female hyena	11	321.2	135
Female hyena	12+D	193.0	81
Female hyena	13	203.9	86
Female hyena	14+A	277.7	117
Female hyena	15+C	219.1	92
Male tiger	16	209.6	88
Male tiger	17	283.1	119
Female lion	18	179.5	75
Average	–	–	102%

extruded with a straw, and a portion of the egg was consumed as crepes served with a spinach and feta filling. The volume of egg, more than one liter per egg, vastly exceeded the amount that three archaeologists could consume in one meal.

To allow for analysis at the end of the experiment, all of the flasks were broken against a flat rock. Significantly, no additional percussion marks resulted from this activity, which signifies that only specific types of impact are capable of creating conchoidal fractures.

3.1. Results

These experiments confirmed the practicality of the methods used to manufacture single-holed OES flasks at the West Coast Ostrich Ranch. Whether the experimental OES were tapped with rounded artifacts or pecked with pointed artifacts, the resulting conchoidal openings (Fig. 15) were similar in size and shape to the OES fragments from Geelbek and to those modified by carnivores at the Tygerberg Zoo. Furthermore, the manufacture of two adjacent holes using percussion was unsuccessful, indicating that the two-holed openings from *Equus* may indeed result from carnivores.

The measurement of 104 OES containers manufactured at the West Coast Ostrich Ranch resulted in an average weight of 238 ± 37 g and openings of 20.0 ± 4.1 mm (Fig. 16). The weight is 14% lower than Humphreys' [16] oft-cited value of 272 ± 25 g. However, he regards his figure as an unrepresentative sample of seven OES flasks measured from a museum collection. In this light, the new data better approximate the weight of an average OES flask because they represent a larger sample size from a "natural" population.

4. Discussion

In order to apply the results of these experiments and interpret them with regard to OES flasks, it is necessary to discuss the natural history of ostrich nests and the behavior of those animals that scavenge them. It is also important to establish ethnographical uses of OES flasks and to examine their presence in the archaeological record. This discussion provides the framework necessary to assess alternative hypotheses for interpreting modified OES.

4.1. Ostrich nests

The relevant nesting habits of ostrich in arid parts of southern Africa is summarized here. Although breeding may occur throughout the year, it peaks during the dry season of the austral spring and summer [11]. Before mating, the male excavates a nest as a shallow depression in sandy soil usually on bare ground [38]. After mating, a major hen and 2–5 minor hens lay their eggs in a single nest, although the minor hens lay eggs in multiple nests. The hens deposit up to 30 eggs in a common nest over the course of 18–20 days. Since about 20 eggs fit beneath an incubating ostrich, the remainder are ejected by the major hen, who shows a preference for her own [4].

The creamy white eggs are highly variable in texture, gloss and size, with an average size of 125×150 mm [38]. The maximum weight of a full egg is about 1.5 kg. Although ostriches synchronize the brood's emergence by regulating the position of the eggs within the nest, under optimal conditions 80–85% of the brood hatch after 42 days. Thus, the unhatched eggs become available to scavengers. More important, ostriches often assist the chicks' emergence by pecking on the eggs (Hemett, pers. comm.). Increased predation by carnivores and vultures leads to decreased hatching potential, with a figure as low as 33% in eastern Africa [4].

4.2. Predation of ostrich egg nests

Adult brown hyenas are noted consumers of ostrich eggs [1,22,24,36,37] and will even carry unbroken eggs in their mouths over long distances, up to 6.8 km [22].

Mills [22] observed one female hyena's predation of an unattended nest of 26 ostrich eggs over the course of a night's foraging in the Kalahari. Within four hours the female ate five of the eggs at the nest and radially distributed 13 eggs in the bush up to 600 m away. By the

Table 2
Geelbek. Summary of experimental data comparing the various experimental categories with regard to number of specimens (*n*), average hole size, range of hole size, standard deviation of the measured apertures and number of resultant holes per egg. Only standard deviations for the larger samples are presented. "Indet." indicates insufficient data.

	Carnivore experiment						OES flasks			Geelbek		Vogelsang (1998)	
	All animals	Both hyenas	Female hyena	Male hyena	All felines	Single holes	Literature review	Ostrich farm	Experimental data	*Equus*	*Snoek*	*Pockenbank*	*Apollo 11*
n=	35	26	21	5	9	4	25	104	8	46	10	57	45
Average hole size in mm	8.2	9.0	8.4	11.4	5.9	12.0	13.1	20.0	12.8	11.0	8.4	Indet.	19.0
Range of holes in mm	1–16	3–16	3–16	5–15	1–15	7–16	10–15	10–38	9–23	1–27	4–15	7–35	7–30
Standard deviation in mm	4.2	3.6	3.1	–	–	–	2.4	3.9	–	6.5	–	–	7.5
Number of holes per egg	2.3	2.0	2.1	1.7	4.5	1	1	1	1	Indet.	Indet.	Indet.	Indet.

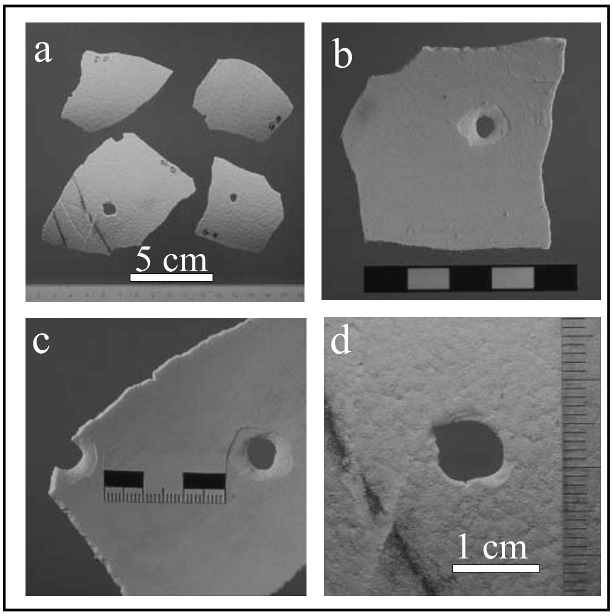

Fig. 11. Geelbek. (a) Examples of the range of holes made by the hyenas at the Tygerberg Zoo; (b) one hole; (c) two holes; and, (d) evidence for an irregular shaped, chipped opening on the outer egg surface with tooth marks in the lower left. (Photos (a–d) H. Jensen.)

following afternoon, she had removed all of the eggs from the nest and continued to eat the eggs stored in the bush. A second brown hyena had already begun to eat some of her stores. Mills surmises that the behavior of distributing food in the bush, or "scatter hoarding," minimizes the hyena's loss to other scavengers. Mills ([23]: 81) relates how:

> When eating an ostrich egg at the nest, the [female brown] hyena … bit a small opening in the top of it using her premolars. She then lapped up the contents with its tongue … As the level in the egg dropped she bit the egg open further, continuing in this way until she had finished. Any of the contents that spilled on the sand were lapped up, but on the whole she was careful not to spill any …

This description meshes well with the observations made at the Tygerberg Zoo and aptly describes how a brown hyena devours an ostrich egg.

Other species are known egg scavengers, as documented by the remains of regurgitated OES in the dens of the spotted hyena, *Crocuta crocuta,* [13]. However, Kruuk [19] reports that spotted hyenas in eastern Africa have difficulty opening and transporting ostrich eggs. Egyptian vultures (*Neophron percnopterus*) in southern and eastern Africa have been observed cracking open ostrich eggs by throwing stones at them [11,19,34,39]. In one case, after failed attempts by a golden jackal (*Canis aureus*) and two spotted hyenas, an Egyptian vulture succeeded in opening an egg, only to be chased off by two hooded vultures, that were in turn scared off by a spotted hyena [19]. Another possibility which was described in the Northwest Cape over 150 years ago, but which Skead [35] discounts, is that whilst in flight, the Egyptian vultures drop stones on the eggs.

4.3. Ethnographical documentation and archaeological evidence for OES flasks

OES flasks are well documented in southern Africa both ethnographically (cf. [3,20,32,33]) and archaeologically (cf. [8,17,29,41]). Deacon and Deacon [7] associate the presence of OES flasks with LSA archaeological contexts as they play a significant role in the burial practices of Khoisan and LSA people (cf. [9,10,21]).

The most frequent type of OES flasks are those with a single hole at the narrow or tapered end of the egg (cf. [9,10,20,25,30,32]). Most of the measured apertures range from 10–15 mm (Table 2) (cf. [20,29,30]) and were manufactured using one or possibly a combination of techniques: drilling, punching, grinding or hammering. Although it is possible to perforate the broad end of an ostrich egg to create a container, this design seems less practical and is not reported. A less common variant is a flask with an aperture in the middle of its side [25,29]. The least frequent "mid-way" variant, perforated between the end and side, is described from the Northern Cape by Rudner [30] and Morris and von Bezing [27].

The most accepted interpretation for these containers is that they held water after the original contents were emptied (cf. [2,3,20,32,33]). Alternate uses for storage are documented by the presence of ground specularite [15,21,30], fragments of ostrich eggshell [31] or ant larvae [2] found inside the containers. Broken eggshell flasks were recycled into OES beads and pendants [20,32].

For storage, they were sealed either with a plug, grass [20], clay or beeswax [29] and buried underground in caches [25,27,31] or even hidden in trees [32]. Recent reports from the Northern Cape document the presence of spouts molded from a resinous material attached to the opening. Both Henderson [12] and [26] attribute the spouts to the Khoisan as a localized development dating from the 19th century.

Although the presence of a broad variety of engraved patterns on the exterior of OES flasks confirms their connection with human activity [17], most sources remark that engravings are relatively infrequent [20,25]. The containers often become polished from frequent usage, or perhaps intentionally, and some are decorated with charcoal or red ochre [29,30]. Morris and von Bezing [27] report staining from an organic material on one flask, presumably resulting from rope or leather netting used for transport.

A single example of a double-holed container, a "mid-way" variant perforated twice along the same

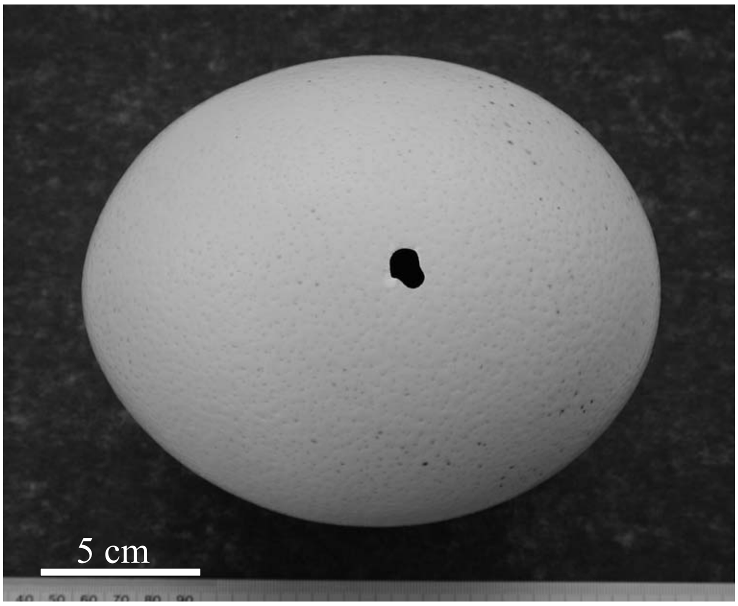

Fig. 12. Geelbek. An example of a complete, single-holed OES made by a hyena. The egg was recovered before the hyena ate it.

Fig. 13. Geelbek. A rounded stone was used during the OES flask-making experiment. (Photo U. Maurer.)

longitudinal axis, but on opposing hemispheres, is displayed at the South African Museum. Rudner ([29]: 82) also describes one double-holed flask among a cache of seven from the Northern Cape that:

> … has a small hole (4 mm) almost opposite the main hole [which was 10 cm in diameter and on the side]. On emptying this shell a small disc, the size of the large hole, fell out—it must have fallen in when the opening was being made.

These instances seem to reflect an alternate design for OES containers.

Scant evidence exists for MSA flasks in southern Africa [14,40]. Vogelsang's analysis of the diameters of reconstructed openings from stratified sites in south-western Namibia shows similarity to the Geelbek data, with measured diameters ranging from 7–30 mm (Table 2; Vogelsang, pers. comm.). While the data from *Pockenbank* display a bimodal distribution like *Equus*, the data from *Apollo 11* appear unimodal, like *Snoek* [40]. Additionally, excavations from a secure MSA context at Diepkloof in the Western Cape resulted in the recovery of 13 OES apertures in association with pieces of decorated OES (Poggenpoel, pers. comm.). Given this

Fig. 14. Geelbek. A reed was used to chip out and enlarge the opening and to mix the egg contents. (Photo U. Maurer.)

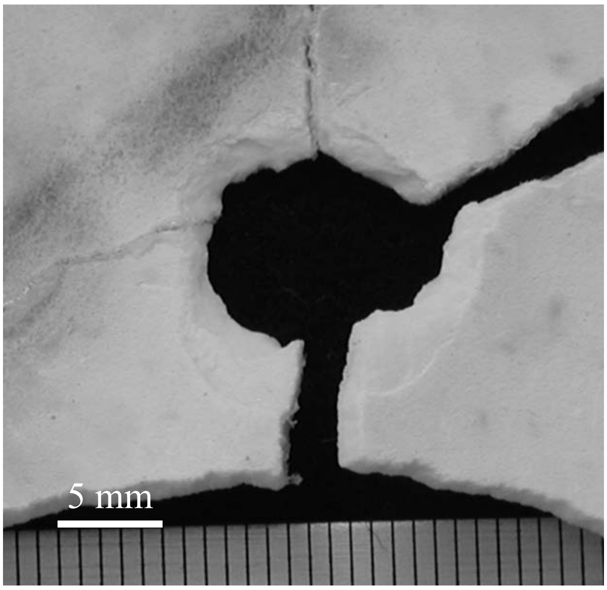

Fig. 15. Geelbek. This hole on the interior surface of an OES resulted from the impact created using a tablespoon during the flask-making experiment.

paucity of data, the MSA dates for OES fragments from Geelbek [5] represent an unusual occurrence.

5. Conclusions

In summary, OES flasks documented from archaeological and ethnographical contexts in southern Africa resemble, in both size and appearance, OES fragments that are clearly modified by carnivores. This observation makes the positive identification of OES flasks a difficult task.

While openings such as those documented at Geelbek appear similar to those from OES flasks described in the literature, their mere existence should not automatically imply a flask. The attributes presented in Table 3 offer a working list of criteria to establish a positive identification. Lacking defining characteristics, the interpretation of a rim fragment of OES must be considered as inconclusive. Thus, traces of grinding, chipping or beveling which appear on the outside of an OES should be interpreted only as supporting evidence for identifying an OES flask, as these traits also result from carnivore feeding. Therefore, it must be assumed that the double-holed fragments from Geelbek instead offer the best evidence for predation by carnivores.

Taphonomic evidence must also be cited to support an anthropogenic origin for the rim pieces of OES flasks. For example, the presence of crushed or etched bone could indicate scavenging by hyenas. Behavior such as scatter hoarding by hyenas should also be considered in relation to the distribution of OES at a site, and other scavenging agents, such as lions or Egyptian vultures, must be taken into account. Finally, research specifically including microscopic analysis is needed to examine how ostrich eggshell modified by humans differs from that modified by carnivores.

Returning to the three possibilities presented in the introduction, a summary of the findings follows:

5.1. Ostrich nests that were scavenged by carnivores

The probability that the Geelbek OES fragments result from scavenging by carnivores is high. The strongest support for this hypothesis is the presence of two-holed pieces from *Equus* and *Snoek* set amongst a

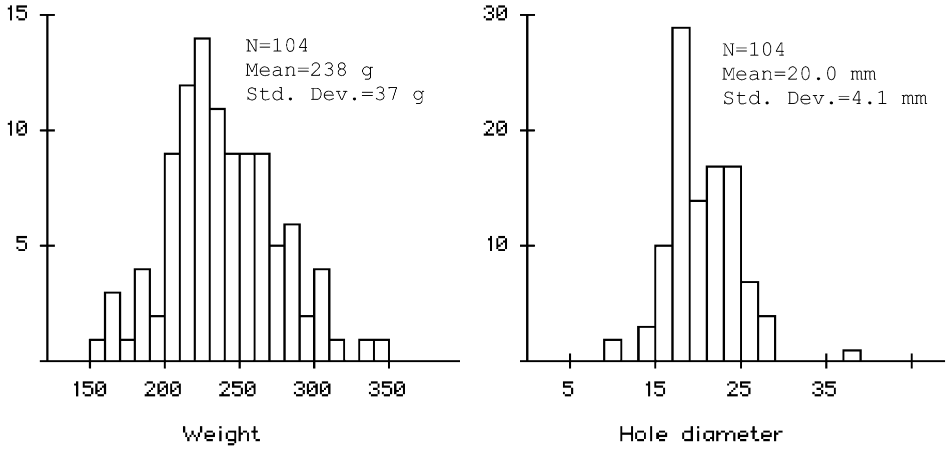

Fig. 16. Geelbek. Histograms of the weight of a "natural" population of empty OES flasks and the diameter of their openings measured at the West Coast Ostrich Ranch on 16 January 2003.

Table 3
Geelbek. List of criteria for identifying OES flasks at archaeological sites

List of criteria to identify whether modified fragments of OES at archaeological sites represent rim pieces of flasks:
1. Well-stratified site with no evidence of carnivore activity
2. Complete or refitted, single-holed OES
3. Subsequent modification to opening (e.g. resin spout, stopper)
4. Engraving (e.g. geometric patterns, lines)
5. Decoration (e.g. charcoal, ochre)
6. Use wear on the outer surface (e.g. polish, staining, or discoloration from organic materials)
7. Trace of contents (e.g. specularite, ochre, ant larvae, OES fragments)
8. Openings consistently made at one location on several eggs (e.g. cache)

Criteria which may indicate OES flasks, but which should not be used independently:
1. Undecorated opening with conchoidal fracturing on the inner surface
2. Opening with a chipped, beveled or ground outer surface

predominance of single-holed pieces. Furthermore, the apertures of most of the single-holed pieces measured less than 10 mm, a diameter smaller than that typically associated with flasks. However, two arguments support the flask hypothesis. First, the bimodal distribution of the diameter of the apertures from *Equus* deviates from the unimodal distribution observed in *Snoek* and the carnivore experiment. This suggests two modes of origin, with the second "hump" coinciding with the typical range for OES flasks. Second, hyenas in the wild tend to scatter hoard their finds across large territories. Thus, the concentration of at least eight ostrich eggs in *Equus* is less likely to result from scavenging. The behavior of scatter hoarding exhibited by the female hyena at the Tygerberg Zoo and exemplified by her radial displacement of the OES supports this conclusion.

5.2. Natural remnants of a hatched ostrich brood

If the OES finds reflect the remains of a hatched brood, they should include examples with traces of pecking from the inside, which is not the case at Geelbek. Instead the apertures clearly show that impact came from the outside. Of course, pecking by hens to assist the emergence of the chicks cannot be overlooked as a potential source of modification.

5.3. Geologically broken eggshells

If the eggs were broken by geological forces, there should be no indication of intentional breakage. Modifications such as percussion marks or ground, chipped or beveled edges should not be present. Since the OES present at Geelbek appears modified, the breakage by geological or other passive taphonomic forces is deemed unlikely.

Acknowledgements

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South African Museum maintains the artifacts from Geelbek under the accession numbers: SAM-AA-9008 through 9011 and 9020. W. Fourie and J. Spence of the Tygerberg Zoo near Cape Town helped immensely in the development and implementation of the carnivore experiment. G. Kanigowsky and H. Omar of the West Coast Ostrich Ranch and M. Michau of Doornhoek Ostrich Farm provided information about ostriches and furnished the eggs for the OES experiments. Special thanks are due A. Fernandes for his support in the field and N. Conard for his assistance with the manuscript. The archaeological research in the West Coast National Park was approved by the South African Heritage Resources Agency (SAHRA Permit No. 80/02/02/012/51) and enabled through cooperation with the South African National Parks Board. The project was fully funded by the Department of Prehistory and Quaternary Ecology at the University of Tübingen through a research grant from the *Deutsche Forschungsgemeinschaft*.

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Appendix B.5

Kandel, A.W. & Conard N.J. (2005) Production sequences of ostrich eggshell beads and settlement dynamics in the Geelbek Dunes of the Western Cape, South Africa. *Journal of Archaeological Science* 32, 1711-1721.

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Production sequences of ostrich eggshell beads and settlement dynamics in the Geelbek Dunes of the Western Cape, South Africa

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Abstract

The archaeological record attests to the significance of ostrich eggs as a valuable resource for the people of the Later Stone Age. People over a broad geographic range used ostrich eggs to provide nourishment, storage and ornamentation. This paper focuses on the production, use and discard of ostrich eggshell beads recovered from open-air sites in the Geelbek Dunes of the Western Cape, South Africa. We present a comprehensive production chain for analyzing the manufacture of beads and introduce the concept of a heuristic *production value* for evaluating the degree of completion reflected by an assemblage. The pattern of fabrication and the distribution in size allow for a detailed analysis of the beads that points to specific behavioral patterns involved in their production. This analysis yields information about the duration and intensity of site use, as well as the individual members and cultural affinities of the groups who made the beads. We document the intentional use of fire to blacken the majority of the beads as an aesthetic choice. Combined with the results from AMS radiocarbon dating, the majority of the beads from Geelbek provide insight into the socio-economic identity of their manufacturers: small groups of hunter–gatherers who inhabited and used specific locations on the strandveld near Langebaan Lagoon.

Keywords: Later Stone Age; Landscape archaeology; Open-air sites; Ostrich eggshell beads; Hunter–gatherers

1. Introduction

In 1998 the Department of Prehistory and Quaternary Ecology of the University of Tübingen began the *Geelbek-Anyskop Ausgrabungs und Survey Projekt* (GAASP) in the West Coast region of Western Cape Province, South Africa (Fig. 1). Over the course of the eight intervening field seasons, a team of archaeologists from Tübingen surveyed and monitored 114 deflation hollows within the Geelbek Dunes of the West Coast National Park (Fig. 2) and excavated finds from 23 of these open-air localities [6,7,15,17]. These localities include Middle Stone Age (MSA) and Later Stone Age (LSA) sites selected from both archaeological and paleontological settings of varying find density. Although these localities are presently covered by highly mobile sand dunes, during most periods of occupation, the modern set of dunes had not yet migrated into this region, according to G. Franceschini's Doctoral Thesis (2003) from the University of Cape Town. Instead, the area was characterized by *strandveld* vegetation of low, scrubby brush, as evinced by calcified rhizoliths (fossilized roots) that are visible in the loosely consolidated, uppermost, geological horizon named Ancient Dune II (AD II) by Felix-Henningsen et al. [9]. Our

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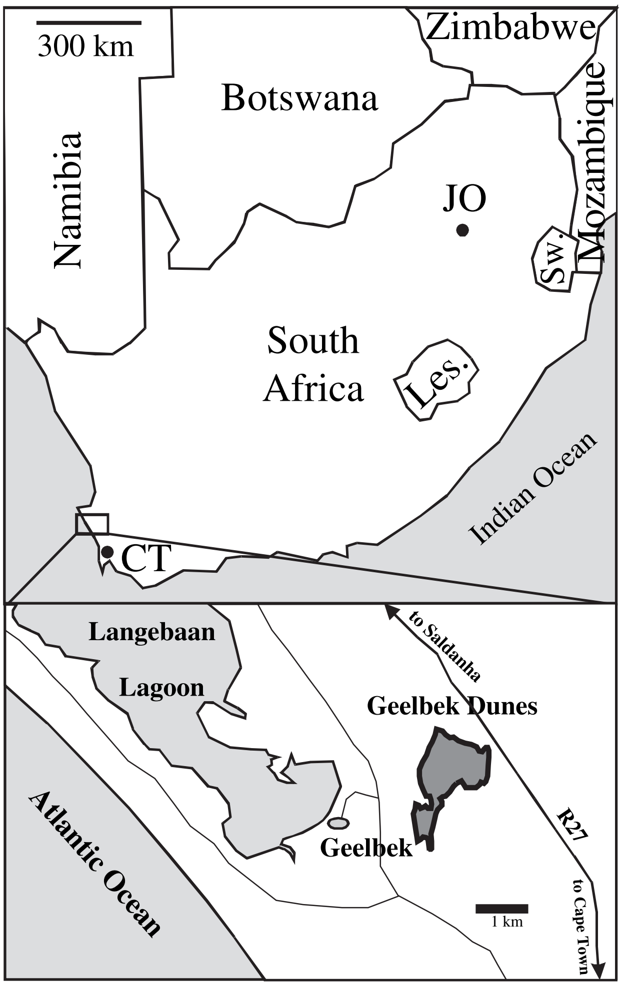

Fig. 1. Regional map of Southern Africa showing the location of the Geelbek Dunes in Western Cape Province. (CT = Cape Town, JO = Johannesburg.)

research strategy uses the devegetation and deflation caused by mobile sand dunes as a means of sampling the otherwise invisible archaeology of the *strandveld.*

The most frequent inhabitants at Geelbek during the LSA were hunter–gatherers who knapped stone tools characterized mainly by segments, backed bladelets and small scrapers made from silcrete, quartz and several other fine grained raw materials. They also utilized ground stone tools made on coarse grained rocks including metamorphosed greywacke, quartzite and granite. Their use of terrestrial resources focused on small animals such as tortoise, small bovid and dune mole rat. Less frequent remains of medium and large sized bovid, as well as rhino and elephant, attest to the use of larger fauna for subsistence. Domesticated species, which would indicate the presence of herders, are rare. From ostrich eggshell (OES) they produced small and occasionally large beads. The LSA inhabitants of Geelbek also used marine resources, despite their location 5 km from the sea. Marine resources included whale [16], seal, penguin, fish, crustaceans and mollusks. Marine shells also provided the raw material to create scrapers and ornaments.

The presence of numerous stone features shows that the LSA people often returned to this area. Burned concentrations of calcrete blocks mark locations of stone hearths that often form a focal point for scatters of many classes of finds [16]. Unburned concentrations of calcrete may indicate unused hearths, working areas or living areas [1]. The presence of plain, spouted and lugged ceramic vessels may attest to occupations by herders at some of the localities, but the importance of pottery as an indicator of herders is contested [22]. Finally, various historical artifacts from the 18th to 20th centuries bring the scope of archaeological remains into the present. In 2003, A. Malan and J. Klose from the University of Cape Town analyzed the modern finds, which include artifacts such as clay pipes [18], Chinese provincial ware, refined industrial ware, a bone pen knife, powder tins and a coin minted in 1843 among the shards of ceramic, glass and metal.

2. Background

The production and use of OES beads have been well documented ethnographically [4,24,25]. Although ostrich eggs may have originally met nutritional needs or been utilized for storage purposes [19,24], the bead-making process begins when an ostrich egg breaks, either intentionally or accidentally. Larger fragments can be directly processed into ornaments such as discs and pendants [31]. The smaller pieces may be used as they are or further fragmented to a desirable size. The resulting OES pre-forms, or blanks, were often stored in OES containers [23]. Starting with the blanks, the production chain takes one of two typical directions. One entails the initial drilling of angular blanks followed by rounding, while the other involves the initial rounding of blanks followed by drilling [8,20,31]. Intentional burning to darken the beads could, in theory, occur at any point during the sequence.

Beck [3] devised a system to describe any type of bead based on its form, perforation, color, material and decoration. With specific reference to OES beads, Plug [20] defined nine production stages, including broken ones, outlining the steps associated with bead preparation. For the purpose of this analysis, we expanded Plug's [20] system, incorporating a total of 12 forms into a sequence that describes the production of a single bead from initial blank to finished product (Table 1 and Fig. 3). In this paper, "blank" (stage 1) signifies an angular, unmodified, fragment of OES of appropriate dimension to enable the manufacture of a finished bead. A "bead" refers to any stage of production, while "finished bead" (stage 11) designates only the final,

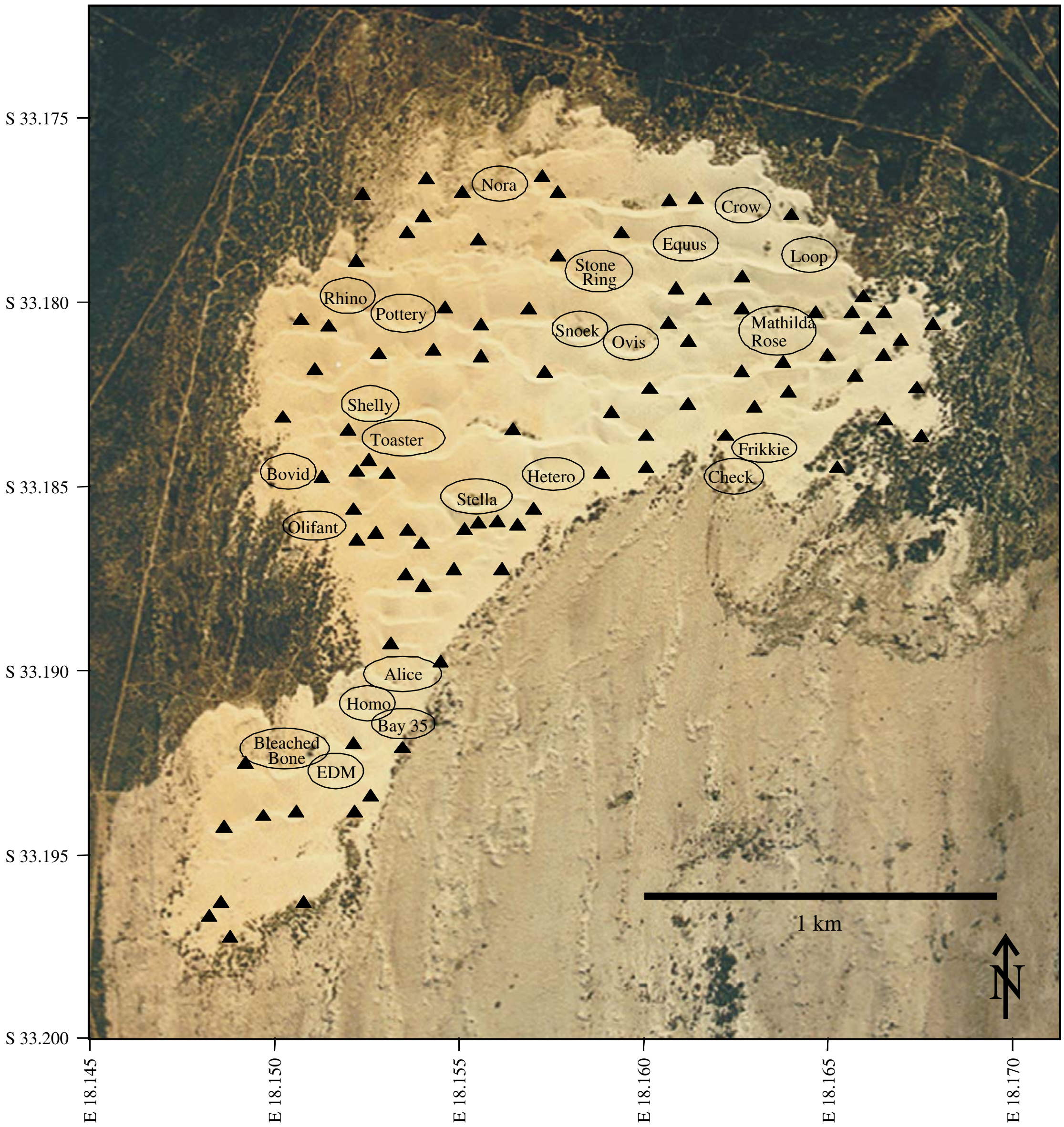

Fig. 2. Aerial photograph taken in April, 2000 showing the extent of the Geelbek dune field. The names of the 23 deflation hollows where large-scale, systematic excavations were conducted are indicated in ovals. The other surveyed bays are indicated by triangles. The devegetated area to the southeast of the dunes resulted from the Hopefield fire that charred a total of 18,400 ha along the West Coast in January, 2000.

completed form. A broken, finished bead (stage 12) represents the final stage in the system of production, use and discard.

In order to describe and compare the localities at Geelbek we introduce a heuristic term, the *production value* (pv), to quantify the degree to which a group of beads has reached the endpoint of manufacture. The pv ranges from 1 to 12 and represents the arithmetic mean of the analytical results. Thus, a pv of 1 indicates a group of blanks, while a pv of 12 represents a collection of broken, finished beads. The pv is a code that represents the process involved in the transformation of a piece of OES into a finished bead. In the same way, we employ the standard deviation as a heuristic means of describing the range of production stages present in a population of beads. Thus, a lower standard deviation indicates a greater degree of uniformity in production.

Our reason for conducting such an analysis is based on Jacobson's [11] premise that the presence of certain bead production stages indicates the length of occupation and the extent to which specific activities occurred at a given locality. Incorporating ideas about bead manufacture from the descriptions of Drury [8] and Schapera [24] among others, Jacobson associates bead production with places where women lived. Where blanks are absent, for example at a site used briefly, such as a kill site, he infers the absence of women. At sites occupied for a short duration where a small family

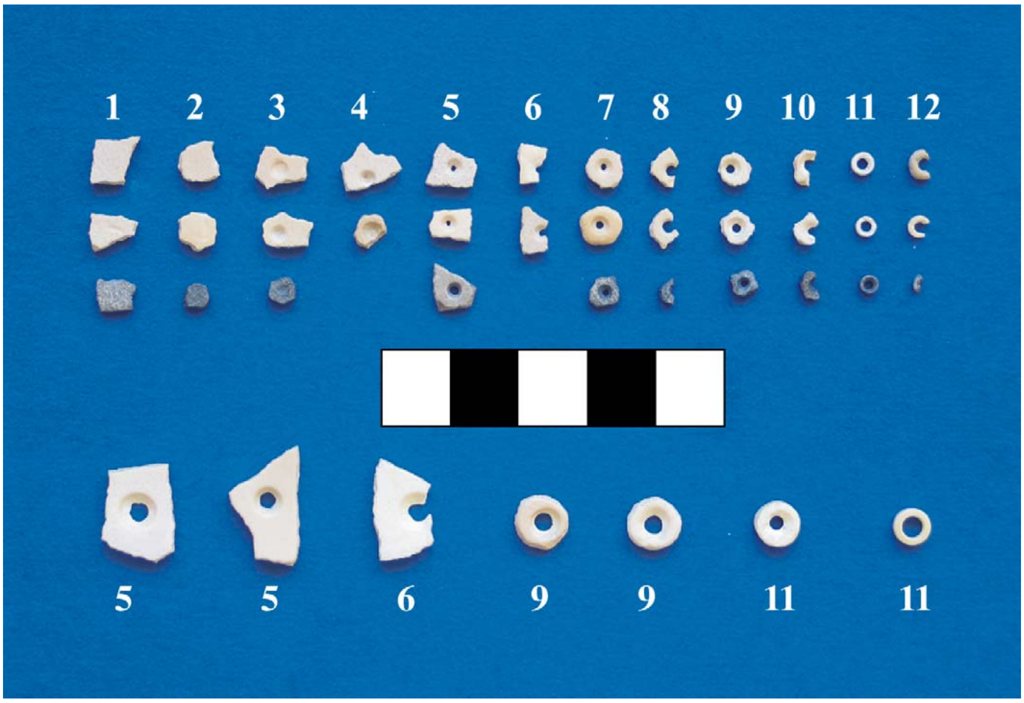

Fig. 3. Photograph documenting the 12 stages of bead production used in this analysis. The small, unburned beads in the top two rows were recovered from the localities *Nora* and *Shelly*, while the small, burned beads in the third row were excavated in *Pottery* and *Nora*. The large beads in the bottom row come from *Toaster*. See Table 1 for key.

group might be present, such as where meat processing occurred or at a transit camp, he suggests that finished beads would be more common, while unfinished beads would be lacking. For sites of long occupation, such as base or aggregate camps, he expects a greater range of forms to be present. Thus, Jacobson correlates a wider spectrum of production forms and sizes with more intense and longer use of a site. Jerardino [13] emphasizes the usefulness of this approach in trying to calculate find densities in relation to the duration and intensity of an occupation.

Table 1
Definitions of the 12 production phases of ostrich eggshells beads identified in this paper, keyed to the photograph in Fig. 3

Code	Bead production phase
0	Indeterminate
1	Angular blank
2	Rounded blank
3	Complete, partially drilled blank
4	Broken, partially drilled blank
5	Complete, perforated blank
6	Broken, perforated blank
7	Complete, perforated, slightly formed bead
8	Broken, perforated, slightly formed bead
9	Complete, perforated, almost bead form
10	Broken, perforated, almost bead form
11	Complete, finished bead
12	Broken, finished bead

Jacobson [11,12] argues that the production of finished beads in the LSA contains a temporal dimension that relates their maximal diameter to different cultural groups. In his analysis he observed three types of sites that are characterized by a tendency towards the production of: (1) predominantly small finished beads; (2) a mixed distribution of small and large finished beads; and, (3) predominantly large finished beads. Jacobson surmised that the small finished beads were associated with groups of pre-pottery hunter–gatherers (Type I). A mixture of smaller and larger finished beads (Type II) indicated a contact or mixed period, while groups of earlier (Type IIIA) and later (Type IIIB) post-pottery herders preferred increasingly larger forms of finished beads. Although Jacobson [11] posits 7.5 mm as the division between small and large beads, the boundary separating the majority of beads appears between 5 and 6 cm. Smith and Jacobson's [27] report on the excavations at Geduld (Namibia) supports the validity of this approach. Yates' [33] stratigraphically controlled statistical analysis of the finished beads from Geduld confirms that bead size increases with time. Yates' results also show that a divide at 5 cm is appropriate.

Smith et al. [29] propose a model to conceptualize the material differences between hunter–gatherers and herders, incorporating average OES bead size, as well as find densities of domesticated stock and pottery. Yet even within this conceptual framework, the results presented by Smith et al. [29] suggest that variability in bead size can be expected. This model seems plausible, as subsequent studies have demonstrated [26,34]. However, Sadr et al. [22] note that differences in material remains at Kasteelberg, about 45 km northwest of Geelbek, at least during the past two millennia, may portray diverse economic strategies and not necessarily separate cultural groups. Sadr [21] argues that pigeonholing specific attributes as indicators of hunter–gatherers or herders may be too arbitrary and unproductive.

To test these different models we plan to compare the conclusions about production of OES beads at Geelbek with the results obtained from other finds, including faunal remains, lithic artifacts and pottery. Only by using multiple lines of evidence we can assess the role of these sites in the LSA economies and settlement dynamics of the West Coast.

3. Methods

The GAASP team surveyed an area of 400 ha in the Geelbek Dunes and succeeded in identifying open-air localities suitable for detailed investigation. The field work entailed the careful recovery of finds from 23 of the selected localities (Fig. 2). Using a total station, the excavators piece-plotted materials, including all lithic artifacts, faunal remains (> 2 cm), marine shell (> 1 cm), OES fragments (> 1.5 cm), all beads, all pottery and all find classes from the colonial and modern eras. The GAASP team also documented and measured features of burned and unburned calcrete and excavated 1695 m^2 units chosen mostly in areas of higher find density. By dry sieving the buckets of sand through 10 and 1.0 mm screens, the excavators were able to recover the majority of lithics and OES beads, as well as representative samples of bone, tortoise, microfauna and marine shell. The use of very fine screens led to the successful recovery of very small OES beads and fragments that researchers often overlook [33].

The incorporation of all information into MS-Access databases created the framework for subsequent data-entry during laboratory analysis. Using ESRIs ArcMap 8.2, the team integrated the field and laboratory databases into a GIS that includes aerial, topographic, orthographic, geologic and Landsat maps. The result is a single, geographically referenced, mapping system that can be applied regionally. As far as we know, this type of detailed spatial analysis of large, open-air localities has not been previously conducted in Southern Africa [6,7]. The use of such a comprehensive mapping system allows the dataset of each find to be easily accessed and correlated to its precise geographic setting. Widespread use of such a system would facilitate inter-site comparison in the West Coast region and beyond.

In the laboratory, GAASP members measured, weighed and described the OES beads. For each bead, the team recorded external diameter, thickness and internal aperture to the tenth of a millimeter and measured weight to the hundredth of a gram. To separate small from large beads, GAASP used a limit of 5 cm following Yates' [33] work. For every bead analyzed, the team recorded the following attributes:

- complete circumference (yes/no)
- complete aperture (yes/no)
- type of perforation (none, drilled from one side, drilled from both sides)
- direction of perforation (none, from inside of shell, from outside of shell, both sides)
- production stage code (1–12)
- color (white, beige, light brown, brown, light gray, gray, gray/black, black, indet.)
- patina (yes/no)
- burned (yes/no)
- polished (yes/no)
- bead code (1 = OES bead, 1.1 = small OES bead < 5 mm, 1.2 = large OES bead ≥ 5 mm)
- additional comments (e.g., indication of wear facets).

In 2000, C. Weiss of the University of Tübingen applied this system in her Master's Thesis to analyze 1780 OES beads from Mumba Cave in Tanzania. Based on our experience the system is applicable to any assemblage of OES beads.

4. Results

The following summarizes the results of the analysis of the beads (Table 2). Of the total number of OES beads ($n = 1045$) from Geelbek, the small beads (< 5 mm) vastly predominate ($n = 1024$). Although the team recovered beads from seven localities, almost all of the small beads come from three localities, *Pottery*, *Shelly* and *Nora* ($n = 1019$) with the remaining small beads ($n = 5$) from *Loop* and *Toaster*. The size distribution of the 272 small, finished beads from all localities yields an average diameter of 3.10 ± 0.32 mm and an average aperture of 1.52 ± 0.33 mm. The team found 66% of the small beads in the 1.0 mm screens ($n = 675$). The high recovery of small beads underscores the importance of using such a fine mesh.

Of the 21 large beads found at the localities of *Toaster*, *Stella*, *Loop* and *Snoek*, five finished beads were present, with an average diameter of 6.68 ± 0.99 mm and an average aperture of 3.04 ± 0.73 mm. As one might expect, a smaller proportion of large beads (29%) came from the fine screen ($n = 6$) as compared to the small beads. This bias is clearly related to the size of the beads.

Table 2
Summary of data on all ostrich eggshell beads collected from seven localities

	All beads (*n*)	Finished beads (*n*)	Percent finished (%)	Diameter (mm)				Aperture (mm)	
				Mean	Std. Dev.	Min	Max	Mean	Std. Dev.
Small beads < 5 mm									
Pottery	613	190	31	3.04	0.22	2.3	3.8	1.57	0.34
Shelly	219	69	32	3.16	0.38	2.5	4.2	1.37	0.23
Nora	187	8	4	3.19	0.20	2.9	3.4	1.48	0.21
Loop	3	3	100	3.97	0.83	3.3	4.9	1.83	0.32
Toaster	2	2	100	4.40	0.28	4.2	4.6	1.55	0.21
Total	**1024**	**272**	**27**	**3.10**	**0.32**	**2.3**	**4.9**	**1.52**	**0.33**
Large beads > 5 mm									
Toaster	11	3	27	6.60	1.25	5.3	7.8	3.03	1.01
Stella	5	0	0	na	na	na	na	na	na
Loop	4	1	25	7.40	na	na	na	2.80	na
Snoek	1	1	100	6.20	na	na	na	3.30	na
Total	**21**	**5**	**24**	**6.68**	**0.99**	**5.3**	**7.8**	**3.04**	**0.73**
All beads	**1045**	**277**	**27**	**3.16**	**0.58**	**2.3**	**7.8**	**1.55**	**0.39**

Diameter refers to the maximum external dimension of a finished bead. The aperture of a finished bead is the maximum internal diameter of the hole drilled into it.

In all, 60% of the beads are visibly burned, either black or gray, while the remainder appear unburned (Fig. 4). Among the assemblages of small, finished beads, 91% are burned at *Pottery*, 28% at *Shelly*, but none at *Nora*. Nor are any of the large, finished beads burned. In contrast to the high degree of burning at *Pottery*, only 20% of faunal remains and marine shell appear burned. Additionally, the presence of the entire range of production forms, from blank to finished bead, for both burned and unburned beads suggests two separate chains of production. The favoring of small, burned beads at *Pottery* indicates a stylistic choice by the individual manufacturers.

Plots of the size of the finished beads indicate several interesting trends. First, the difference in size between small and large, finished beads is distinct (Fig. 5), supporting the division at 5 cm. Second, the diameters of burned, finished beads overlap the range of unburned, finished beads (Figs. 5 and 6A), indicating a similar mode of production regardless of whether a bead was burned or not. Third, the apertures of burned, finished beads are generally larger, but exhibit a bimodal distribution, whereas the unburned, finished beads display a unimodal distribution (Fig. 6B) that corresponds to the smaller size range of burned apertures. The dual size range of burned apertures could indicate two separate modes of production, or may merely result from the enlargement of some of the apertures from use, a consequence of wearing strung beads. Finally, burned, finished beads are thinner than unburned, finished beads (Fig. 6C) because the eggshell begins to delaminate during the process of burning.

Among the localities *Pottery*, *Shelly*, *Nora* and *Toaster*, analysis of the production stages underscores the dissimilarities among the respective production chains, an indication that they represent separate events (Fig. 7a–d). Detailed analysis of the three localities, *Loop*, *Stella* and *Snoek*, with fewer than 10 beads is not included here. The definition and use of production value (pv) and standard deviation are explained in Section 3 of this article.

At *Pottery* ($n = 613$) the majority of the small beads are burned and exhibit a polished patina on the inside surface of the eggshell. The distribution is unimodal and demonstrates a production chain that is strongly skewed toward just the final stages (Fig. 7a), with $pv = 9.08 \pm 2.01$. Almost complete (stage 9) and finished beads (stage 11) vastly predominate. Although most of the intermediate stages are present, they represent proportionately far fewer beads.

In contrast, early and late stages of small, unburned beads predominate at *Shelly* ($n = 219$), with the production stages distributed more uniformly than at *Pottery* (Fig. 7b). Finished beads (stage 11) and blanks (stage 1) are most frequent, and the intermediate forms

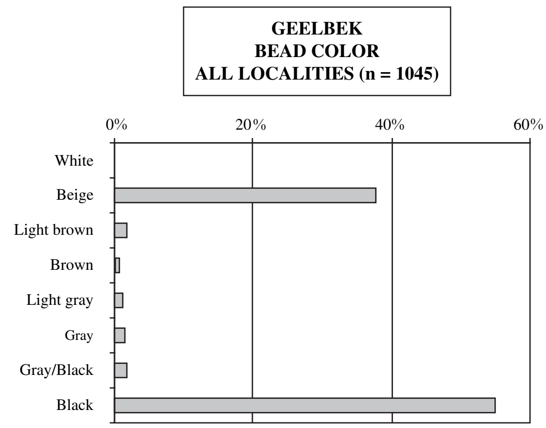

Fig. 4. Distribution of color for 1045 beads from all production stages.

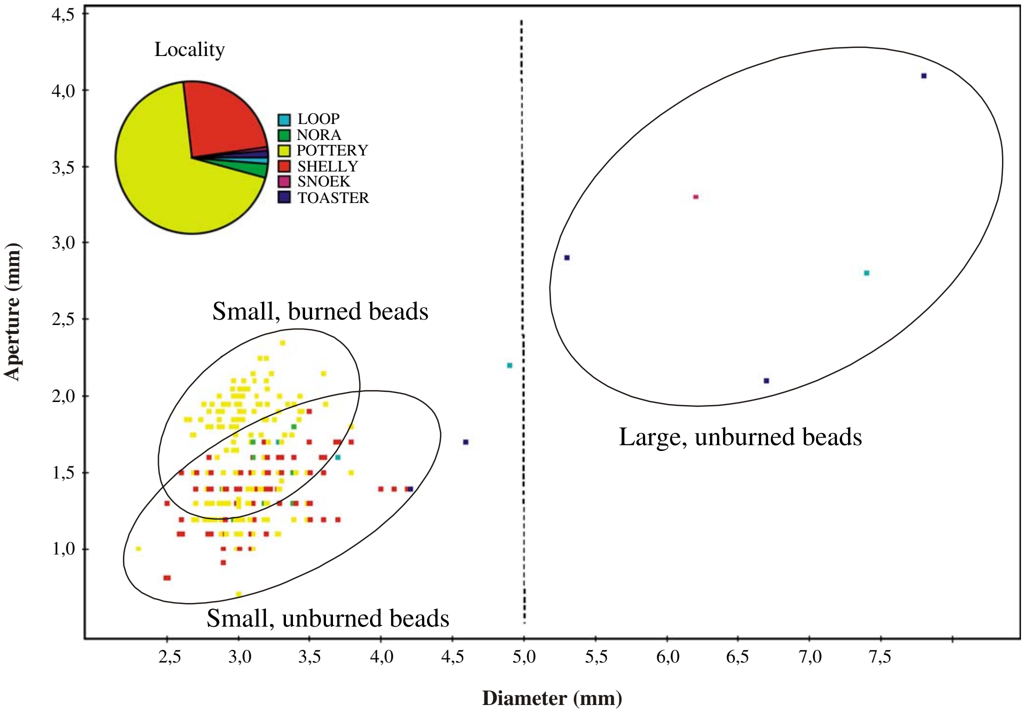

Fig. 5. Graph of the external diameter of 272 finished beads plotted against their internal apertures. The clusters are represented schematically.

ascribe a U-shaped distribution. The intermediate stages are more common than at *Pottery*. In fact pv = 6.26 ± 4.22, indicating the degree to which a typical bead reached the mid-stage of manufacture but with a wider range of distribution.

At *Nora* ($n = 187$) unburned small beads predominate (Fig. 7c). The curve is unimodal, but in contrast to *Pottery*, illustrates a trend toward earlier stages of production. Burned examples are present only in the earlier production stages. Intermediate forms are also more frequent, as indicated by pv = 3.91 ± 2.91. Blanks (stage 1) and broken, perforated forms (stage 6) are most common.

At *Toaster* ($n = 13$), where large, unburned large bead production prevailed, finished beads (stage 11) and complete, perforated blanks (stage 5) are most frequent (Fig. 7d) with pv = 7.82 ± 2.64. Only two small finished beads are present with pv = 11. The population of beads from *Toaster* is too small to make more specific determinations about bead production.

4.1. Burn experiment

To complement the archaeological research, the GAASP team conducted two series of burning experiments. The first attempted to recreate the observed range of OES color and texture by varying the intensity of burning, regulating the oxygen concentration and manipulating the organic content. The second examined natural variation in the color of OES fragments which burned as a result of a natural bush fire. The results indicate that intentional use of fire at a low to moderate

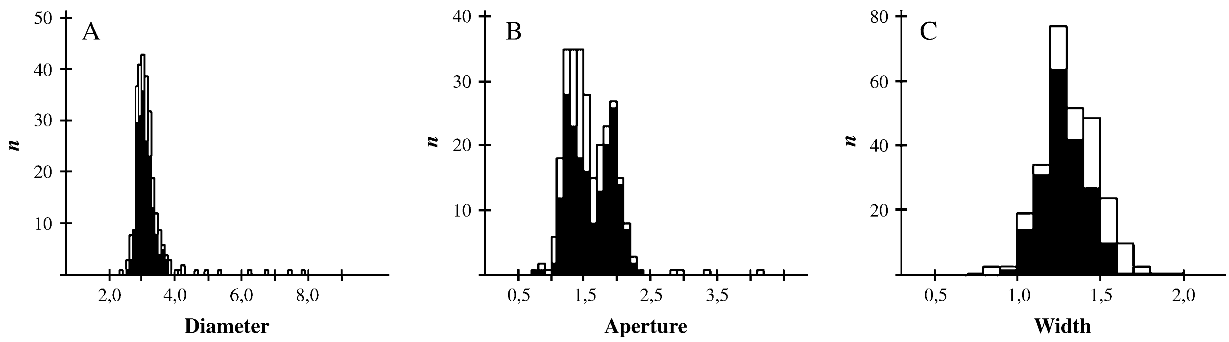

Fig. 6. Histograms graphing the distribution of (A) external diameter, (B) internal aperture, and (C) width (thickness) of 272 finished beads from seven localities. The blackened bars represent burned beads, while the white bars represent unburned beads. Measurements along the x-axis are in mm.

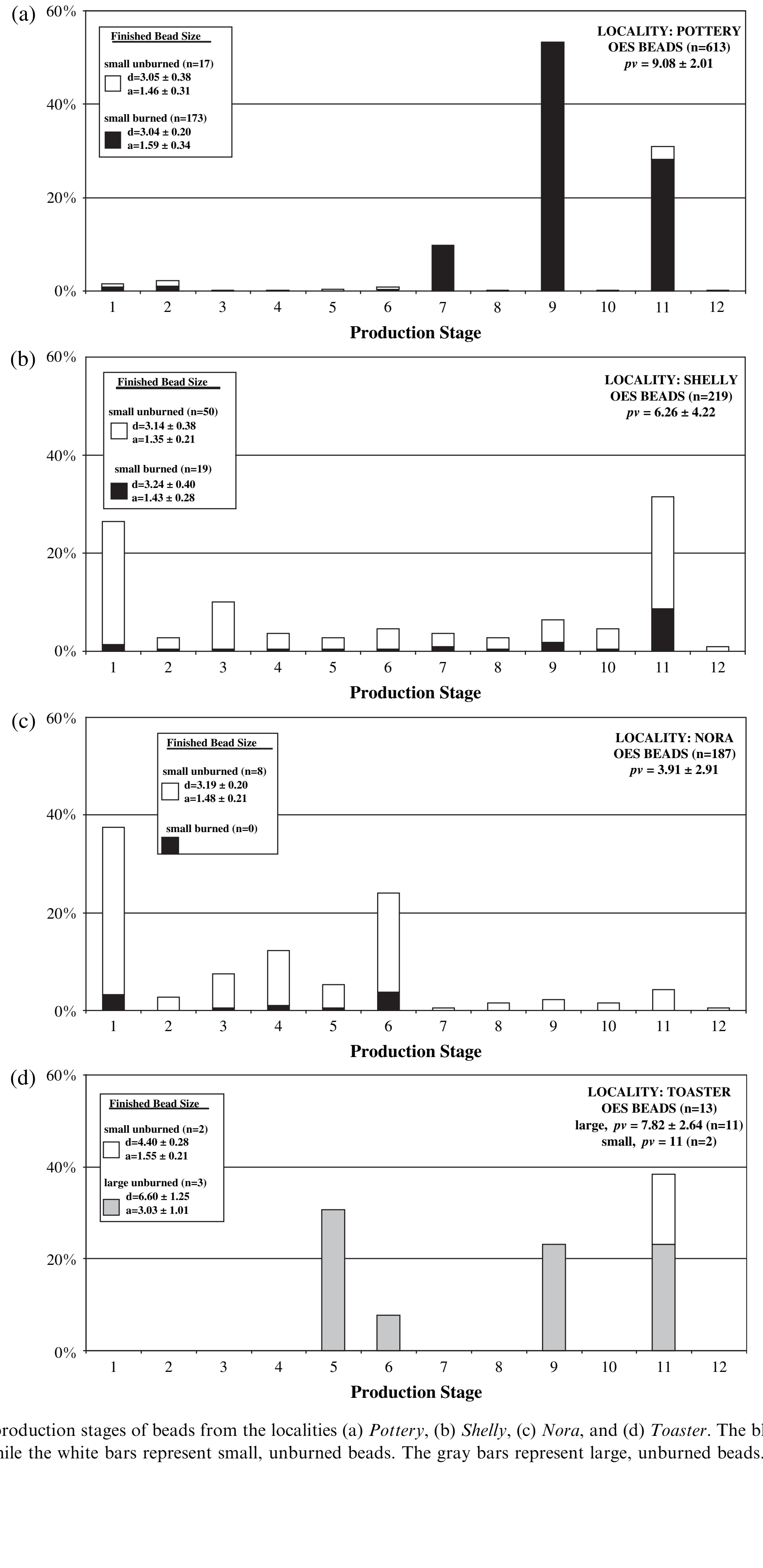

Fig. 7. Distribution of production stages of beads from the localities (a) *Pottery*, (b) *Shelly*, (c) *Nora*, and (d) *Toaster*. The blackened bars represent small, burned beads, while the white bars represent small, unburned beads. The gray bars represent large, unburned beads.

temperature under a reducing atmosphere with the addition of organic materials enabled the makers of the beads to control their color. High temperature and long exposure resulted in pronounced delamination and subsequent deterioration of the OES, making it unsuitable for further use. These results will be reported in greater detail in a subsequent publication.

4.2. Radiocarbon dating

Here we present the results of AMS radiocarbon dating conducted on six of the OES beads at the Leibniz Laboratory in Kiel (Table 3). A correction factor of 180 ± 120 was first subtracted for OES [10,30], and then the result was calibrated using CalPal 2004-SFCP [32]. The combined error was determined by adding the uncertainties of the individual values in quadrature. The small beads from the localities of *Pottery*, *Shelly* and *Nora* cluster in a time range from 550 to 380 cal BC, placing them in the period of pre-pottery hunter–gatherers before either herding or ceramics became established in the southwestern Cape. These dates coincide with the coastally oriented "mega-midden" period of the 1st millennium BC [5,14]. Although a bead blank from *Nora* was analyzed, we assume a relationship to the small beads because only small beads are in evidence there.

The large beads from *Toaster* and *Snoek* date to the late 1st and mid-late 2nd millennia AD, respectively and fall into the period after herders and pottery entered the southwestern Cape. In this case, the economic identity of the bead makers cannot be securely ascertained. However, the analysis of the other cultural remains from *Toaster* and *Snoek* will shed light on this question.

Finally, a single, large bead from *Loop* with a diameter of 7.40 mm yielded an early date of 1820 ± 150 cal BC, placing it firmly within the period of pre-pottery hunter–gatherers. Although this single piece of data appears to contradict the expectations of Jacobson [11,12] and Yates [33], it falls within the expected range of variability reported by Smith et al. [29: Fig. 6a] for pre-pottery hunter–gatherer sites at Paternoster and Kasteelberg C.

5. Conclusions

At Geelbek all of the small beads (<5 mm) from *Pottery*, *Shelly* and *Nora* fall into Jacobson's [11] Type I site which was occupied by pre-pottery hunter–gatherers. No large beads were recovered from these localities. The ^{14}C dates of 550–380 cal BC support this interpretation and correspond well with radiocarbon dates on marine shell obtained from these localities. The good agreement of these dates and the similarity of cultural remains at *Pottery*, *Shelly* and *Nora* suggest that groups of hunter–gatherer occupied these three localities episodically. Further observations can be drawn about the site-specific behaviors involved in the production of ostrich eggshell beads at these Geelbek localities.

At *Pottery*, 613 small beads are present in three separate areas. Despite a significant investment of time, the inhabitants abandoned, discarded or lost these almost finished and finished beads. The predominance of burned beads and their presence through all stages of production indicate that burning was an intentional part of the process. Based on Jacobson's [11] model, these results suggest that *Pottery* served as a short-term camp for a small family group of pre-pottery hunter–gatherers. Although the analysis of bead manufacture indicates a predominance of almost complete forms, the strong skewing of the production curve towards the later end suggests that some of these beads may have been manufactured elsewhere. However, clear indications of wear facets were not evident.

In an attempt to quantify variability in bead making, Smith et al. [28] analyzed two separate strands of beads from an ethnographic collection, one small and one large. They concluded that an individual bead maker controls 92% of an assemblage of beads to within 1 mm, assuming that these strands were indeed made by one person. If the observations made by Smith et al. [28] are

Table 3
Summary of AMS radiocarbon dates on six ostrich eggshell beads

Find no.	Lab ID	Method	Material	Uncal. date	Std. Dev.	Corrected and calibrated age (years)			Diameter (mm)	Aperture (mm)
				BP	±	mean	±	1σ		
LO 298	KIA-17756	AMS	OES Bead, large	3670	30	1820 BC	150	3620–3923	7.40	2.80
NO 1321.8	KIA-17755	AMS	OES Bead, bored	2580	25	550 BC	170	2499–2664	na	1.10
PO 1006	KIA-17761	AMS	OES Bead, small	2500	25	450 BC	210	2396–2602	3.80	1.80
SH 2935.11	KIA-17757	AMS	OES Bead, small	2465	25	380 BC	180	2152–2517	2.50	0.80
TO 1548	KIA-17760	AMS	OES Bead, large	1260	25	940 AD	140	863–1141	7.80	4.10
SN 1327	KIA-17758	AMS	OES Bead, large	380	20	1540 AD	110	60–382	6.20	3.30

In addition to the uncalibrated dates, corrected and calibrated ages based on CalPal 2004-SFCP are reported here [32]. A correction factor of 180 ± 120 was used in accordance with Vogel et al. [30]. Key to find numbers: LO = Loop; NO = Nora; PO = Pottery; SH = Shelly; TO = Toaster; SN = Snoek.

applied to the assemblages from Geelbek, the small beads from *Pottery*, and the other localities as well, are consistent with their stemming from a single strand.

The largest of the three scatters of beads at *Pottery* is associated with several large, flat blocks of unburned calcrete that may represent working surfaces. The second scatter is associated with a concentration of lithic artifacts and some burned and unburned OES fragments, possibly representing the source material for the manufacture of the beads. The third and smallest scatter of beads is associated with burned calcrete blocks. This feature represents a hearth around which cluster a rich concentration of lithic artifacts made from diverse raw materials, as well as the remains of tortoise [2], small bovids, marine shell and most notably, whale barnacles [16]. The richness and diversity of these finds suggest that the *Pottery* locality was used intensively during this occupation.

Based on its bead production curve, *Shelly* offers evidence that a family group of pre-pottery hunter–gatherers used this site as a comparatively long-term base camp where the activity of bead-making occurred. Here the production stages are more evenly distributed, as shown by an intermediate production value. In contrast to *Pottery*, unburned bead production clearly outweighs the burned component. Two distinct activity areas can be recognized in *Shelly*, both of which are associated with a midden-like accumulation of marine shell and faunal remains around which a rich scatter of lithic artifacts is present. Again, the high density of finds supports an intensive use of the locality, in this case, as a comparatively long-term camp.

At *Nora*, the inhabitants produced small beads in two areas. The beads from *Nora* are distinguished from the other localities by their general state of incompleteness, as shown by a low production value. Although many production stages are present, few of the beads correspond to categories beyond stage 6: since they broke during drilling, the beads were discarded. The beads are associated with a hearth of burned calcrete that also serves as a focal point for intensive stone knapping. Other classes of finds include faunal remains, OES fragments and shell, but these are distributed evenly across the surveyed area. Jacobson's model suggests that *Nora* served as a comparatively long-term camp for a family group. Whether the makers of the beads were "beginners" or only engaged in the earlier stages of bead production is not clear.

Most of the beads from *Toaster* correspond to Jacobson's Type III site occupied by post-pottery herders. The radiocarbon date of a bead and the large number of pottery shards support this conclusion. The large beads are scattered loosely across the locality in possible association with the widespread concentration of pottery. Nonetheless, the economic identity of the manufacturers of these beads remains unclear. Domesticated livestock have not yet been identified among the faunal remains, while lithic artifacts seem to be present in quantities and types similar to other Geelbek localities where hunter–gatherers are indicated. The population of beads is too small to define specific activities related to the production of beads.

Due to the small number of beads found at the remaining localities, *Stella*, *Loop* and *Snoek*, Jacobson's model cannot be readily applied, nor can a meaningful production value be determined. Nonetheless, certain information can be gleaned from the evidence. For example, despite the young radiocarbon date on a large bead from *Snoek*, the presence of cut-marked eland remains and a lithic assemblage dominated by backed bladelets suggest that post-pottery hunter–gatherers contributed to this assemblage. At *Loop* the unexpected pre-pottery date on one large bead also indicates that its manufacturers were hunter–gatherers and not herders. However, it is also possible that an older source of raw material, found on the landscape, was used to manufacture the bead [15]. Nonetheless, these results indicate that the chronology of small vs. large beads cannot be viewed as universal.

Tools associated with the manufacture of beads, such as grooved stones or drills, are present at several localities at Geelbek, but they are not always associated with the beads themselves. Grooved and smoothed stones are known from *Pottery* and *Shelly* while drills have been documented at *Nora*, *Toaster* and *Rhino*. This is somewhat puzzling, since our interpretation of the production chain points to the manufacture of beads at these localities. One explanation is that the tools associated with bead manufacture were not recovered because they were transported elsewhere.

In closing it is clear that the small finished beads offer very specific insights into the habits of their manufacturers. The people who made the small beads were pre-pottery hunter–gatherers, as supported by the results of the radiocarbon dating. However, the makers of the large beads cannot always be identified. In fact, the date on the oldest large bead indicate that hunter–gatherers were responsible for its manufacture and contrasts with the presently accepted model. Finally, while our results point to the utility of Jacobson's model, we still need to compare the interpretations derived from the OES beads with those resulting from diverse analyses of faunal remains and lithic artifacts that are currently underway.

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Appendix B.6

Kandel, A.W. & Conard, N.J. (2003) Scavenging and processing of whale meat and blubber by Later Stone Age people of the Geelbek Dunes, Western Cape. *South African Archaeological Bulletin* 58: 91-93.

SHORT COMMUNICATION

SCAVENGING AND PROCESSING OF WHALE MEAT AND BLUBBER BY LATER STONE AGE PEOPLE OF THE GEELBEK DUNES, WESTERN CAPE PROVINCE, SOUTH AFRICA

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ABSTRACT

Although it has been postulated that the scavenging of beached whales played an important role in the subsistence strategy of Later Stone Age people in southern Africa, there exists limited material evidence to support this hypothesis. At the locality Pottery in the Geelbek Dunes of the Western Cape, new analysis has demonstrated a clear association between 34 pieces of whale barnacle (Coronula diadema) and a roasting platform consisting of burned calcrete. This relationship confirms that LSA people scavenged whales from the shores of southern Africa, while processing the meat and rendering the blubber at inland locations.

Introduction

Smith & Kinahan (1984) describe whales as an 'invisible' resource because their remains are difficult to detect at archaeological sites. Although the opportunistic use of whale vertebrae as stools and of ribs as elements of housing structures is reported at sites such as the Ugab River Mouth in Namibia (Smith & Kinahan 1984), the sheer size of most whale bones limits the viability of its transport beyond the beach. Nieuhof's diary from AD 1654 relates how indigenous people ate oily whale meat and blubber directly from the stranded carcass or buried these resources in the sand (Raven-Hart 1971) and Smith & Kinahan (1984) tell how dried whale meat was eaten raw or rehydrated and cooked. An entry in Van Riebeeck's AD 1654 journal describes how the indigenous people rendered whale blubber, stored the oil in dried kelp and then drank it or smeared it on their bodies (Thom 1952). Therefore, little or no inorganic evidence would remain to document the use of this valuable resource.

Jerardino & Parkington (1993) suggest an alternative to looking for whale bones at archaeological sites. They cite the remains of coronuline barnacles, one of several genera commonly known as whale barnacles (Darwin 1854, Scarff 1986), as material evidence that prehistoric people processed and ate whales. The implication is that the barnacles were carried to these sites attached to the skin of whales and then discarded. The presence of these crustaceans is documented at several LSA sites along the West Coast, including the long dune cordon south of Eland's Bay, Eland's Bay Cave, Dune Field Midden and Duiker Eiland (Fig. 1), confirming that whale meat and blubber were transported to these localities. However, the data do not allow one to establish how this resource was used.

The commensal relationship between coronuline barnacles and their hosts remains poorly understood. During the austral spring, the barnacle larvae are thought to swarm around their hosts, whose migratory routes pass along the coastline of southern Africa (Scarff 1986; Findlay & Best 1995). The larvae spend the remainder of their less than year-long life attached to the skin of their host (Scarff 1986). While most authors document some variability in host specificity, it is accepted that *Coronula diadema* (Fig. 2) associates with humpback whales at a frequency greater than 90% (Jerardino & Parkington 1993; P. Best, pers. comm.) Other whale barnacles are hosted by different species (Scarff 1986). Some of the large, edible whales that are known to host whale barnacles and strand themselves along the beaches of southern Africa include the humpback whale (*Megaptera novaeangliae*), the southern right whale (*Eubalaena australis*), the false killer whale (*Pseudorca crassidens*) and the fin whale (*Balaenoptera physalus*), among others (Best 1991; Smith & Kinahan 1984).

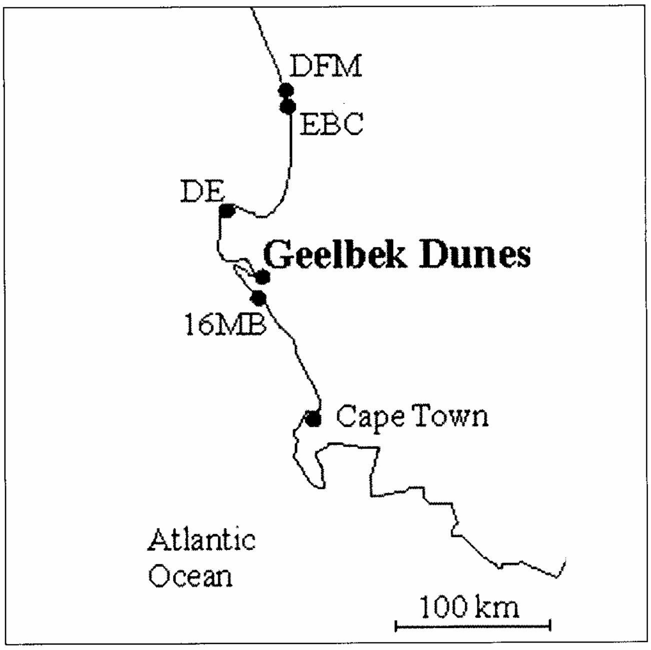

Figure 1. Map depicting the Geelbek Dunes and other localities mentioned in text. (DFM = Dune Field Midden; EBC = Eland's Bay Cave; DE = Duiker Eiland; 16MB = Sixteen-Mile Beach.)

Although the chance stranding of whales cannot provide the basis for subsistence, it can serve as a significant and even predictable economic windfall. The abundance of individual whales along the coastline of southern Africa peaks between August and October (Smith 1993; Best 1995). Historically, a higher frequency of stranding would have resulted from the greater population of whales present before the onset of commercial whaling in southern Africa in the AD 1770s (Best & Ross 1989). Best's (1994) data on catches of humpbacks during 1909–1914 indicate that the original population on southern Africa's west coast exceeded 17 000 but that this was nearly eliminated by 1914 (P. Best pers. comm.). By the time humpback whales were protected in 1963, less than 3000 individuals remained worldwide (Best & Ross 1989). Although census data for the present population are not available, the American Cetacean Society estimates that 15 000–20 000 humpbacks exist worldwide (Calambokidis & Weinrich 1996). Other large species of whales have seen an equally dramatic fluctuation in their numbers since commercial whaling began (Best & Ross 1989).

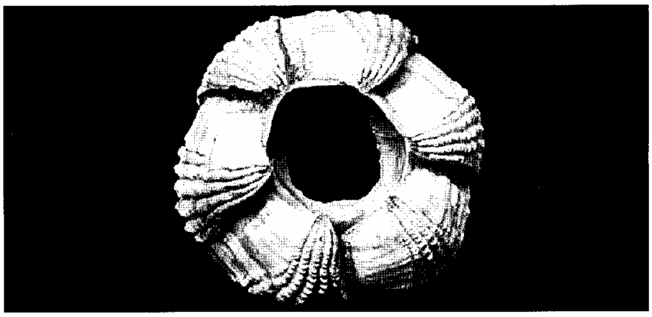

Figure 2. Photograph of *Coronula diadema*, approx. 75 mm in diameter. Courtesy of Mr T. Ohta and FOSSILS OF JAPAN.

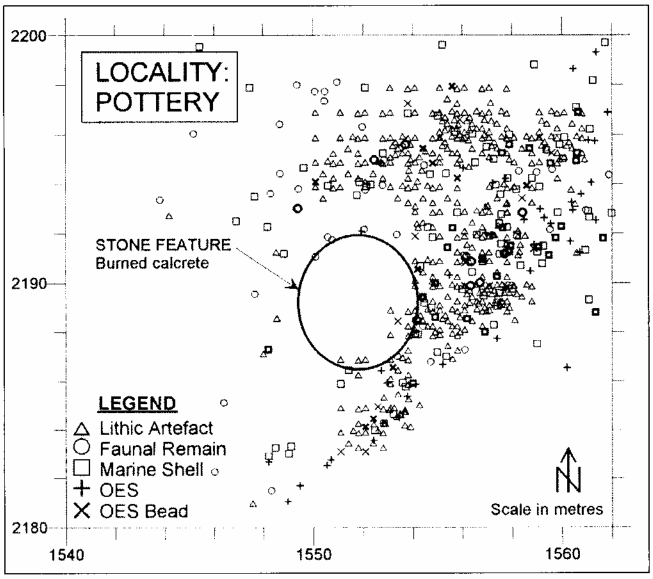

Figure 3. Distribution of major categories of finds around a burned stone feature in *Pottery*. The symbols in the legend denote unburned finds, while burned finds are depicted by the same symbols with heavier lines.

Specific data on the beaching habits of large whales in southern Africa are provided by G. Avery (pers. comm.), who reports six whales over the course of his 26-year, monthly survey of Sixteen Mile Beach (Fig. 1), that is, one stranding every 4.3 years over a 15 km stretch of this beach. Avery's list of stranded whales includes the following species: humpback, southern right, sperm (*Physeter macrocephalus*) and Bryde's (*Balaenopetra edeni*) or Minke (*Balaenoptera acutorostrata*). Smith & Kinahan's (1984) data from the Western Cape during 1963–1981 illustrate a similar pattern of beaching viewed over the 500 km of coastline from Cape Agulhas to St. Helena Bay, averaging 7.3 strandings per year. Thus, for a hypothetical beach segment 15 km long, this result equates to one whale every 4.6 years.

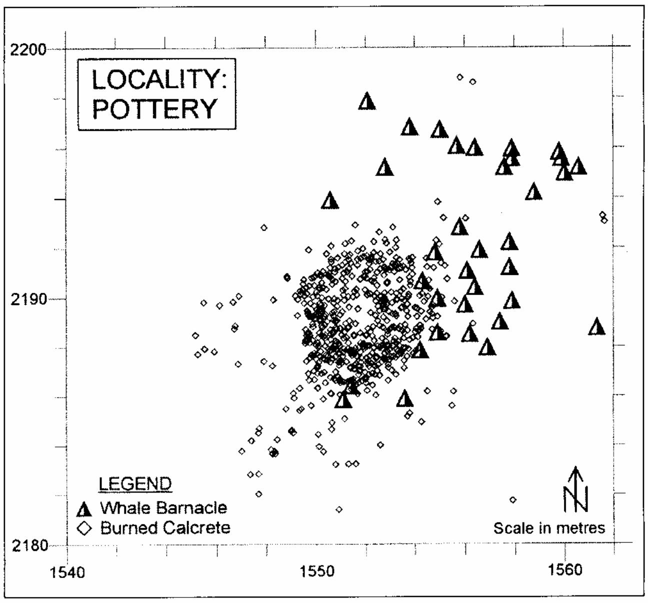

Figure 4. Distribution of *Coronula diadema* around a roasting platform in *Pottery*.

Discussion

At the locality *Pottery*, one of many deflation hollows located in the Geelbek Dunes, more than 3600 piece-plotted finds were collected from a 1.07 ha open-air setting on the semi-consolidated Ancient Dune II (Conard *et al.* 1999; Kandel *et al.* 2003). This geological horizon is characterized by a decalcified pale brown to yellow fine-grained sand interlaced with strongly calcified fossilized roots known as rhizoliths. The age of this stratum is 6000±1000 BP based on IRSL dating of the sand grains, which provides a maximum date for the formation of this ancient dune and, thus, the finds lying upon it. A weakly developed soil horizon points to a brief period of sub-humid conditions after the deposition of the ancient sand dunes (Felix-Henningsen *et al.* 2003).

A stone feature composed of 595 blocks of burned calcrete ranging up to 200 mm formed the focal point for many of the finds recovered from *Pottery* (Fig. 3). Similar stone features are documented elsewhere in the Western Cape Province (c.f. Avery 1974; Robertshaw 1979) and are generally recognized as stone hearths or roasting platforms. At the locality *Pottery*, lithic artefacts, marine shells, faunal remains, ostrich eggshell and beads are scatted around, but not within, this feature. About 19% of the associated faunal remains and 23% of the marine shells are burned but no traces of charcoal or burned materials were documented from within the feature. This description fits well with Avery's (1974:110) second category of stone feature, one '...with a clean sand matrix which may represent blown-out hearths or platforms.'

In addition to the other categories of finds, 34 pieces of the coronuline barnacle, *C. diadema*, are distributed around the stone feature (Fig. 4), representing an MNI of at least six barnacles. Consistent with the burned fauna and marine shell, 23% of the pieces of barnacle are burned. This evidence strongly suggests that people harvested stranded humpback whales on the coast and carried pieces of whale, with coronuline barnacles still attached, at least 4 km inland to a camp at the locality *Pottery*. Here they processed the whale meat and blubber and lit a fire on locally collected calcrete blocks. After the people had cooked the meat and rendered the blubber on this hearth, the barnacles, some of them burned, were discarded around its periphery.

Although the barnacles themselves have not yet been dated, radiocarbon dates for other marine finds from *Pottery* include a retouched white mussel (*Donax serra*) scraper dated to 2715±25 uncal. BP (KIA-17751) and a bulk sample (10% burned) of black mussel (*Choromytilus meridionalis*) dated to 2950±60 uncal. BP (Pta-8691). An ostrich eggshell bead (small variety; diameter 3.8 mm, opening 1.8 mm) yielded a date of 2500±25 uncal. BP (KIA-17761). Calibrating these dates and correcting them for reservoir effects yields dates relating to the pre-ceramic period.

The pre-ceramic age for the dated samples, the lack of domesticated stock and the presence of small beads, an indicator of hunter-gatherer groups (Jacobson 1987), tend to support the suggestion that, in this case, hunter-gatherers were responsible for utilizing whales as a resource. However, the presence of three ceramic vessels also documents a later phase of settlement at *Pottery*, hence the name of the locality. It is interesting to note that burned calcrete features are present at other Geelbek localities, such as *Nora*, *Toaster* and *Check*, with similar geological contexts and archaeological remains. So far, the presence of *C. diadema* has been confirmed at *Nora*, and it will be interesting to see if the pattern found out at *Pottery* occurs at the other LSA sites.

Acknowledgements

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Appendix B.7

Conard N.J. & Kandel, A.W. (In press) The economics and settlement dynamics of the later Holocene inhabitants of near coastal environments in the West Coast National Park, South Africa. Manuscript accepted for publication in *Festschrift for Manfred Eggert.*

The economics and settlement dynamics of the later Holocene inhabitants of near coastal environments in the West Coast National Park, South Africa

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Abstract

Survey and excavation in the Geelbek Dunes of the West Coast National Park documented the archaeology of 23 deflation hollows containing Middle and Later Stone Age finds from diverse stratigraphic contexts. This paper focuses on the best preserved sites resting on the youngest of the fossil dunes at Geelbek. These assemblages post-date the formation of the Ancient Dune II horizon 5000 years ago. The archaeological record from Geelbek provides unique information on the near coastal human adaptations in recent millennia and allows the reconstruction of the economics and settlement dynamics of the inhabitants of the strandveld. The localities at Geelbek document a highly mobile pattern of settlement and subsistence based on an opportunistic mix of terrestrial and marine resources. Even after pottery becomes visible in the record, domesticated animals including sheep are rare. The lithic assemblages contain microlithic elements and projectile points that are consistent with hunting and gathering economies. Numerous stone hearths are present at Geelbek and document the rendering of whale blubber among other types of cooking activity. Occupations were generally short-lived, but the data suggest that the entire strandveld was used for hunting, gathering, processing food, knapping stone, producing ornaments and occasionally for burials. The stable isotope data from a sample of three human skeletons suggest that consumption of marine foods was higher around 2000 years ago than in the later periods of the Later Stone Age. Data from other near coastal environments are needed to test the degree to which the results from Geelbek can be used as a proxy for how people used the strandveld of the Western Cape in recent millennia.

Introduction

Recent years have seen lively debate on the archaeology of hunter-gatherers and herders in the Western Cape. Smith et al. (1991) stress the distinct nature of these economic and cultural systems, and thereby argue that herders, accompanied by sheep and using pottery, first entered the Western Cape about two thousand years ago. Sadr (2004) has countered that the distinction between hunter-gatherers and herders is less clear cut. He suggests that sheep herding could have arrived without a major migration of people, and that there was considerable interaction between both cultural groups. The various points of view and archaeological background to this debate have been summarized in recent publications (e.g., Sadr et al. 2003; Sadr 2004; Parkington & Hall in press), and this question is discussed in reports on pottery (e.g., Sadr & Smith 1991; Sampson & Sadr 1999), fauna (e.g., Klein & Cruz-Uribe 1989; Smith 1998; Webley 2002), human skeletal data (e.g., Pfeifer & Sealy 2005), stable isotopic research (e.g., Sealy & van der Merwe 1987) and other lines of reasoning.

Here we use the data from Geelbek to address this question from a different angle. The work at Geelbek has documented 23 archaeological localities in detail and provides information on finds from an area of over 80,000 m^2. The data obtained from this large surface area allow us to identify new kinds of sites and gain new insights into how near coastal environments were used in recent millennia. Rather than asking whether the inhabitants of Geelbek were hunter-gatherers or herders, with all the assumptions these terms often bring with them, we prefer to consider the specific activities that can be identified in the deflation hollows at Geelbek and use these observations to draw conclusions about the economic practices and settlement dynamics of the people who left diverse classes of material at Geelbek. As we will see, the data from Geelbek blur the boundaries between on and off-site archaeology, providing a different kind of dataset than that available from the shell middens, caves and rich open-air sites that have thus far been the focus of archaeological research in the Western Cape. We hope that this strategy will increasingly allow archeologists to determine what happened across the entire landscape and help researchers gain a more complete view of past lifeways, based in part on the ephemeral sites and scattered finds within the fynbos biome.

Geographic Setting and Research Design

As early as the 1960s visitors to the Geelbek Dunes of the Western Cape Province of South Africa identified deflated archaeological finds in association with faunal remains. The Geelbek Dunes are situated within the West Coast National Park, 5 km from Sixteen Mile Beach along the open Atlantic Ocean and 2 km from the protected tidal flats of Langebaan Lagoon (Fig. 1). In the late 1990s we initiated the *Geelbek-Anyskop Ausgrabungs- und Survey-Projekt* (GAASP). Over the course of eight field seasons from 1998 through 2005 a team of archaeologists from the University of Tübingen documented 23 open-air, archaeological and paleontological localities among 114 deflation hollows in the Geelbek Dunes (Fig. 2) (Conard et al. 1999; Conard 2002; Kandel et al. 2003; Conard et al. 2004; Dietl 2004; Kandel 2004). These localities include Middle Stone Age (MSA) and Later Stone Age (LSA) sites of varying find density. Although these localities are presently covered by highly mobile sand dunes, during most periods of occupation, the modern set of sand dunes had not yet migrated into this region (Franceschini 2003). Instead, the sandy soil was frequently stabilized by strandveld vegetation of low, scrubby brush, as indicated by calcified rhizoliths (fossilized roots) that are visible in the loosely consolidated, uppermost, geological horizon named Ancient Dune II (ADII) by Felix-Henningsen et al. (2003).

The research strategy at Geelbek takes advantage of the movement of the mobile sand dunes as a means to provide access into the otherwise largely invisible archaeology of the strandveld. Our underlying assumption is that the archaeology inside and outside of the dune field is similar. The key difference is that within the dunes, the migrating sand impedes the growth of vegetation, allowing deflation to occur and thereby exposing archaeological finds from progressively deeper strata. Detailed studies of the deflation hollows at Geelbek document that the dunes migrate northwards at an average rate of 8-10 meters per year. Thus, with time researchers can use a migrating deflation hollow as a moving window to study a large portion of the landscape.

Over the course of eight seasons of fieldwork, the GAASP team has used precision piece-plotting to recover over 30,000 finds from a total surface area of more than 80,000 m^2. In addition to these surface collections, an area greater than 1600 m^2 has been excavated to gain representative samples of the small finds that escape observation during survey. The work at Geelbek represents one of the first multi-disciplinary studies of large, open-air sites in southern Africa using a computer-based Total Station to piece plot finds. The stored data have been geo-referenced to topographic maps, aerial photographs and satellite images using ArcView 8.2 to provide a fully integrated, referential database that can be expanded in all directions.

The stratigraphy in the Geelbek dune system is not ideal since the finds lie upon exposed, deflated ancient dune (AD) surfaces. Thus, archaeological materials can deflate downwards through the stratigraphic sequence. However, the loss of stratigraphic resolution mainly affects the lower lying calcrete deposits, where MSA and LSA materials can lie side by side. In more favorable geological settings, such as on the less deflated surfaces of ADII and the underlying ADI, materials are often found in association. In certain cases we were able to document the assemblages as they deflated, so that their spatial integrity compares to that of an undisturbed site from an excavated context. Using systematic experiments, we documented and quantified the effects of deflation on materials of varying size, shape and density (Kandel et al. 2003). As one might expect, strong wind more easily displaces flat objects of low density, like shell fragments and small bones. Thus, while deflation may compromise the spatial integrity of the finds, the horizontal association of the objects does not radically change. Denser finds typically migrate vertically and slightly down slope during deflation, regardless of the wind direction. Although lithic and pottery scatters become more diffuse with deflation, refitting and spatial studies show that archaeological associations survive the seemingly destructive effects of deflation (Kandel & Conard 2003).

Here we focus on the assemblages found above ADII (Felix-Henningsen et al. 2003). The deposition of ADII consistently dates between 5-6 ka based on two IRSL dates from the Quaternary Dating

Laboratory in Pretoria and two OSL dates from the luminescence dating laboratory in the Department of Geomorphology at the University of Bayreuth (Tab. 1). The key assemblages overlying ADII come from the six localities of Check, Nora, Pottery, Shelly, Snoek and Toaster. For comparison, we also include the locality Rhino as an example of a temporally mixed assemblage. Table 2 presents the results of 20 radiocarbon dates on archaeological materials from these seven localities. The dates document episodes of occupation and use of these sites primarily during the last three millennia, with the main focus of occupation evident between about 700 and 400 cal BC (Fig. 3).

The GAASP team collected and piece-plotted the surface finds from 23 of the deflation hollows in multiple episodes between 1998 and 2005. The team plotted all lithic artifacts, ostrich eggshell beads and fragments of pottery, as well as terrestrial and marine faunal remains larger than 2 cm. Excavated sediments were screened through 10 and 1 mm mesh and produced large samples of smaller finds. The surface area of these localities ranges from less than 1,000 m^2 up to more than 10,000 m^2, and the area of excavation ranged up to 293 m^2. Table 3 presents an overview of the materials recovered from the six later Holocene localities, as well as Rhino.

In the present context it is important to carefully define spatial and geographic terms. We refer to the immediate coastal zone corresponding to the 200 m wide strip of land along the shoreline. The coastal zone includes the coastline and littoral dunes. Substantial shell middens are commonly found in this zone, where the transport costs of marine resources are minimal. The archaeological localities at Geelbek are not in the immediate coastal zone, but rather, within the near coastal environment. We use the term near coastal strandveld or more generally, near coastal environment, to refer to this region. As depicted in Acocks (1988), the West Coast strandveld can extend as much as 30 km inland. A more recent assessment of this vegetation zone by Low & Rebelo (1996) uses the term “dune thicket” instead of strandveld. When we refer to the near coastal strandveld, we are referring to the area between the inland side of the littoral dunes and 10 km inland. Our definition of the spatial extent of the near coastal environment is meant only as a rough guideline, and does not imply that a significant ecological divide exists 10 km inland.

Within the near coastal environment, we expect to see considerable local and regional variation in the archaeological record. The work at Geelbek builds on earlier research by Manhire et al. (1984) in deflation hollows near Elands Bay. Research at Geelbek reflects the first systematic attempt to document the low density archaeological signature of the near coastal environment as a means of developing models for the prehistoric use of this zone. Prior to the late 1990s the technology did not exist for precise, high speed piece-plotting of large areas as undertaken at Geelbek.

The appraisal of the landscape as immediate coast, near coastal environment and inland area reflects our interest in linking geomorphological and vegetational criteria with human economic behavior. A validation of such an approach is suggested by the trend toward decreasing amounts of marine resources with increasing distance from the coast. While the signal is noisy, there is an exponential decline in the abundance of archaeologically visible coastal resources as one moves inland. However, this assumption must be used with caution. The large, coastal shell middens may have served primarily as food processing centers to produce lightweight, stored foods that could be easily transported inland for consumption at a later time (Parkington 1976). Some sites in near coastal and even inland settings further than 10 km from the Atlantic Ocean preserve abundant evidence for the use of marine resources. At Kasteelberg A and B, located 5 km from the coast, seal is the dominant component of the faunal assemblages (Klein & Cruz-Uribe 1989).

Terrestrial Resources

The terrestrial fauna from Geelbek represents the largest assemblage of material in the GAASP collection, with over 13,000 piece-plotted finds from all localities. Yet in some respects, it is the most difficult to interpret. While it is clear that people are the primary agents who brought stone artifacts, pottery and marine resources to Geelbek, we often cannot prove which agent led to the accumulation of terrestrial fauna. Occasional impact fractures or cutmarks demonstrate a direct link between people and the fauna, but more often than not, the causal association is difficult to demonstrate. Burning is well-documented among the faunal assemblages and regularly associated with calcrete features, but some degree of burning might also result from natural bushfires (Avery et al. 2004). Work is currently underway to demonstrate or refute the association between terrestrial faunal elements and human behavior.

Here we take the data from the terrestrial fauna (Tab. 4 & 5) at face value. In terms of bone counts, the carapaces of the angulate tortoise (*Chersina angulata*) dominate most of the assemblages. The second most abundant faunal remains come from small bovids (size class 1) including steenbok (*Raphicerus campestris*). Cape hare (*Lepus capensis*) and the Cape dune mole rat (*Bathyergus suillis*) are next most represented. Taken together, these small animals dominate all of the Holocene faunal assemblages. Larger fauna include eland (*Taurotragus oryx*), black rhino (*Diceros bicornis*) and elephant (*Loxodonta africana*). When present, the larger species dominate in terms of their weight percent but are poorly represented at the localities on ADII. The remains of an eland bearing cutmarks and impact fractures at the locality of Snoek and the remains of an elephant with evidence of burning at Toaster are two exceptions to the general pattern reflected in the assemblages dating to the last 5000 years.

Thus, mainly small terrestrial animals, and occasionally large mammals, contributed to the diet of the occupants of the younger LSA localities at Geelbek. Based on the populations of large, medium and small game now living in the West Coast National Park coupled with early reports by Europeans from the West Coast (Skead 1980), there is every reason to assume that the Geelbek strandveld supported substantial populations of game in prehistoric times. This fauna would have played an important role in the subsistence practices of the people using the near coastal environments. The presence of hunting gear including numerous backed points and several bone linkshafts in the LSA assemblages is consistent with this interpretation.

One of the most enigmatic aspects of the faunal record of the Western Cape is the paucity of evidence for sheep. Other than Kasteelberg (Klein & Cruz-Uribe 1989; Sadr et al. 2003) where some excavated units contain high numbers, most sites include low numbers of sheep bones. Some cave sites, including Boomplaas (Deacon et al. 1978), Die Kelders (Schweitzer 1979) and Blombos (Henshilwood 1996) have produced small assemblages of sheep dating to after 2000 BP. Open-air sites including Dunefield Midden dating between 1300 and 1400 cal AD have also yielded small assemblages of sheep (Parkington et al. 1992). However, other than at Kasteelberg, sheep played only a minor role as a source of meat.

Smith (2005) has consistently argued that sheep are most valuable on the hoof as milk producers and would rarely be slaughtered. This view echoes that of Richard Redding (pers. comm.) and other Near Eastern archaeozoologists who for years have stressed that pastoralists are archaeologically invisible. Outside villages, where domesticates dominate many Near Eastern faunal assemblages and burial sites (Uerpmann et al. 2000), sites documenting mobile pastoralists are essentially unknown, despite concerted efforts to find evidence of this economic form. This being the case, the general lack of sheep bones at the localities of Geelbek and other sites in the Western Cape should not be taken to assume uncritically that herders were absent from the region. Nor should this near invisibility of herders be taken as proof that hunter-gatherers dominated the landscape. For the time being, we remain poorly equipped to define the relative strengths of hunter-gatherer and herding populations. Smith (1998 & 2005) stresses that the ideological basis of herding and the importance of delayed return strategies would conflict with the economic strategies of immediate return employed by hunter-gatherers. Thus, while social relations probably existed between herders and hunter-gatherers, we should not expect the fully fluid movement between these subsistence strategies as Sadr (2004) suggests.

Due to the poor chances for preservation in an open-air setting, we have no direct evidence for the use of botanical resources at Geelbek. However, the presence of adzes and scrapers, discussed below, suggests that plant remains were worked on these sites. Based on archaeological data from cave sites, there is good reason to assume that plant materials including grasses and reeds for bedding, corms, seeds and fruit for dietary needs and wood for cooking played an important role in the daily activities of the people who inhabited the near coastal environment (e.g., Liengme 1987; Binneman 2000).

Marine Resources

While less dominant then the terrestrial resources, marine resources at Geelbek include over 3000 piece-plotted finds, 80% of which is concentrated in the localities found above ADII (Tab. 3). Of the marine resources, mollusks account for the largest category of finds by far. The occupants of Geelbek carried shells of black mussel (*Choromytilus meridionalis*), white mussel (*Donax serra*) and, to a lesser degree, limpets (mostly *Cymbula* spp. and *Scutellastra* spp.) into the near coastal strandveld for consumption (Tab. 6).

Since the shoreline has not moved significantly during recent millennia, a configuration similar to today's can be assumed for the sandy coastline along Sixteen Mile Beach (Compton & Franceschini 2005). Given the scarcity of rocky substrate within the intertidal zone, the black mussels and limpets likely originate from further away. Potential collecting areas exist to the north, on the Postberg Peninsula, or to the south, near Ysterfontein. In either case, the shells of these rocky dwelling species would have been carried at least 15 km before being consumed and discarded at Geelbek. Despite their frequency, the dietary value of the black mussels made only a modest contribution to diet based on Buchanan's (1988) data. White mussels, which favor a sandy coast, were collected at a minimum of 5 km away. These robust shells provided an attractive raw material for manufacturing scrapers, and it may be this specialized use that outweighs their dietary contribution. About 18% of the white mussels show evidence of retouch, with a maximum of 66 shell scrapers documented at Shelly (Tab. 6).

This being said, we emphasize that the ephemeral shellfish accumulations in the near coastal strandveld at Geelbek contain a fractional amount when compared to middens on the coast. Significant accumulations of shell abound in the archaeological literature of the Western Cape (e.g., Klein 1972; Schweitzer 1979; Parkington et al. 1992). For example, the 859 m^2 excavated at Dunefield Midden near Elands Bay produced over two metric tons of shellfish remains (Tonner 2005). In contrast, the richest locality at Geelbek, Shelly, yielded 4.6 kg of shell from 4750 m^2, followed by Nora with 1.3 kg and Pottery with 0.5 kg. We would expect the volume of shell to diminish inland in the near-coastal strandveld (e.g., Jerardino & Yates 1996) since the processing of shellfish occurred mainly near the shoreline (Parkington 1976)

Compared to the mollusks, crustaceans from Geelbek play a minor role. Two mandibles of the rock lobster (*Jasus lalandii*) have been recovered from Pottery and one from Shelly. Their contribution to the LSA diet at Geelbek was no doubt small, but like the black mussels and limpets, they would have been collected along rocky shorelines about 15 km away. At many of the West Coast sites including Paternoster, Dunefield Midden and Elands Bay Cave, the frequency of lobster is significantly greater (Robertshaw 1977; Parkington et al 1992; Jerardino & Navaro 2002).

The only marine vertebrates documented at Geelbek are two finds of Cape fur seal (*Arctocephalus pusillus*) from separate localities and four finds of African penguin (*Spheniscus demersus*) from three localities (Tab. 5). Similar to shellfish and rock lobster, these sparse finds suggest the occasional transport of seal and penguin into the strandveld. Again the context of this behavior is different than at more intensively used sites like Dunefield Midden (Parkington et al. 1992) or Kasteelberg (Klein & Cruz-Uribe 1989), where seals are the most represented species of the faunal assemblages. As we suggest for the shellfish, seal was not systematically acquired and then processed at Geelbek. The limiting variable, however, is not the distance from the open coast, since sites like Kasteelberg contain abundant seal bones despite being located as far from the coast as Geelbek.

Further information about the use of marine resources comes from the localities of Pottery and Nora where whale barnacles (*Coronula diadema*) provide evidence for the transport of whale meat and blubber inland (Kandel & Conard 2003). Whales stranded on Sixteen Mile Beach were occasionally available to the inhabitants of Geelbek, who carried packages of skin, blubber and meat at least 5 km inland for processing and rendering. At Pottery the context of the barnacles around a burned calcrete hearth documents the importance of this resource as early as 2900 cal BP (Tab. 2).

Small numbers of fish vertebrae are present at most Geelbek localities. The collections include scattered remains of sea white catfish (*Galeichtys feliceps*), white steenbras (*Lithognathus*

lithognathus) and white stumpnose (*Rhabdosargus globiceps*) (Cedric Poggenpoel pers. comm.). While it is likely that humans used fish as a resource, we remain cautious about such pronouncements based on this evidence. For now, we are unable to rule out the possibility that sea birds were responsible for regurgitating the bones in the near coastal strandveld (Graham Avery pers. comm.).

The archaeological signal for the use of all marine resources points to high mobility and a diverse pattern of use. Nowhere at Geelbek is large-scale processing of marine resources documented. On the contrary, the use of marine resources at Geelbek points to a high degree of flexibility and mobility.

Lithic Artifacts

The 23 localities contain over 8900 lithic artifacts, most of which date to the LSA. At some localities a clear MSA component also exists (Conard et al. 2004; Dietl 2004; Dietl et al. 2005). The lithic artifacts are found in varying densities on the surface or immediate subsurface of the deflation hollows. This pattern of distribution allowed the GAASP team to piece-plot all of the visible lithic artifacts while surveying the deflated surfaces. Subsequent excavation and screening of the sediments through 10 mm and 1 mm mesh led to a significant increase in the recovery of smaller lithic artifacts.

Given that the intensity of excavation varied greatly among the localities, the most representative way to compare lithic densities at Geelbek is to consider the density of finds per unit area surveyed. It is important to reiterate that collections extend over the entire area studied and include what would traditionally be referred to as both on and off-site. The large size of the areas surveyed explains the very low density values that range from 0.03 artifacts/m^2 at Check to 0.44 artifacts/m^2 at Shelly (Tab. 3). The shallow depth of the archaeological deposits and the complexity of estimating the amount of deflated sand make it impossible to calculate a density per unit sediment volume (artifacts/m^3) as is often done in the Western Cape (e.g., Jerardino 1995). Thus, it remains to be demonstrated if these figures provide meaningful comparative values for the intensity of occupation in the near coastal strandveld beyond the Geelbek Dunes.

The lithic artifacts from the MSA of Geelbek have been described elsewhere (Dietl 2004; Dietl et al. 2005), and the LSA artifacts have been reported in tabular form with illustrations (Conard et al. 1999; Conard 2002; Kandel et al. 2003). While the lithic assemblages from the surface of ADII are still under study, we will consider some of the key observations made thus far.

The radiocarbon dates (Tab. 2) indicate a period of more intense occupation during the middle of the first millennium cal BC in this part of the near coastal environment. The finds from Nora, Pottery and Shelly fall into the period corresponding to Buchanan's (1988) "megamidden" period in the coastal Western Cape. The locality Toaster yielded a date in the earliest first millennium cal AD. The localities Check and Toaster both produced dates in the latter part of the first millennium cal AD, while a human bone from the locality Homo also falls into this period. Radiocarbon dates from the second millennium cal AD come from the localities Crow, Hetero and Snoek. The calibrated ages include a correction factor for either ostrich eggshell (Vogel et al. 2001) or the reservoir effect in marine shell.

Selected lithic artifacts are illustrated in Figure 4, and a summary of the analytical data is presented in Table 7. While a detailed discussion of the context and composition of each assemblage is beyond the scope of this paper, some basic conclusions about the lithic assemblages can be drawn. First, artifacts from approximately contemporaneous accumulations show considerable variation. For our current purposes, we exclude finds smaller than 10 mm in order to avoid swamping the signal with the abundant small debitage (5-10 mm) and microdebitage (<5 mm). If we consider the formal tools from Nora, Pottery and Shelly, the results are relatively consistent. Formal tools comprise 7% (n=15 of 208), 3% (n=4 of 142) and 6% (n=21 of 373) of the respective totals. At other localities like Snoek the ratio of formal tools reaches a considerably higher value of 15% (n=33 of 221) (Tab. 7). Within the assemblages of formal tools, the higher the ratio of backed pieces (backed points, segments and backed bladelets), the greater the trend toward a hunting tool kit. This index ranges from 0% (n=0 of 4) at Pottery up to 85% at Snoek (n=28 of 33). The other localities display intermediate values from 24% to 35%. If we consider the ratio of adzes and scrapers as a percentage of formal tools, we can create a functional index that relates to the preparation of botanical resources and hides (Tab. 8). The scraper and adze index shows an inverse effect as compared to the backed ratio, and ranges from 6% (n=2 of 33) at Snoek up to 75% at Pottery (n=3 of 4). Despite the limited sample size, these data provide insight into the specific types of activities that occurred at these localities.

Independent of a detailed assessment of the cultural chronology of the region and ignoring the issues related to the possible presence of mixed assemblages, the lithic assemblages at Geelbek are clearly variable. This variation demonstrates that prehistoric people used the near coastal environments for a wide variety of purposes after the deposition of ADII some 5000 years ago.

The study of the abundance of lithic raw materials and reduction sequences also provides economic information about the use of near coastal environments. Here we utilize the data from all size classes of lithic artifacts. The abundance of the lithic raw materials represented among the chipped stone finds is summarized in Table 9. With the exception of Snoek, quartz dominates all of the assemblages. Only at Snoek does silcrete predominate. Other raw materials including quartzite, crypto-crystalline silicate (CCS), silcrete and granitic rocks are present in descending order of representation. Although these materials are not readily available in the open strandveld, the majority originate locally (Floss 1994) within 20 km of Geelbek. The presence of high portions of cortical debitage and cores at Nora, Pottery and Shelly indicates that primary knapping took place at these localities. On the other end of the spectrum, localities like Snoek are characterized by the lowest abundance of cortical debris and the highest proportion of retouched forms. In other cases, including the localities Alice, Bleached Bone Check and Loop, the presence of single backed points suggests a failed hunt, an animal that got away (Yellen 1977). Thus, the research strategy of documenting areas with extremely low artifact densities helps reconstruct sites and completes our limited view of landuse that was based mainly on the study of high density cave and midden sites.

Pottery

Eight localities at Geelbek have produced prehistoric, sand-tempered pottery dating from the last 2000 years. The quantities vary from a few isolated sherds, presumably from single pots at Loop, Check, Crow and Equus, to over 400 pieces from at least three pots at Toaster (Tab. 10). Most of the pots are highly fragmentary, but refitting has thus far produced relatively complete vessels from Stone Ring and Pottery. The pot from Stone Ring is a small, spouted vessel, 167 mm in diameter measured at its widest point, with a pointed base and bosses on its neck (Fig. 5). The ceramic from Pottery represents a large, undecorated mid-section of about 300 mm diameter with carbonized residues on its interior.

The concentration of ceramics at Stone Ring is associated with a bored stone, and the vessel fits within the seriation from Kasteelberg A and B (units 12-16) (Sadr & Smith 1991). Rudner (1968, 495: Fig. X.6) describes similar vessels from Ysterfontein in the Western Cape and other regions of southern Africa. Radiocarbon dates for Kasteelberg B (units 12-16) fall between 1300 and 800 BP and are associated with large numbers of seal and sheep bones (Sadr & Smith 1991). This has led Smith to argue for a strong link between the presence of pottery and herders. However, Sadr (2004) has more recently suggested that pottery may have entered the Western Cape independent of the migration of herders into the region.

Studies on organic residues indicate that ceramic vessels were often used to cook, render or store various animal products (e.g., Patrick et al. 1985; Copley et al. 2004). By comparing experimental results to the observed residues patterns on pottery from Dunefield Midden, Stewart (2005) demonstrated how vessels with pointed bases were likely propped up in loose sand for cooking. New results on spouted vessels from Kasteelberg D confirm the cooking of marine-derived fats (Copley et al. 2004). Such spouted vessels are similar to that described from Stone Ring. Initial results from the residue analysis on the plain ceramics from the locality Pottery conducted by the University of Bristol's Organic Geochemistry Unit document the presence of lipids that provide suggestive, but not conclusive, evidence that the vessels contained marine lipids, as well as other fats (Mark Copley pers. comm.). These data suggest that pots at Geelbek were used in connection with marine resources and presumably in other contexts as well.

As discussed above, the locality Pottery yielded evidence for the rendering of whale blubber, but the associated dates fall clearly in the pre-pottery period. Thus, the ceramics at Pottery cannot be temporally associated with the majority of cultural remains that date to the first millennium cal BC. While the means used to render whale oil have yet to be conclusively demonstrated, historical data point to its use and storage. For example, in van Riebeeck's diary from 1654 (Thom 1952) he documents the storage of oil in sea bamboo kelp (*Ecklonia maxima*). An informal test on three kelp stalks found on Sixteen Mile Beach showed that each bulb could hold about one liter of fluid. Other containers may have included ostrich eggshells and animal skins (e.g., Budack 1977).

Features

The most notable archaeological features at Geelbek are 49 circular to oval-shaped concentrations of calcrete found on ADII (Tab. 11). This total should be viewed as an estimate, given that the features tend to merge with their neighbors when spaced closely together. Only two of these features are composed exclusively of natural-colored, beige calcrete blocks averaging 12 cm in size and ranging up to 50 cm. Most are comprised of darker, gray to black calcrete blocks averaging 6 cm in size and ranging up to 30 cm. More than 85% of the measured calcrete blocks were darker than the natural beige color. The undeflated features typically have diameters of 2-3 meters, but after deflation, the distribution of calcrete is usually in the range of 3-5 meters. There is no indication that these features predate the formation of ADII 5000 years ago.

The frequency of the features varies within each locality. For example, both Toaster and Shelly include no fewer than ten features each, while six localities contain only one. The distribution of these features covers all parts of the Geelbek Dunes. They are more abundant in the north and west, with the western deflation hollows containing the highest numbers. The unsurveyed locality named Hearth beyond the western edge of the dune field includes eight calcrete features on ADII.

Stone features are among the most visible archaeological features from many coastal sites of the Western Cape (Avery 1974; Robertshaw 1979; Kandel & Conard 2003; Hine 2004; Sealy et al. 2004). At Pearly Beach on the south-western coast, Avery (1974) identified four types including: (1) stone hearths with ashy matrix; (2) stone hearths without ashy matrix; (3) burial coverings; and (4) possible base anchorages of huts or windbreaks. Until now, most of the dates associated with hearths stem from the last two millennia, with one exception. Charcoal from a stone hearth at Duiker Eiland on the West Coast dated to 2280 ± 45 BP (Robertshaw 1979). In addition to the archaeological remains, reports about stone hearths come from historical documents, such as this description from the diary of G. Meister in 1688 (Raven-Hart 1971, 347): "…[they] make a hole in the earth, and throw down into it a layer of pebbles. On this they make a fire, and when the stones are bravely heated they take this fire away and lay meat on them, and above the meat they again throw on stones, and then wood and glowing embers and thus let it roast." While not all of the features show clear signs of burning, the majority do, and the terms that have been applied to them including stone hearth and roasting platform appear appropriate.

At Geelbek the material used to construct these features was locally available calcrete. Since most of the features are found atop ADII, natural modes of transport can be ruled out. In cases of extreme deflation, the features rest directly on calcrete. Nonetheless, the features themselves remain intact and visible. The darker pieces are on average smaller, and thus more fragmented, than the beige pieces, which supports the hypothesis of burning. Our observations after an intense bushfire in 2000 (Fig. 2) indicate that the degree to which calcrete pieces from these features are burnt was not achieved. Nor was experimental burning in a fireplace successful in replicating the dark color of the calcrete. Further research in this area is needed, but we propose that burning in a reducing environment or in the presence of fat could produce the observed coloration.

The best functional data from the stone hearths at Geelbek comes from the locality Pottery where about 20% of fauna and marine shell around the periphery of Feature 1 are burned. Amongst the finds are 35 pieces of whale barnacle, one of which dates to 1090 ± 60 cal BC (2900 ± 35 BP). We view this as strong evidence that this stone hearth was used for cooking whale meat and rendering blubber as early as 2900 years ago. In Toaster, where ten hearths are present, the discovery of charred elephant remains (as yet undated) suggests that the features here may be associated with the windfall of a successful hunt or the bounty of scavenging.

Stone hearths may well have been useful for controlling and storing the heat produced by fires for cooking or roasting large animals or large volumes of other food. Those that lack signs of burning may have been under construction or served purposes other than food preparation. For example, these concentrations of calcrete could have stabilized the otherwise soft, sandy substrate to create firm working surfaces, seats or, as suggested by Avery (1974), bases for windbreaks or living structures.

While stone hearths are most commonly associated with coastal and near coastal environments, two stone hearths are preserved at the Anyskop Blowout in the West Coast Fossil Park at Langebaanweg (Conard 2002). This hilltop locality lies 20 km from the open coastline. There are few indications that marine resources were used at Anyskop, and the remains of large mammals are scarce. These observations warn against assuming that all stone hearths served the same function. Many more dates for these features and additional contextual information are essential for establishing their function and role in the system of settlement and subsistence practiced in the Western Cape. Additional information on their presence in more inland settings would also help to test the hypothesis that they are mainly associated with near shore regions. Other than Anyskop and Boomplaas Cave (Deacon et al. 1978) we are not aware of their existence in other inland settings.

Ornaments and Bone Tools

Several types of ornaments and bone tools are present in the deflation hollows at Geelbek. Most notably, the localities on ADII have yielded 1047 ostrich eggshell (OES) beads in various stages of production (Tab. 12) (Kandel & Conard 2005). The localities of Nora and Shelly document an emphasis on producing unburned OES beads, while the assemblage from Pottery is characterized mainly by burned, finished beads. Following Jacobson's (1987) line of argument, sites where beads are produced were more likely occupied by woman and children for longer periods than sites that do not document the production of beads. These results need to be viewed in a broader context, but taken at face value, the production of OES beads could be considered as an indicator of complex social units including families at Nora, Shelly and probably Pottery (Kandel & Conard 2005).

Other examples of ornaments have been recovered at Geelbek, such as the complete, unperforated, nacreous, oval ornament from Toaster, measuring 37 mm by 64 mm, made from perlemoen (*Haliotis midae*). Another worked piece of perlemoen from Stella may represent a blank for a similar type of ornament. Found among the sherds of the spouted vessel from Stone Ring is a single cowry (*Cypraea* sp.) shell, a mollusk that is often associated with personal adornment. In these cases, we do not yet have reliable dates for the finds.

Bone tools are represented by an engraved linkshaft with cross-hatches from Homo, six undecorated ones from Crow and one from Shelly. From Toaster comes a tool consisting of a worked rib bone, pointed at both ends, 112 mm long, 10 mm wide and 3.6 mm thick. To our knowledge this tool type has not been described in the archaeological literature, and we are not sure what use it served.

Human bones

Among the more than 13,000 piece-plotted bones from Geelbek, 23 finds of human remains have been recovered. Despite their scarcity, these bones provide important insight into the lifeways of the later LSA occupants of the near coastal strandveld. Colleagues at Groningen ran accelerator dates on three human bones, and Judith Sealy of the University of Cape Town's Archaeometry Laboratory measured stable carbon and nitrogen values (Tab. 13). The oldest skeletal remains from the locality Loop date to 50 ± 50 cal BC. The isotopic measurements from this individual produced one of the highest $\delta^{15}N$ values known from the Western Cape and indicate an unusually high consumption of marine foods. This male of 157 ± 3.6 cm stature (Alan Morris, pers. comm.) was not a herder who subsisted on products stemming from domesticated sheep. The other individuals are from the localities Homo and Hetero and date to 920 ± 60 cal AD and 1510 ± 80 cal AD respectively. Their isotopic signals fall within the typical range of values from the Western Cape during the last two millennia and most likely indicate a mixed diet of marine and terrestrial resources. They too were not subsisting entirely on domesticated sheep or other terrestrial resources. These results are consistent with other data from human skeletal remains that point to mixed economic forms (Pfeiffer & Sealy 2005).

Conclusions

The overall archaeological signal from Geelbek points to a non-specialized economy in which small numbers of people practicing a settlement system with high mobility sporadically used the strandveld for diverse activities. These data come from large-scale, systematic, surface collection and excavations in low density accumulations in the veld several kilometers from the Atlantic Ocean near Langebaan Lagoon. This type of archaeological setting has been largely overlooked by earlier research that instead focused on higher density caves, rockshelters and shell middens. The geological setting at Geelbek provides a chronological framework for studying these low density sites. The results from Geelbek grow in meaning when we consider that this sample of sites provides a behavioral signal that can be extrapolated into a much larger area of the strandveld of the Western Cape. If we are correct, future study of this geomorphological zone will provide similar evidence for high mobility, low intensity landuse in the largely undifferentiated strandveld. Particularly in areas such as springs or water holes would we expect to find evidence for more frequent and intensive use of this zone. Future modeling of subsistence and settlement can apply the data from Geelbek to approximate the way people used this part of the landscape during recent millennia. Similar analyses based primarily on the MSA lithic assemblages at Geelbek and Anyskop (Dietl 2004; Dietl et al. 2005) and Acheulean lithic artifacts at Anyskop (Conard 2003) indicate that this research strategy also provides valuable data from much earlier periods.

The results indicate that even low intensity use of the landscape and highly mobile settlement patterns can leave a recognizable archaeological signature. The data help reconstruct past systems of behavior and constrain models for prehistoric economies of the Western Cape. As more data from brief occupations like those at Geelbek become available, we will increasingly be able to link prehistoric people to the landscape in which they lived. In doing so, we will be able to fill in large gaps in the archaeological record of the far richer sites that have traditionally been the focus of excavations and analyses. This work will help us to identify places where brief stops and encampments occurred, where hunting took place based on the loss of hunting equipment, and even where animals got away during stone age hunts. Most of these low visibility activities provide important lines of evidence for reconstructing how people lived in the past. Other than the presence of a few pots and a few large OES beads, we see no indications that Geelbek was home to people that practiced herding. In the context of this paper we begin to see the elusive movements of the hunter-gatherers who persisted in the near coastal environments long after the arrival of new ideologies and economic forms brought by herders and pastoralists to the Western Cape (Parkington 1984; Smith 1998).

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Figure Captions

Figure 1. Geelbek Dunes. Map of southwestern Africa showing the location of the Geelbek Dunes and other place names mentioned in the text.

Figure 2. Geelbek Dunes. Aerial photograph taken in Apr. 2000 showing surveyed localities (triangles) and excavated sites (named, in ovals). The devegetated area in the south resulted from a bushfire that spread from Ysterfontein to Hopefield in Jan. 2000, covering a distance of 45 km and an area of 18,000 ha.

Figure 3. Geelbek Dunes. Plot of corrected and calibrated radiocarbon dates from the seven main localities discussed in the text.

Figure 4. Geelbek Dunes. Lithic artifacts from several localities: 1. backed point (B35-701); 2-4. backed bladelet (CH-395.1, SN-1304, SN-212); 5. segment (SN-187); 6. backed point with tanged base (PO-2443); 7-8. adze (NO-1401, SH-1523); 9. side scraper (SH-194); 10. end scraper (PO-2261); 11. platform core (SH-1570); 12. hammerstone (PO-3293); 13. platform core on hammerstone (SH-877); 14. fragment of bored stone (EQ-1072). Drawings by S. Feine.

Figure 5. Geelbek Dunes. Illustration of spouted, pointed-base, ceramic vessel from Stone Ring Drawing by S. Feine.

Table Captions

Table 1. Geelbek Dunes. Results of luminescence dating of the Ancient Dune (AD) horizons. ADI is a reddish-brown, consolidated, fine to medium grained sand, while ADII is a yellowish-brown, loosely consolidated, fine grained sand which contains calcified rhizoliths (fossilized root casts).

Table 2. Geelbek Dunes. Results of radiocarbon dating on marine shell, ostrich eggshell (OES) and faunal remains from localities discussed in this paper.

Table 3. Geelbek Dunes. Summary of field data from localities discussed in this paper. Key: *Preliminary data reported for Check and Snoek; **Fauna, OES and shells include the total number of piece-plotted finds plus bulk samples.

Table 4. Geelbek Dunes. Summary data for faunal analytical groups. Key: *Data from Check exclude 212 unanalyzed finds; **Preliminary data reported for Snoek and Toaster; ***Rhino includes ADII, ADI and calcrete.

Table 5. Geelbek Dunes. Detailed faunal analysis showing predominant species. No data available for Check. Key: *Preliminary data reported for Snoek and Toaster.

Table 6. Geelbek Dunes. Analytical results for marine shell. Note that black mussels live on rocky shorelines and dominate all of the assemblages, while white mussels live on a sandy coast.

Table 7. Geelbek Dunes. Results of lithic analysis. The percentage of tools is highest at Snoek and lowest at Pottery. Key: *Preliminary data reported for Check; **Data from Shelly exclude 873 unanalyzed finds; ***Data from Snoek exclude 31 unanalyzed finds.

Table 8. Geelbek Dunes. Breakdown of formal tools comparing the ratio of backed tools and the ratio of scrapers and adzes. These ratios are inversely proportional and indicate hunting on the one hand and plant and hide working on the other.

Table 9. Geelbek Dunes. Summary of raw material types. Quartz dominates all of the assemblages, except for Snoek, where silcrete dominates. Key: *Preliminary data reported for Check; **Data from Shelly exclude 873 unanalyzed finds; ***Data from Snoek exclude 31 unanalyzed finds.

Table 10. Geelbek Dunes. Summary of ceramics from all localities and the estimated minimum number of vessels.

Table 11. Geelbek Dunes. Summary of calcrete blocks from all localities and the estimated minimum number of features. Key: *The locality Hearth was not systematically studied, but the location of each feature was plotted.

Table 12. Geelbek Dunes. Tabulation of production stages of ostrich eggshell beads.

Table 13. Geelbek Dunes. Results from radiocarbon dating and C/N analysis on human remains.

FIGURE 1

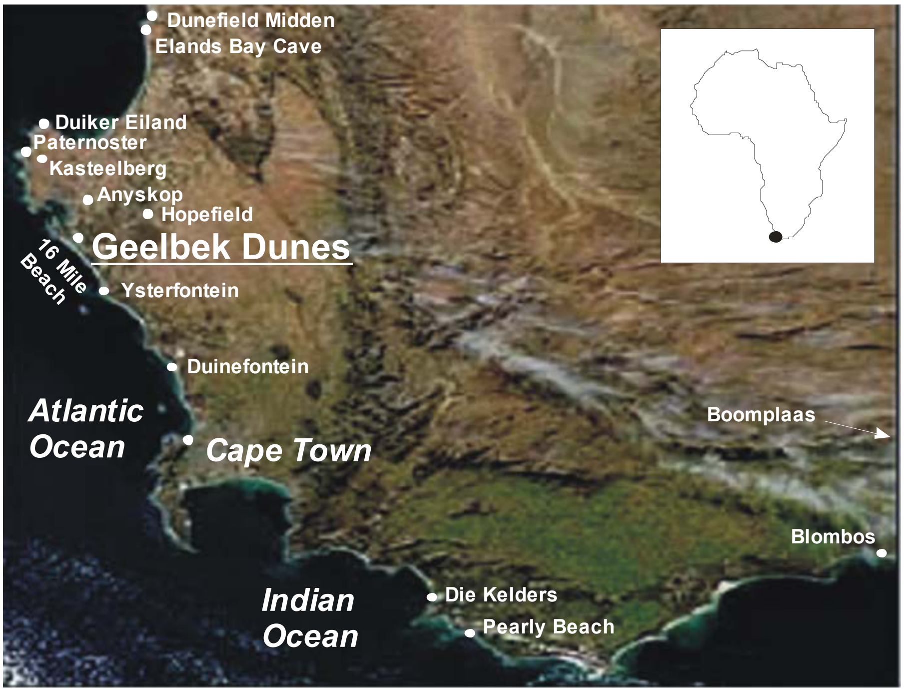

FIGURE 2

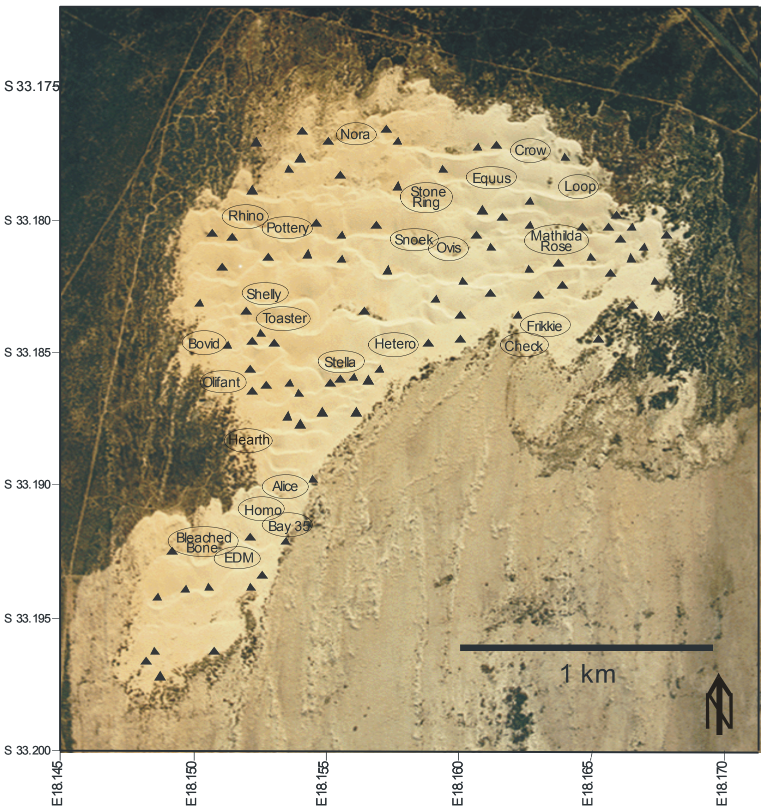

FIGURE 3

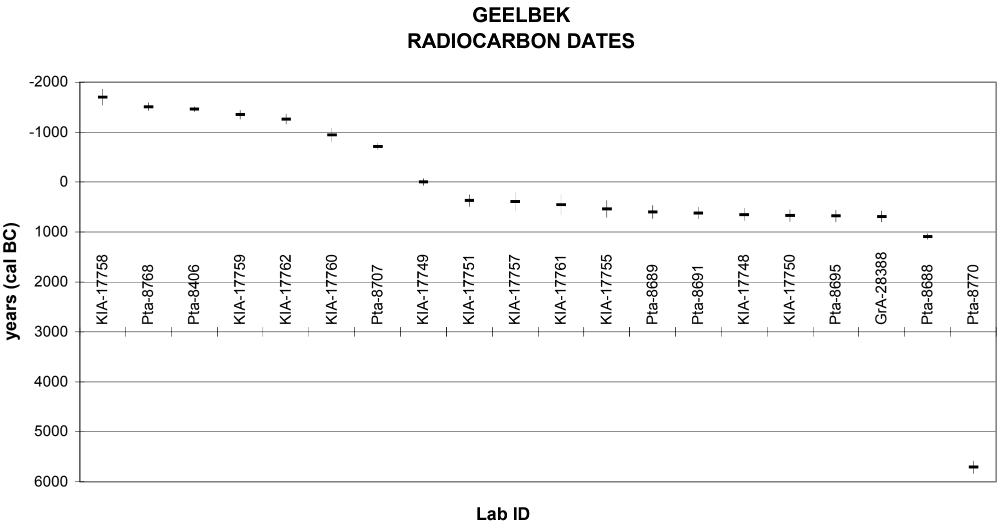

FIGURE 4

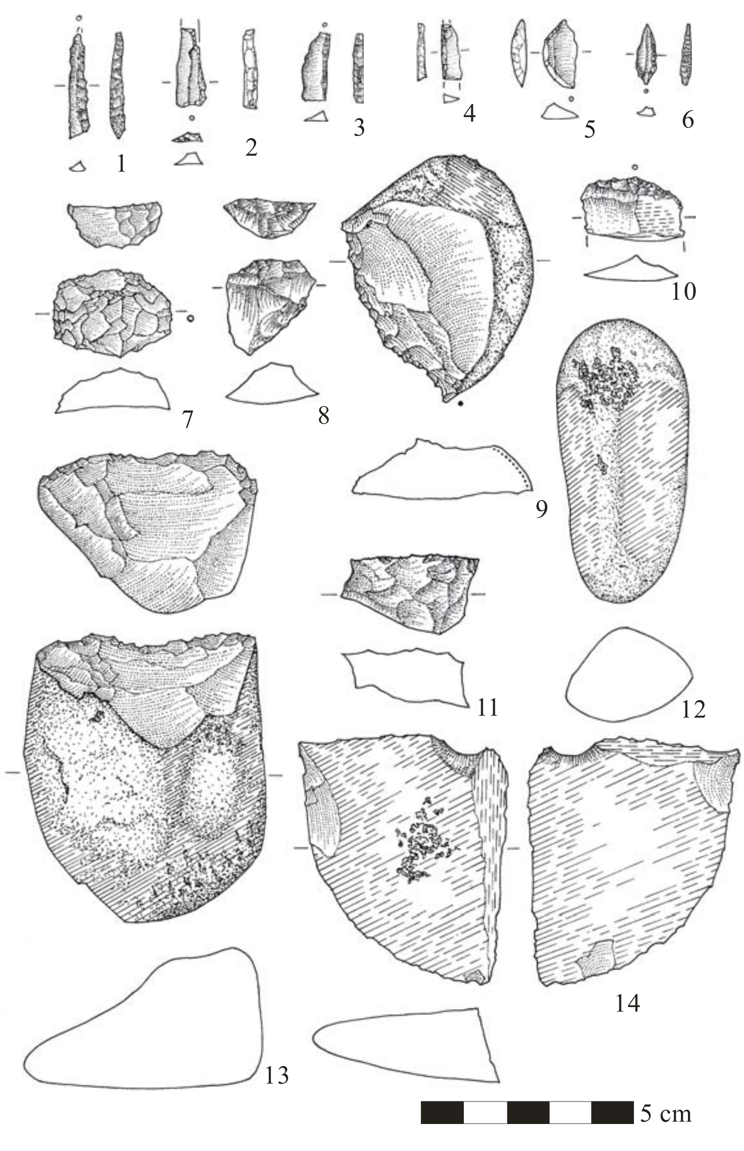

FIGURE 5

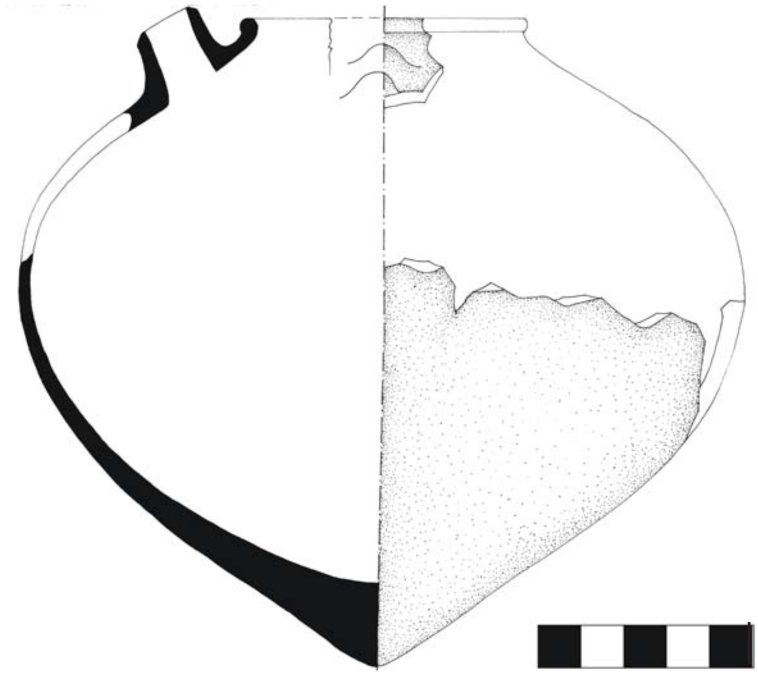

TABLE 1

Locality	Index	Lab ID	Method	Material	Geological Unit	Depth (cm)	Date ka	+/-
SNOEK	1646	MGF5-BT7	OSL	sand	ADII (reworked)	30	1	0,1
ALICE	553	MGF3-BT11	OSL	sand	ADII	150	5	0,5
ALICE	552	MGF3-BT10	OSL	sand	ADII	50	5	0,5
STELLA	1910	GB-SC-1	IRSL	sand	ADII	80	5	1
POTTERY	3713	GB-PO-3713	IRSL	sand	ADII	60	6	1
RHINO	1776	GB-RH-1776	IRSL	sand	ADI	150	10	1
ALICE	554	MGF3-BT12	OSL	sand	ADI	170	10	1
STELLA	1911	GB-SB-1	IRSL	sand	ADI	15	11	1

TABLE 2

Locality	Index	Bulk sample	Lab ID	Method	Material	Modified	Detail	uncal BP	+/-	cal BC	cal +/-
SNOEK	1327	-	KIA-17758	AMS	OES	yes	Large bead	380	20	-1700	160
SNOEK	1600	-	Pta-8768	14C	bone	-	Eland humerus	410	45	-1510	80
SNOEK	1525	-	Pta-8406	14C	bone	-	Eland thoracic vertebra	460	45	-1460	50
SNOEK	500	-	KIA-17759	AMS	OES	yes	Perforated OES	775	40	-1350	90
SNOEK	493	yes	KIA-17762	AMS	OES	yes	Perforated OES	890	20	-1260	100
TOASTER	1548	-	KIA-17760	AMS	OES	yes	Large bead	1260	25	-940	140
CHECK	1214	yes	Pta-8707	14C	shell	-	Black mussel	1730	45	-710	70
TOASTER	2627	-	KIA-17749	AMS	shell	yes	White mussel scraper	2385	25	1	70
SHELLY	2935.11	-	KIA-17757	AMS	OES	yes	Small bead	2465	25	390	190
POTTERY	1006	-	KIA-17761	AMS	OES	yes	Small bead	2500	25	450	210
NORA	1321.8	-	KIA-17755	AMS	OES	yes	Small bead preform	2580	25	540	170
POTTERY	3730	-	KIA-17751	AMS	shell	yes	White mussel scraper	2715	25	370	120
SHELLY	2514	yes	Pta-8689	14C	shell	-	Black mussel	2870	20	600	130
POTTERY	3050	-	GrA-28388	AMS	shell	-	Whale barnacle	2900	35	1090	60
SHELLY	3406	-	Pta-8688	14C	shell	-	Granite limpet	2905	20	620	120
POTTERY	527	yes	Pta-8691	14C	shell	-	Black mussel	2950	60	650	130
SHELLY	1251	-	KIA-17748	AMS	shell	yes	White mussel scraper	2960	30	670	120
NORA	951	-	KIA-17750	AMS	shell	yes	White mussel scraper	2970	25	680	120
NORA	1223	yes	Pta-8695	14C	shell	-	Black mussel	2980	20	690	110
RHINO	2419	-	Pta-8770	14C	bone	-	Eland metacarpus	6800	140	5710	130

TABLE 3

Summary	CHECK*	NORA	POTTERY	RHINO	SHELLY	SNOEK*	TOASTER	TOTAL
TOTAL AREA (m^2)	4851	2256	10722	3803	4750	3758	2900	**33040**
EXCAVATED AREA (m^2)	122	214	293	210	214	98	0	**1151**
LITHIC DENSITY (total m^2)	0,03	0,40	0,06	0,29	0,44	0,07	0,08	**0,16**
LITHIC DENSITY (excavated m^2)	1,21	4,19	2,22	5,28	9,79	2,76	na	**4,70**
Material Code	CHECK*	NORA	POTTERY	RHINO	SHELLY	SNOEK*	TOASTER	TOTAL
FAUNA**	572	208	1233	987	1095	939	893	**5927**
LITHICS	148	897	650	1108	2095	270	241	**5409**
MODERN	5	10	6	1	5	1	24	**52**
OES**	158	25	137	62	115	182	32	**711**
OES BEADS	0	187	614	0	220	1	13	**1035**
POTTERY	3	38	76	0	0	0	409	**526**
SHELLS**	405	300	410	75	1089	44	174	**2497**
TOTAL	**1291**	**1665**	**3126**	**2233**	**4619**	**1437**	**1786**	**16157**

TABLE 4

	LOCALITY	CHECK*		NORA		POTTERY		RHINO		SHELLY		SNOEK**		TOASTER**		TOTAL	
	Primary geological unit	*ADII*		*ADII*		*ADII*		*all****		*ADII*		*ADII*		*ADII*			
Group Code	Predominant species	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**
Amphibian	Frog indet.							1	0,1					1	0,1	2	0,04
Reptile	Chersina angulata	118	34	110	53	226	22	279	29	697	64	313	38	300	34	2043	38
Fish	Galeichthys feliceps			1	0,5	11	1	1	0,1	4	0,4	1	0,1	10	1	28	1
Bird	Francolinus capensis	19	5	12	6	43	4	7	1	13	1	53	6	80	9	227	4
Rodent	Bathyergus suillus	10	3	15	7	25	2	46	5	33	3	69	8	55	6	253	5
Hare	Lepus capensis			17	8	58	6	14	1	18	2	9	1	11	1	127	2
Fauna-1	Raphicerus spp.	46	13	43	21	590	56	265	27	292	27	135	16	251	28	1622	30
Carnivore	Mellivora capensis			1	0,5	6	1	73	8	9	1			12	1	101	2
Fauna-2	Small medium bovid	13	4	3	1	15	1	25	3	4	0,4	13	2	24	3	97	2
Fauna-3	Large medium bovid	135	39	4	2	33	3	53	5	6	1	61	7	23	3	315	6
Fauna-4	Taurotragus oryx	5	1	2	1	38	4	102	11	13	1	176	21	41	5	377	7
Fauna-5	Diceros bicornis							79	8					21	2	100	2
Fauna-6	Loxodonta africana							21	2	3	0,3			57	6	81	2
TOTAL		**346**	100	**208**	100	**1045**	100	**966**	100	**1092**	100	**830**	100	**886**	100	**5373**	100
Bulk faunal samples		14		0		188		21		3		109		7		**342**	
ALL FAUNA		**360**		**208**		**1233**		**987**		**1095**		**939**		**893**		**5715**	

TABLE 5

Species Code	Common Name	NORA	POTTERY	RHINO	SHELLY	SNOEK*	TOASTER*
Amphibians, Reptiles							
Frog indet.				1			1
Snake indet.				10	2		4
Tortoise indet.					2		1
Chersina angulata	Angulate tortoise	110	226	269	693	119	295
Fish							
Fish indet.		1	8	1	3		1
Galeichthys feliceps	Sea white catfish		3		1		5
Lithognathus lithognathus	White steenbras						4
Rhabdosargus globiceps	White stumpnose					1	
Birds							
Bird indet.		4	12	1	4	3	9
Afrotis afra	Black korhaan						5
Alopochen aegypticus	Egyptian goose						3
Burhinus capensis	Cape dikkop	2					
Corvus capensis	Cape crow						22
Francolinus africanus	Grey-winged francolin				1		13
Francolinus capensis	Cape francolin	6	28	2	6		25
Morus capensis	Cape gannet			1		39	
Phalacrocorax capensis	Cape cormorant			1			
Phoenicopterus ruber rosens	Greater flamingo						2
Spheniscus demersus	African penguin			1	2		1
Struthio camelus	Ostrich		3	1			
Rodents							
Small Rodent		1		12			
Georhycus capensis	Cape mole rat				1		
Rhabdomys pumilio	Striped mouse				1		
Medium Rodent			4			1	
Bathyergus suillus	Cape dune mole rat	14	21	34	22		49
Large Rodent			13			6	
Lepus capensis	Cape hare	17	45	14	18	9	11
Bovids							
Bovid, size class 1	Small bovid	17	408	22	160	35	187
Raphicerus spp.		8	73	191	8	21	11
Raphicerus campestris	Steenbok	11	43	1	5	1	
Raphicerus melanotis	Grysbok		3	1	2		
Sylvicapra grimmia	Duiker	1	4	10	2		4
Bovid, size class 2	Small medium bovid	1	2	5	1	1	13
Sheep / Goat				2			1
Bovid, size class 3	Large medium bovid	4	23	3			6
Bovid, size class 4	Large bovid	1	38		5	48	7
Bos (?)	Cattle					4	
Megalotragus priscus	Giant hartebeest			12			
Taurotragus oryx	Eland			40		54	
Pelorovis antiquus	Giant cape buffalo			6		1	
Size class 0, indet.	Microfauna (0-5 kg)				9		6
Size class 1, indet.	Small fauna (5-20 kg)	6	59	40	113	7	49
Size class 2, indet.	Small medium fauna (20-100 kg)	2	13	18	3		10
Size class 3, indet.	Large medium fauna (100-300 kg)		10	48	6		16
Equus capensis	Cape zebra			2			2

Size class 4, indet.	Large fauna (300-1000 kg)	1		44	8	12	33
Size class 5, indet.	e.g., Rhino, Hippo			23			16
Rhinoceros spp.							4
Diceros bicornis	Black rhino			56			
Size class 6, indet.	e.g., Giraffe, Elephant, Whale			9			50
Loxodonta africana	African elephant			12	3		7
Carnivores							
Small Carnivore			4				1
Galerella pulverulenta	Small grey mongoose	1		4	2		6
Genetta genetta	Small spotted genet			1			
Herpestes ichneumon	Large gray mongoose		1				
Ictonyx striatus	Striped polecat		1	2			1
Mellivora capensis	Honey badger			66			
Medium Canid							4
Medium Felid					6		
Arctocephalus pusillus	Cape fur seal				1		
Indet.							
Worked bone					2		1
TOTAL		**208**	**1045**	**966**	**1092**	**362**	**886**

TABLE 6

Marine Shell Code	Common Name	CHECK	NORA	POTTERY	RHINO	SHELLY	SNOEK	TOASTER	TOTAL
GASTROPODS									
Gastropod indet.			1	1	1	7			**10**
Bullia digitalis	Plough shell	3		1	1	6			**11**
Burnupena cincta	Whelk		4	3					**7**
Haliotis midae	Perlemoen (abalone)							5	**5**
Turbo cidaris cidaris	Alikreukel (periwinkle)					1			**1**
PATELLIDS									
Limpet indet.						4	1	1	**6**
Dendrofissurella scutellum	Keyhole limpet	2	1	7	4	10	13	15	**52**
Crepidula capensis	Slipper limpet		1			1			**2**
Cymbula granatina	Granite limpet	4		2		56	3	18	**83**
Cymbula oculus	Goat's eye limpet							1	**1**
Scutellestra argenvillei	Argenville's limpet		13			33		6	**52**
Scutellestra barbara	Bearded limpet					2			**2**
Scutellestra cochlear	Pear limpet		2			5			**7**
Scutellestra granularis	Granular limpet		1			31		11	**43**
BIVALVES									
Aulacomya ater	Ribbed mussel					4			**4**
Choromytilus meridionalis	Black mussel	373	158	269	58	593	8	83	**1542**
Donax serra	White mussel	1	45	63	2	261	17	25	**414**
Donax serra (retouched)	Tool (scraper)		12	6		66	1	5	**90**
Glycymeris queketti	Dog cockle							1	**1**
Venerupis corrugata	Venus clam	1		1				3	**5**
CRUSTACEANS									
Coronula diadema	Whale barnacle		1	35					**36**
Barnacle indet.	Acorn barnacle		1	1		7			**9**
Jasus lalandii	Crayfish			2		1			**3**
TOTAL		**384**	**240**	**391**	**66**	**1088**	**43**	**174**	**2386**
Bulk shell samples		21	60	19	9	1	1	0	**111**
ALL SHELL		**405**	**300**	**410**	**75**	**1089**	**44**	**174**	**2497**

TABLE 7

Lithic Code	CHECK*	NORA	POTTERY	RHINO	SHELLY**	SNOEK***	TOASTER	TOTAL
Tools	6	15	4	31	21	33	8	**118**
Cores	8	1	5	10	43	4	8	**79**
Flakes	73	151	111	505	232	180	118	**1370**
Angular Debris	8	41	22	91	77	4	15	**258**
CHIPPED ARTIFACTS >10 mm	**95**	**208**	**142**	**637**	**373**	**221**	**149**	**1825**
Tool ratio	6%	7%	3%	5%	6%	15%	5%	**6%**
Small Debris (5-10 mm)	3	471	335	362	580	-	32	**1783**
Microdebitage (<5 mm)	25	204	147	60	195	11	2	**644**
ALL CHIPPED ARTIFACTS	**123**	**883**	**624**	**1059**	**1148**	**232**	**183**	**4252**
Ground Stone Tools	2	2	12	2	27	-	4	**49**
Manuports (unchipped stone)	6	11	13	47	38	7	30	**152**
Geofacts (includes ochre)	17	1	1	-	9	-	24	**52**
TOTAL LITHICS	**148**	**897**	**650**	**1108**	**1222**	**239**	**241**	**4505**

TABLE 8

Tool Code	CHECK	NORA	POTTERY	RHINO	SHELLY	SNOEK	TOASTER
scraper, large		1		2			
scraper, medium		1	1				
scraper, small		3	1	1	4	2	
scraper, side	4			1	1		
TOTAL SCRAPERS	4	5	2	4	5	2	0
segment	1	4		5	2	2	
backed point	1			2	3	14	
backed bladelet		1		4		8	1
backed blade						4	1
TOTAL BACKED PIECES	2	5	0	11	5	28	2
ret on flake				10	4		1
ret on blade						1	1
ret on bladelet				4			
misc ret		1			3		
TOTAL MISC. RETOUCH	0	1	0	14	7	1	2
adze		2	1		3		1
drill				1		1	1
unifacial point (tanged)		1	1				
denticulate				1	1	1	2
indet		1					
TOTAL MISC. TOOLS	0	4	2	2	4	2	4
TOTAL FORMAL TOOLS	**6**	**15**	**4**	**31**	**21**	**33**	**8**
Backed Tool Ratio	**33%**	**33%**	**0%**	**35%**	**24%**	**85%**	**25%**
Scraper & Adze Tool Ratio	**67%**	**47%**	**75%**	**13%**	**38%**	**6%**	**13%**

TABLE 9

Raw Material Code	CHECK*		NORA		POTTERY		RHINO		SHELLY**		SNOEK***		TOASTER		**TOTAL**	
	n	%	n	%	n	%	n	%	n	%	n	%	n	%	**n**	%
Calcrete	16	11							41	3			15	6	**72**	2
CCS	3	2	104	12	86	13	5	0,5	329	27			1	0,4	**528**	12
Silcrete	54	36	26	3	26	4	56	5	99	8	217	91	24	10	**502**	11
Granitic/Igneous	9	6	14	2	8	1	348	31	30	2	6	3	23	10	**438**	10
Quartz	58	39	418	47	318	49	579	52	497	41	12	5	120	50	**2002**	44
Quartzite	2	1	320	36	42	6	88	8	173	14			14	6	**639**	14
Metamorphic /Sedimentary	3	2	6	1	164	25	27	2%	37	3	2	1	19	8	**258**	6
Other	3	2	9	1	6	1	5	0,5	16	1	2	1	25	10	**66**	1
TOTAL	**148**	100	**897**	100	**650**	100	**1108**	100	**1222**	100	**239**	100	**241**	100	**4505**	100

TABLE 10

Locality	Ceramic (n)	Estimated minimum # of vessels
CHECK	3	1
CROW	2	1
EQUUS	1	1
LOOP	17	1
NORA	38	2
POTTERY	76	3
STONERING	66	1
TOASTER	409	3
TOTAL	**612**	**13**

TABLE 11

Locality	Calcrete blocks (n)	Estimated minimum # of features
BOVID	39	3
CHECK	203	2
EDM	1	1
EQUUS	497	3
HEARTH*	na	8
HOMO	424	1
LOOP	25	1
MATILDA ROSE	11	1
NORA	284	1
OLIFANT	1	1
POTTERY	967	3
RHINO	2	1
SHELLY	609	10
SNOEK	5	1
STELLA	1	1
STONERING	1	1
TOASTER	1186	10
TOTAL	**4256**	**49**

TABLE 12

Bead Code	Description	LOOP	NORA	POTTERY	SHELLY	SNOEK	STELLA	TOASTER	TOTAL
0	indeterminate			1	1				**2**
1	angular blank	1	70	10	58		5		**144**
2	rounded blank		5	14	6				**25**
3	complete, partially drilled blank	1	14	1	22				**38**
4	broken, partially drilled blank		23	1	8				**32**
5	complete, perforated blank		10	2	6			4	**22**
6	broken, perforated blank		45	5	10			1	**61**
7	complete, perforated, slightly formed bead	1	1	60	8				**70**
8	broken, perforated, slightly formed bead		3	1	6				**10**
9	complete, perforated, almost bead form		4	327	14			3	**348**
10	broken, perforated, almost bead form		3	1	10				**14**
11	complete, finished bead	4	8	190	69	1		5	**277**
12	broken, finished bead		1	1	2				**4**
	TOTAL	**7**	**187**	**614**	**220**	**1**	**5**	**13**	**1047**

TABLE 13

Locality	Index	Lab ID	Method	Material	Detail	uncal BP	+/-	cal age	cal +/-	Lab ID	Collagen Yield	δ13C	δ15N	C/N ratio
HETERO	101	GrA-17558	AMS	bone	human tibia	405	40	1510 AD	80	UCT-8070	6,8	-14,8	11,0	3,1
HOMO	103	GrA-13530	AMS	bone	human femur	1100	50	920 AD	60	UCT-8069	5,9	-16,1	12,9	3,2
LOOP	1600	GrA-17565	AMS	bone	human radius	2040	35	50 BC	50	UCT-8071	22,0	-9,8	16,7	3,0

Appendix B.8

Dietl, H., Kandel, A.W. & Conard N.J. (2005) Middle Stone Age settlement and land use at the open-air sites of Geelbek and Anyskop, South Africa. *Journal of African Archaeology* 3, 233-244.

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MIDDLE STONE AGE SETTLEMENT AND LAND USE AT THE OPEN-AIR SITES OF GEELBEK AND ANYSKOP, SOUTH AFRICA

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ABSTRACT

The analysis of stone artefacts from the open-air localities of Geelbek and Anyskop in the Western Cape of South Africa offers new insight into the behaviour of Middle Stone Age hunters and gatherers. We examined five deflation bays in these mobile dune systems which, in contrast to caves or rockshelters, display large-scale spatial patterning with regard to the distribution of lithic artefacts and faunal remains. The definition of raw material units enabled us to reconstruct the patterns of production, use and discard of stone artefacts. The results reveal that hunters and gatherers, such as those who produced Howiesons Poort stone artefacts, employed diverse planning strategies in terms of raw material exploitation, transport technology and site use. Although the faunal remains are not yet fully evaluated, the presence of stone points and segments suggests that hunting played an important role among the activities documented at Geelbek and Anyskop. The low number and heterogeneity of the stone artefacts suggest that people of the Middle Stone Age were highly mobile.

RÉSUMÉ

L'étude de l'industrie lithique des sites de plein-air de Geelbek et Anyskop situés au Western Cape en Afrique du Sud a permis d'élargir nos connaissances sur le comportement des chasseurs-cueilleurs au cours du Middle Stone Age. L'étude en question a porté sur cinq baies de déflation dans un système de dunes mouvantes, ce qui, en l'absence de contraintes topographiques propres aux occupations sous abris ou en grotte, nous a permis d'aborder la question de l'organisation spatiale à large échelle des vestiges lithiques et fauniques.

La distinction de différentes unités de matière première au sein de l'inventaire s'est avérée utile pour la reconstitution de la production effectuée sur place et de la sélection des supports.

Les résultats tendent à nous montrer que les chasseurs-cueilleurs, comme par example ceux porteurs de l'industrie du type Howiesons Poort, ont eu recours à plusieurs stratégies de planification en termes d'exploitation du site, d'économie de débitage et de matière première.

Alors que l'étude des restes fauniques est en cours, la présence de pointes lithiques et de segments suggèrent que la chasse devait jouer un rôle non négligeable au sein des activités relevées à Geelbek et Anyskop. Le faible nombre et l'hétérogénéité des artéfacts lithiques suggèrent que les hommes du Middle Stone Age étaient très mobiles.

INTRODUCTION

The question of whether or not Middle Stone Age (MSA) people were behaviourally like their Later Stone Age (LSA) counterparts has been increasingly debated (Klein 2000; McBrearty & Brooks 2000; Wadley 2001; d'Errico et al. 2003; Henshilwood et al. 2002, 2004). Most researchers focus on searching for cultural innovations to analyse the behaviour of MSA hunters and gatherers. Mainly caves and rockshelters have been studied, but these usually lack information about large-scale spatial patterning because the areas excavated are small. The cave sites that feature prominently in the current debate usually provide large assemblages of artefacts that hinder the detailed study of the kind reported here. In contrast to cave sites, deflation hollows in open-air settings in the Western Cape of South Africa offer the possibility to investigate large surface areas containing piece-plotted, archaeological and faunal remains. Additionally, the analysis of specifically defined raw material units has helped to yield new results about mobility, transport, site use, raw material exploitation and technology during the MSA.

Two research projects initiated by the Department of Early Prehistory and Quaternary Ecology of the University of Tübingen targeted the study of low density, archaeological and faunal remains that are found within deflation hollows in two mobile dune systems of the Western Cape. The two dune fields, Geelbek and Anyskop, are located 90 and 115 km north of Cape Town, respectively (Fig. 1). In conjunction with the archaeological work, we conducted geological research to gain a better understanding of the chronostratigraphic relationship among the different deflation hollows (Conard et al. 1999; Conard 2002; Felix-Henningsen et al. 2003; Kandel et al. 2003; Kandel 2004).

The first systematic investigation of the dune systems began in 1998 at the MSA and LSA sites of Geelbek (Conard et al. 1999). The Geelbek Dunes cover more than 4 km^2 and consist of more than 100 individual deflation hollows, of which we studied 23 in detail (Fig. 2). Several geological layers outcrop within the Geelbek Dunes, including at least three calcrete horizons dated to ca. 250, 150 and 65 ka based on IRSL and U-series measurements. Semi-consolidated units include the red-brown sand of Ancient Dune I (ADI), with IRSL dates of 10–11 ka, and the yellow-brown sand of Ancient Dune II (ADII), with IRSL dates of 5–6 ka (Felix-Henningsen et al. 2003). These horizons help to bracket the age of the deflated finds that lie on the surface in the valleys between the active dunes.

The first systematic fieldwork at the Early Stone Age (ESA), MSA and LSA sites of Anyskop began in 2001. This single, large dune field covers about two hectars and is situated on a hilltop in the West Coast Fossil Park (Hendey 1982). To date, only the northern half of the Anyskop Blowout has been studied in detail. Here the geological layers consist of a continuous calcrete horizon overlain by red-brown sand, both of which are not yet securely dated. The presence of Acheulean artefacts found on the surface of the calcrete suggests a minimum age of 250–200 ka (Conard 2002, 2003). We completed the last major field seasons at Geelbek and Anyskop in 2002, and we continue to monitor both dunefields. The MSA stone artefacts from these dune systems provided the material for a Master's Thesis that evaluated the assemblages from Anyskop and four of the deflation bays at Geelbek (Dietl 2004).

METHODS

For the purpose of this paper, we examined lithic artefacts from Anyskop and four of the 23 localities studied at Geelbek. The names of the chosen localities are Equus, Homo/Bay 35, Stella and Toaster. At these localities the field crews surveyed the deflation hollows using a Total Station and piece-plotted thousands of lithic artefacts and faunal remains. We mapped the borders of the geological units and measured the local topography. In selected areas within the deflation hollows we conducted excavations. The crews collected finds from the localities in several consecutive years to observe the patterns of deflation. By monitoring the movement of the dunes, we successfully recovered many finds as they were freshly uncovered by the wind and still lay in situ.

Due to the nature of the sediments and the effects of deflation, none of the geological layers at Geelbek or Anyskop can serve as a high-resolution chronological marker for the archaeological and faunal finds. In localities where the younger layers, ADI and ADII, outcrop, less deflation has occurred, and the assemblages from the LSA sites remain largely intact. At localities where the older calcretes outcrop, a greater degree of deflation has taken place, and LSA, MSA, and (in the case of Anyskop) ESA assemblages can be superimposed upon each other.

Based on taphonomic experiments such as GOME (Geelbek Object Movement Experiment), we established that materials move together as a package during deflation (Kandel et al. 2003). The materials included stones, bones, shell and ostrich eggshell placed on the surfaces of the mobile sand dunes, ADII and calcrete. These experimental studies into the taphonomy of the dune fields demonstrate that the spatial distribution of the archaeological assemblages has remained stable over long periods of time.

Since the field crew recovered artefacts from a variety of contexts at Geelbek and Anyskop, it was necessary to exercise caution in assigning the lithic assemblages to a cultural period. For the MSA, we used technological and typological data from stratified, securely dated sites including Klasies River (Singer & Wymer 1982; Wurz 2002), Blombos Cave (Henshilwood et al. 2001), Hollow Rock Shelter (Evans 1994) and Apollo 11 (Vogelsang 1998).

We analysed the cores from Geelbek and Anyskop using the Unified Taxonomy introduced by Conard et al. (2004) and described the tools and blanks following sources including Deacon (1982), Singer & Wymer (1982) and Wurz (2002). We recorded weights and measurements, and systematically identified raw materials using rock type, colour and texture. The analysis also used the following factors to help differentiate MSA artefacts from LSA forms: 1) the degree of surface degradation, such as patination, weathering or sandblasting; 2) the spatial patterning of raw material 3) the association of lithic artefacts with heavily mineralised faunal materials including ostrich eggshell; and, 4) the degree of deflation and geological context. For the most part, the technological and typological analyses succeeded in distinguishing MSA stone artefacts from pieces belonging to ESA and LSA industries.

The presence of many varieties of different raw materials at Geelbek and Anyskop provided us with the opportunity to conduct a detailed technological analysis. Following the work of Conard & Adler (1997) and Adler et al. (2003) we grouped stone artefacts belonging to a single “Raw Material Unit” (RMU) together to reconstruct the reduction processes. We use the term “RMU” to refer to a lithologically distinct raw material based upon criteria that include colour, texture, inclusions, degree of homogeneity and cortex (Conard & Adler 1997). One RMU can consist of refitted, as well as non-refitting, lithic artefacts. At Geelbek and Anyskop, RMUs composed of several artefacts suggest production on-site, while RMUs represented by a single artefact indicate their import to the site. An RMU that contains a single artefact corresponds to an isolated find that does not belong to another RMU. This conclusion is made possible because of the large areas investigated. Furthermore, the presence of one diagnostic piece within an RMU allows other non-diagnostic lithic artefacts of the same RMU to be placed into a single cultural phase.

CULTURAL AFFILIATION AND CHRONOLOGY

MSA finds can be recognized by the presence of Levallois and discoid cores, larger platform blade cores, unifacial and bifacial pieces, segments, flake-blades, convergent flakes (points), facetted striking platforms and dorsal preparation (Singer & Wymer 1982; Deacon & Deacon 1999; Wurz 2000, 2002). These charcteristics apply especially to the Still Bay and Howiesons Poort sub-stages of the MSA.

The Still Bay is considered to be older than the Howiesons Poort, but has fewer dated sites. The best dated occurrence of the Still Bay sub-stage occurs at Blombos Cave and indicates an age of ca. 75 ka (early OIS 4) based on OSL dating (Jones 2001; Henshilwood et al. 2002; Jacobs et al. 2003; Tribolo 2003). According to Feathers (2002) the segments and bifacially worked pieces of the Howiesons Poort date between 80 and 50 ka. However, more recent studies show that the dates for the Howiesons Poort cluster around 60 ka, which suggests that the industry coincides with the end of OIS 4 and the beginning of OIS 3 (Tribolo 2003; Wadley & Jacobs 2004).

The localities Homo/Bay35 and Anyskop each yielded a bifacially worked artefact (Tab. 1). However, both Still Bay (Evans 1994; Henshilwood et al. 2001) and Howiesons Poort (Wadley & Harper 1989; Vogelsang 1998) are known to yield bifacial stone artefacts.

The most reliable marker of the Howiesons Poort is the segment, a backed piece that is shaped like a crescent (Figs. 3 & 4) and which is generally ≥ 25 mm long (Deacon 1984). Segments can be described as the *fossiles directeurs* of the Howiesons Poort (Goodwin & van Riet Lowe 1929; Wurz 1999). Based on these technological and typological criteria, some of the stone artefacts from the localities Equus, Stella and Anyskop could be clearly ascribed to the Howiesons Poort Industry. The stone artefact assemblages of Equus and Stella contained two segments each, while Anyskop added 10 more to the inventory (Tab. 1; Figs. 3 & 4).

In the case of Equus, the segments are associated with heavily mineralised, equid, large bovid and rhinoceros remains within a dense scatter of fossilised ostrich eggshells. The eggshell yielded a conventional radiocarbon date of >44 ka bp and an AMS date of >37 ka bp (Kandel 2004). All of these artefacts are found atop a calcrete deposit that has been dated to ca. 110 ka using the U/Th-method. Thus, these associations are consistent with the presence of Howiesons Poort artefacts at Equus.

Stone artefacts from the locality Toaster contained no diagnostic features to help classify them into a specific MSA sub-stage. However, the mean length of the blanks is consistent with those published by Wurz (2002) for Howiesons Poort assemblages. Although suggestive of the Howiesons Poort, these data do not yet justify a secure cultural affiliation.

Due to the high mobility of the dunes and consequent deflation, two additional segments were discovered in 2004 at another locality named Rhino. Their presence here suggests that Howiesons Poort artefacts also exist in other deflation hollows. Thus, assemblages of stone artefacts that were previously indeterminate may, in the future, become attributable to the MSA (Dietl 2004).

SETTLEMENT BEHAVIOUR AND LAND USE

For a better understanding of the settlement behaviour of MSA hunters and gatherers, the palaeoenvironmental data from the Western Cape need to be evaluated. According to Klein (1991) the diameter of humeri of the Cape dune mole-rat (*Bathyergus suillus*) can be considered as a reliable climatic indicator. His analysis of Cape dune mole-rats in the Western Cape suggests that the climate from ca. 110–90 ka (OIS 5d and 5b) and from ca. 74–59 ka (OIS 4) was cool and very moist. The climate became considerably drier between ca. 40–20 ka.

Although climatic inferences based on the formation of hardpan calcrete have certain limitations (Netterberg 1978; Deacon & Lancaster 1988; Eitel 1994), recent studies of fossil hardpan calcrete layers in the Geelbek Dunes suggest that semi-humid to semi-arid climatic conditions prevailed at about 250, 150 and 65 ka (Felix-Henningsen et al. 2003). Calcrete deposits typically form under warm, semi-arid climatic conditions where precipitation ranges between 550 and 800 mm/yr (Netterberg 1969; de la Cruz 1978).

Comparable environmental data can be inferred from heavily mineralised, fossilized faunal remains. At Geelbek the predominance of large mammalian species which preferred grazing over browsing leads to the conclusion that a more humid climate existed in the Western Cape during periods within the MSA (Kandel et al. 2003). In the MSA horizons of Ysterfontein 1, the presence of mammals, such as blue antelope, southern reedbuck and greater kudu, indicates a moist environment rich in grasslands between 70 and 60 ka. (Halkett et al. 2003). Similar results come from the MSA horizons of Die Kelders, where sediment and faunal remains dating between 70 and 60 ka suggest that the environment was moister than during historic times (Avery et al. 1997).

Based on the analysis of climatic and archaeological data, a correlation exists between a favourable environment and a higher population density in the Western Cape (Dietl 2004). In addition to the MSA finds from the Geelbek Dunes and the Anyskop Blowout, several other sites along the western coast of South Africa date to the end of OIS 5a, when a warmer climate prevailed, and to early OIS 4, as the climate cooled. Sites like Ysterfontein 1 (70–60 ka) (Halkett et al. 2003), Die Kelders (70–60 ka) (Avery et al. 1997; Feathers & Bush 2000; Klein & Cruz-Uribe 2000), Diepkloof Rockshelter (with Howiesons Poort segments) (Parkington & Poggenpoel 1987), Peers Cave (with Howiesons Poort segments) (Volman 1984) and Hollow Rockshelter (with Still Bay points) (Evans 1994) provide further support for a time of relatively high population density. This period appears to be followed by a time of hyper-aridity from ca. 40–20 ka during which the population of Southern Africa declined (Deacon 1995).

In the Western Cape sites like Diepkloof (Parkington & Poggenpoel 1987), Hollow Rockshelter (Evans 1994) and Peers Cave (Volman 1984) provide stone artefacts including segments, as well as unifacial and triangular points which could be considered as potential hunting weapons. Geelbek and Anyskop are two additional areas that have produced these tools. Four of the segments show lateral damage which could indicate their use as hunting equipment, as argued by Wurz (1999) at Klasies River. Similarly Singer & Wymer (1982) suggest that segments could have served as barbs or insets (Volman 1984; Deacon 1989). In contrast to the segments, points often show natural fractures at the distal end, which makes it difficult to say whether or not these artefacts were used as hunting weapons.

At Geelbek and Anyskop the five analysed deflation bays present contrasting ratios when comparing "larger" RMUs consisting of several artefacts with those composed of single artefacts (Tab. 1). While the locality Stella contains larger RMUs that suggest more intensive on-site production, single artefacts of varying raw materials predominate at localities like Toaster and Equus (Dietl 2004). This picture implies that, with the exception of Stella, most of the stone artefacts result from multiple, ephemeral occupations by MSA people in the Geelbek and Anyskop areas.

At the localities studied just 13% (n=551) of the more than 4100 stone artefacts (Tab. 2) can be assigned to the MSA. Although a few of the remaining artefacts belong to the ESA at Anyskop, the vast majority belong to LSA industries or cannot be attributed to a specific period. Thus, the small number of MSA finds is consistent with the heterogeneity of the raw materials at the sites and results from the ephemeral use of the landscape by highly mobile hunters and gatherers. Such data require further evaluation at the larger cave sites and rockshelters to clarify whether or not the layers containing Howiesons Poort artefacts and other MSA assemblages document numerous, short, occupational episodes that are analogous to the palimpsests of multiple assemblages like those found at Toaster or Equus.

Conclusions about the RMUs can be drawn by analysing different categories of stone tools found in the larger RMUs versus those consisting of single artefacts (Fig. 5). Segments and side scrapers are found predominantly as single artefacts. This observation implies that these tools were single imports curated by hunters and gatherers for longer periods of time. Thus, they were not produced where they were discarded. This stands in contrast to denticulates which are often represented among the larger RMUs. Seven of eight denticulates are from larger RMUs, whereas 12 of 14 segments and 15 of 16 side scrapers are single artefacts. This result is consistent with Geneste's (1985) hypothesis that denticulates were more frequently left on or near the site where they were produced, unlike other tools, such as segments and side scrapers.

A second observation is that parallel cores (including Levallois cores) and inclined cores (including discoid cores) are more often found as single finds than are platform cores. In contrast to the more standardized parallel and inclined cores, platform cores at Geelbek and Anyskop display great variation in size and form, and varied orientations of the striking platform. This could explain the preferential transport of parallel and inclined cores, both of which would ensure an optimised exploitation of raw material compared to irregular platform cores. Mathematical models by Brantingham & Kuhn (2001) for the Middle Palaeolithic show that the Levallois technique is a very efficient and productive method. The analysis of cores in Geelbek and Anyskop shows that 82% of the parallel cores were made on silcretes coming from more than 12 km away from the sites. This is consistent with the hypothesis derived from the Middle Palaeolithic of Europe that the Levallois method was often used on raw materials which were not exploited near their source (Geneste 1985; Roebroeks et al. 1988).

Based on their use of raw materials, the hunters and gatherers of the Middle Stone Age at Geelbek and Anyskop economized in their behaviour. First, 76% of the identifiable MSA stone artefacts were made on silcrete, which represents the raw material of the highest quality in the studied assemblages. This preference shows that MSA people systematically selected silcrete for the production of artefacts. We followed the definition of Tavoso (1984), Turq (1988) and Floss (1994) that raw materials sourced up to 20 km away can be considered as "local" because they can be procured within the context of an individual's daily rounds. The most common raw materials of the MSA at Geelbek and Anyskop probably came from these local sources. Since we are unable to determine the precise source for each of the many raw materials, we cannot, however, preclude that exotic raw materials were imported from further away. The furthest transport observed is at least 30 km for two cores and a notched triangular point. These quartzite artefacts from the localities Toaster and Equus stem from either the Berg River gravels or the Table Mountain Series of the Piketberg.

Among the artefacts manufactured on silcrete coming from at least 12 km away, both early and late reduction phases are represented. The presence of RMUs with cores and cortical flakes suggests a degree of on-site production, whereas single blanks or tools would have been imported. Some raw materials from more than 20 km away including Table Mountain quarzite show evidence of early reduction based on the presence of cores and cortical flakes. These examples show that the relationship between distance and intensity of reduction is variable.

A closer look at the distribution of the finds in the deflation bays confirms the results of the raw material analysis. A comparison of the localities Stella and Toaster illustrates the differences in raw material utilisation (Fig. 6). Both localities clearly show that more complex settlement structures are only recognisable if hunters and gatherers imported material to exploit and knap on-site. Data from Stella show that RMUs represented by many artefacts are concentrated within relatively well defined areas. This trend suggests that single artefacts dispersed widely over the deflation bays such as those documented at Toaster reflecting background scatters. This pattern has been seen at European sites. These background scatters form a key type of site for reconstructing Palaeolithic settlement systems (Isaac 1981; Roebroeks et al. 1996; Conard & Adler. 1997; Conard 1998, 2001).

Taking another example from Stella, several of the identified RMUs are present in both area A and B (Fig. 6). Assuming that each RMU represents a closed chronological unit (Weißmüller 1995), strict contemporaneity for each of the lithic concentrations in Stella A and B can be assumed. Increased attention to refitting at these sites should help to clarify questions of contemporaneity. At Stella A, seven out of a total of 15 tools belong to two RMUs (#25 and #42). Of the 12 blades found in Stella, eight were from Stella B, each from a different RMU. These differences in raw material economy even indicate contrasting patterns of site use within a single locality.

CONCLUSIONS

Based on the observations of Binford (1996) and Wadley (2001) from caves and rockshelters in Southern Africa, MSA sites typically lack recognizable spatial patterning. Our work at open-air localities in the Western Cape indicates that the distribution of artefacts results from well organised high mobility behavioural strategies. The new pattern of spatial variation and technical organisation documented at Geelbek and Anyskop only emerge when large surfaces are studied (O'Connell 1987; Conard et al. 1999). Thus the methods used here promised to provide new insights into the Stone Age mobility and settlement dynamics.

Assemblages of stone artefact from Geelbek and Anyskop indicate that MSA people in the Western Cape planned the exploitation and use of raw material. The data suggest that hunters and gatherers occupied this part of Southern Africa more intensively during periods of favourable climate. People at Geelbek and Anyskop were highly mobile, leaving behind many low density scatters of artefacts, and did not occupy open-air sites for long periods. Background accumulations of artefacts document ephemeral use of the landscape. The careful collections over large surface areas at Geelbek and Anyskop indicate that settlement patterns can indeed be identified.

We are currently studying patterns of land use during the ESA, MSA and LSA to establish temporal trends in the settlement of the Western Cape. While we see differences in the intensity of occupation between the ESA, MSA and LSA, and more diverse types of sites and features in the LSA, we do not assume that patterns of land use during the MSA represent fundamentally different or "pre-modern" adaptations. This being said, we need to develop hypotheses to explain the specific differences we observe in how ESA, MSA and LSA finds are distributed over the landscape. We think that open-air settings like Geelbek and Anyskop that yield large-scale and at times low density distributions of artefacts can make important contributions to the study of Stone Age archaeology in South Africa.

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TABLES

Table 1. Geelbek Dunes and Anyskop Blowout. Summary of analysis showing the total number of chipped and unchipped stone artefacts from the MSA. (RMU = Raw Material Unit)

Table 2. Geelbek Dunes and Anyskop Blowout. Summary of analysis showing the total number of chipped and unchipped stone artefacts from all time periods. Flake: ≥ 10 mm; small debitage (SD): 10-5 mm; microdebitage (MD): < 5 mm *. (This analysis excludes 490 quartz artefacts from Anyskop.)

FIGURES

Figure 1. Geelbek Dunes and Anyskop Blowout. Map showing the location of Geelbek and Anyskop, as well as other sites in the Western Cape that are mentioned in the text. (Image: NASA Earth Observatory).

Figure 2. Geelbek Dunes. Aerial photo of the Geelbek dunes showing the location of the deflation bays (April, 2000).

Figure 3. Geelbek Dunes and Anyskop Blowout. MSA stone artefacts from Homo (HO), Anyskop (ANY) and Equus (EQ): 1) Platform core; 2) Parallel core; 3) Unifacial point; 4) Segment; 5) Segment; 6) Inclined core. (Drawings: S. Feine).

Figure 4. Geelbek Dunes. MSA stone artefacts from Stella (ST) and Toaster (TO): 1) Parallel core; 2) Retouched point; 3) Inclined core; 4) Segment; 5) Segment; 6) Point; 7) Inclined core. (Drawings: S. Feine, H. Dietl).

Figure 5. Geelbek Dunes and Anyskop Blowout. Graph showing the frequencies of individual tool and core categories from Geelbek and Anyskop combined. This plot demonstrates the different use of single artefacts versus larger RMUs, that is, artefacts made of the same raw material.

Figure 6. Geelbek Dunes. Surfer plots showing the distribution of: a) different larger RMUs (artefacts belonging to the same raw material) from Stella; and, b) single artefacts in Toaster.

	GEELBEK				ANYSKOP
	Equus	Homo/Bay35	Stella	Toaster	Blowout
Description (n)					
Chunks	1	11	9	1	5
Cores	2	24	18	2	74
Flakes	17	27	86	8	142
Blades	2	1	12	-	14
Points	-	-	-	2	2
Segments	2	-	2	-	10
Side Scrapers	-	2	-	-	14
End Scrapers	-	1	-	-	1
Retouched Points	-	-	1	1	4
Notched Pieces	-	-	2	1	4
Denticulates	-	1	7	-	-
Unifacials	1	-	-	-	3
Bifacials	-	1	-	-	1
Other Tools	3	4	2	-	10
TOTAL	**28**	**72**	**139**	**15**	**284**
Detail (n)					
RMUs with 1 artefact	26	43	18	15	205
RMUs with > 1 artefact	1	11	18	-	13
RMUs total	27	54	36	15	218
Manuports	(10)	-	-	-	-
Hammer-/Grindstones	(1)	-	(1)	-	-
Hammerstones	-	-	-	-	(1)

Table 1

	Locality	Chunk	Core	Flake	SD	MD	Tool	Manuport	Total
Geelbek	Equus	13	9	46	7	5	17	32	**129**
	Homo/Bay35	83	46	248	105	9	30	55	**576**
	Stella	56	48	385	203	32	37	51	**812**
	Toaster	15	8	120	32	2	12	53	**242**
Anyskop	Blowout	215	243	945	104	11	151	249	**1918***

Table 2

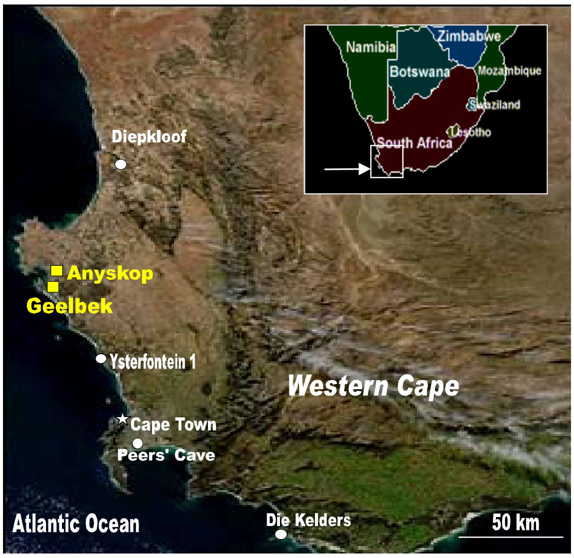

Figure 1

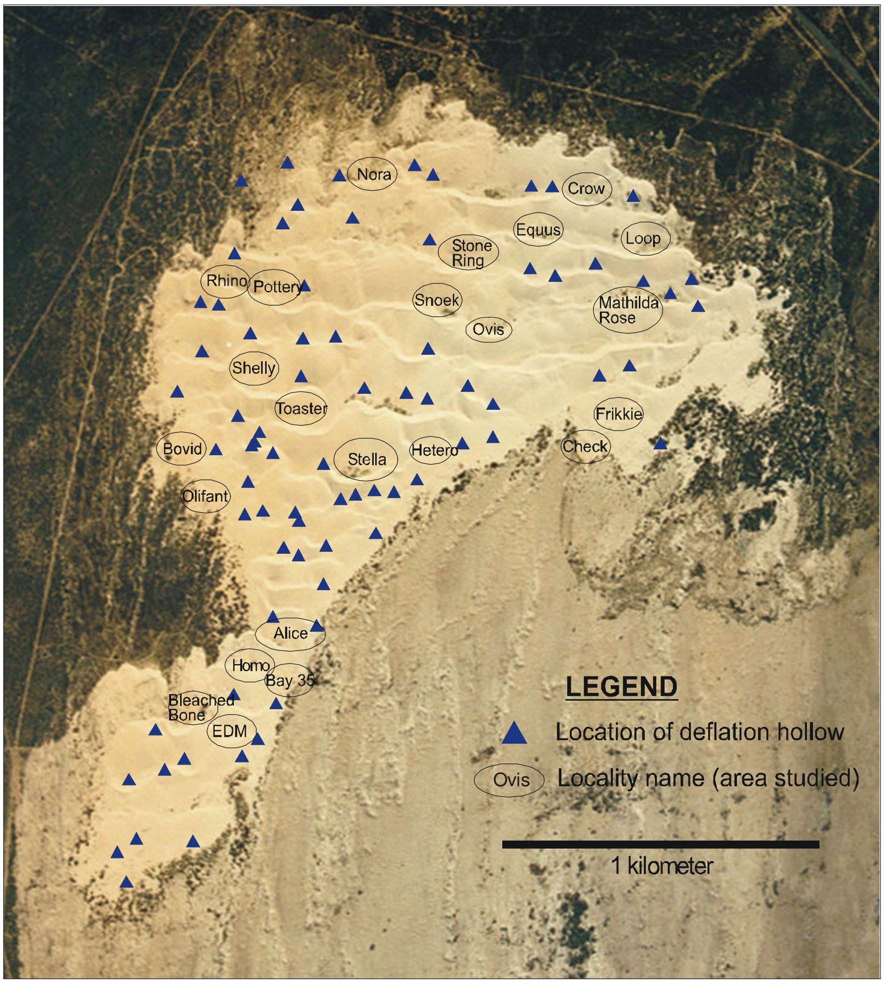

Figure 2

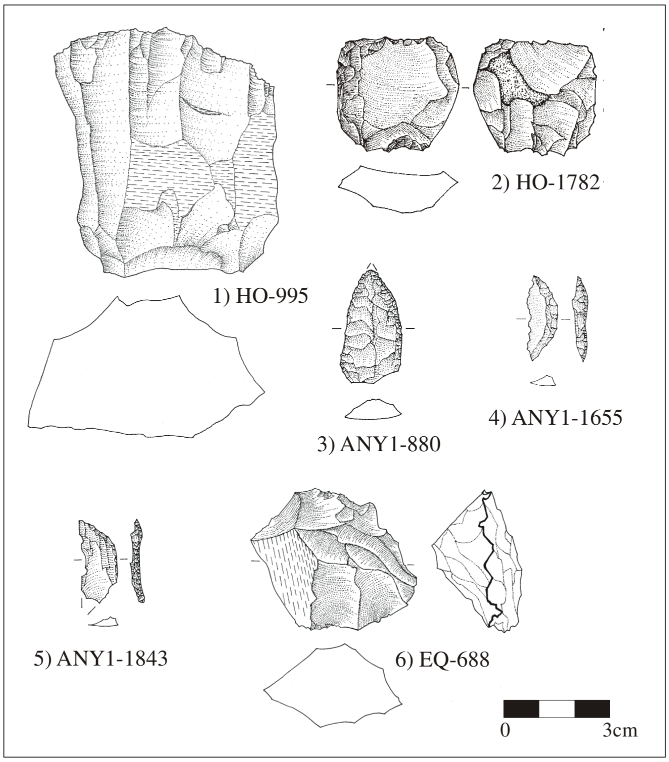

Figure 3

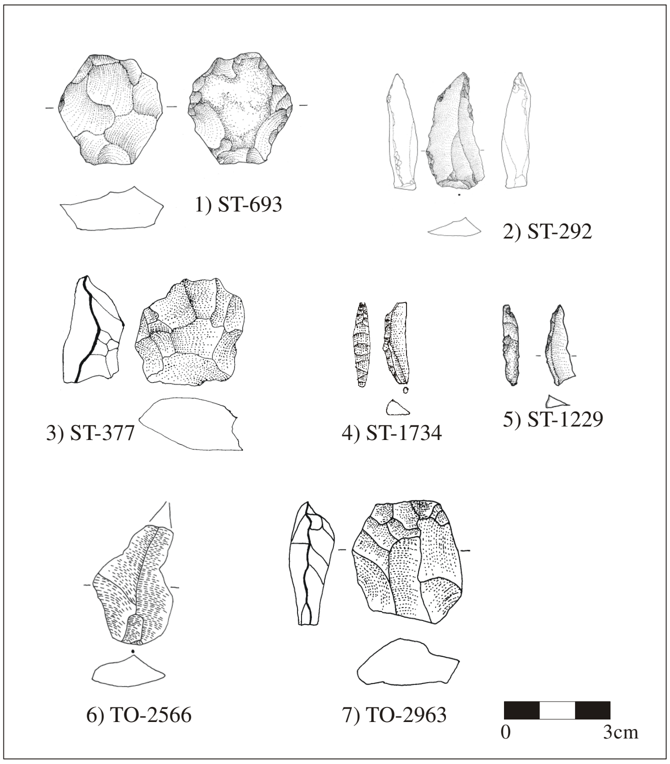

Figure 4

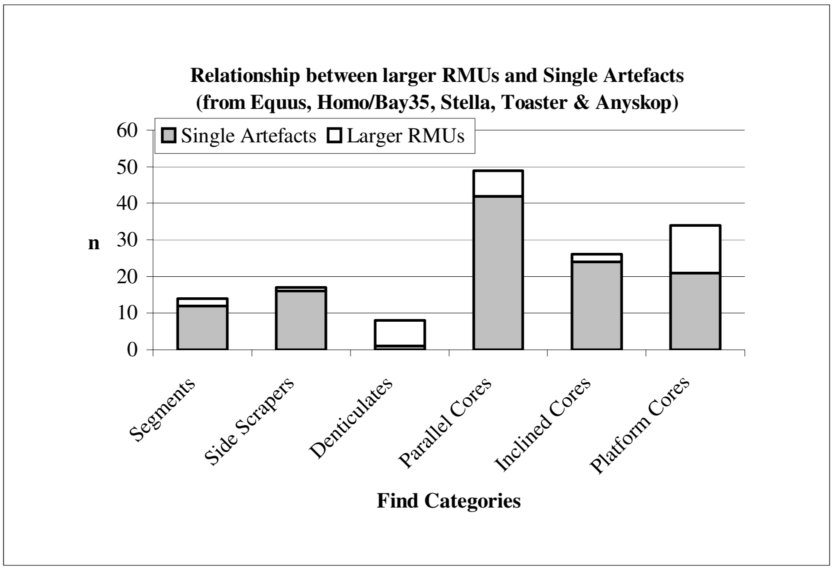

Figure 5

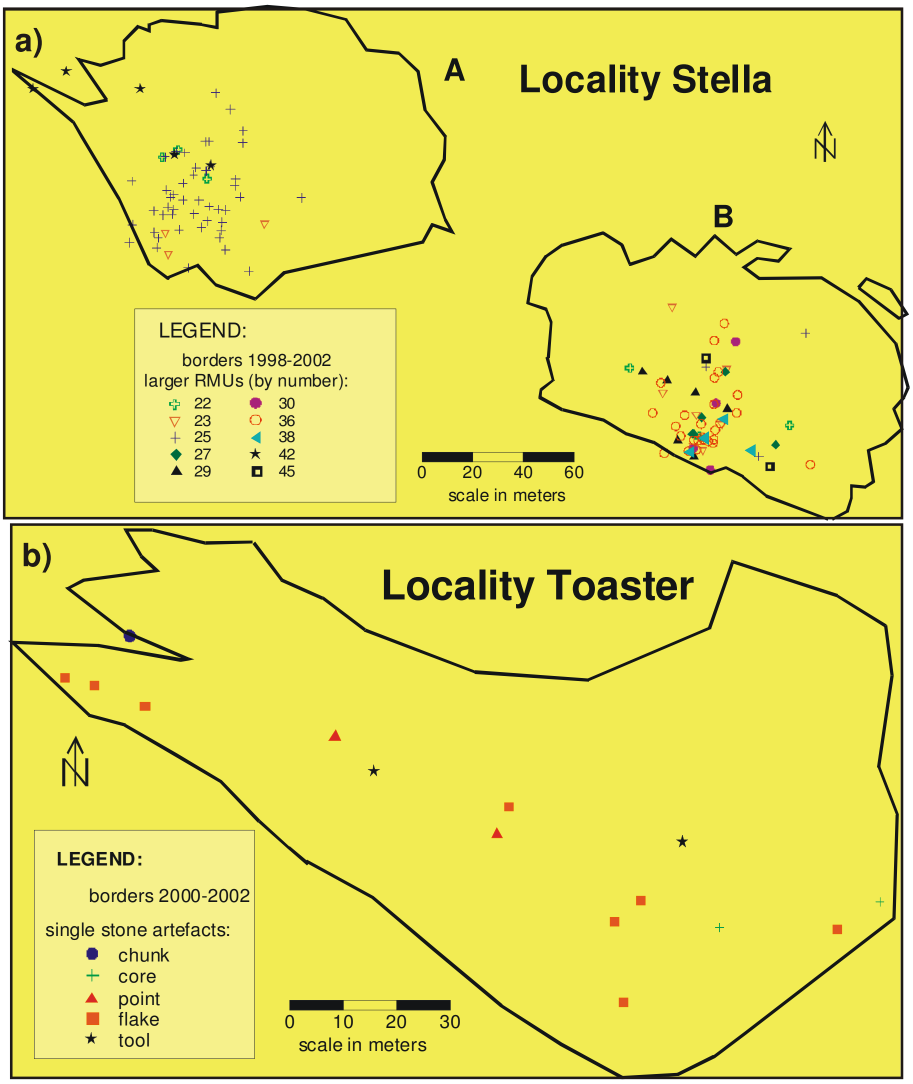

Figure 6

Appendix B.9

Dodonov, A.E, Kandel, A.W., Simakova, A.N., Masri, M. & Conard, N.J. (In press) Geoarchaeological characteristics of open-air Paleolithic sites in the Ma'aloula region, Damascus Province, Syria. Manuscript accepted for publication in *Geoarchaeology*.

GEOMORPHOLOGY, SITE DISTRIBUTION AND PALEOLITHIC SETTLEMENT DYNAMICS OF THE MA'ALOULA REGION, DAMASCUS PROVINCE, SYRIA

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ABSTRACT

This survey of the geology, geomorphology and Paleolithic archaeology of a 300 km^2 area in Damascus Province, Syria focused around the villages of Ma'aloula and Jaba'deen. The study resulted in the definition of seven geomorphological zones that trend northeast-southwest, parallel to the prevailing geological features of the region. The zones span a broad range of elevations from a dry lake bed in the Jeiroud Basin (ca. 800 m) to the peaks of the Anti-Lebanon Mountains (ca. 2350 m). The research focused on assessing the geological and paleoenvironmental history of the region as a backdrop for 500,000 years of Paleolithic settlement. Among the 618 archaeological sites documented thus far, all major archaeological periods from the Lower Paleolithic through the Epipaleolithic are represented. Most abundant are occurrences of the Levalloisian Middle Paleolithic, with 255 new sites documented. Nine Neolithic sites were also included in the survey. The distribution of sites varies during the Paleolithic and reflects the availability of resources, especially of flint and water, as well as the spatial patterns of erosion and deposition on the ancient land surfaces.

INTRODUCTION

In May, 1999 an international team under the direction of archaeologists from the University of Tübingen and the Directorate General of Antiquities and Museums began a geoarchaeological survey project in the northern part of Damascus Province, Syria (Fig. 1). The project centered on the villages of Ma'aloula and Jaba'deen, located about 40 km northeast of the city of Damascus. During the first three field seasons, the research focused on a 100 km^2 area around Ma'aloula and Jaba'deen (Fig. 2). During the subsequent two field seasons, the survey area was expanded to encompass about 300 km^2 (Fig. 3). Figures 2 & 3 depict the names of villages, wadis and other locations mentioned in this paper.

The main focus of the project was to examine the relationship between the archaeological components of scattered Paleolithic artifacts and their geological and geomorphological settings. To accomplish this, the team set out to establish the dynamics of settlement and evaluate the characteristics of paleoenvironmental change in the Ma'aloula–Jaba'deen region. By documenting new Paleolithic sites and investigating the regional geomorphology, the team expanded upon the previous surveys and excavations conducted by Rust (1950) and Solecki & Solecki (1987/1988) near Yabroud, about 20 km northeast of Ma'aloula, and by van Liere (1960/61) and Suzuki & Kobori (1970) at scattered locations in Damascus Province. The new work in the Ma'aloula region represents the largest and most systematic archaeological survey conducted in Syria to date and contributes to the understanding of Paleolithic settlement in the central Levant.

The environment of this region clearly favored the settlement of prehistoric people, based on the large number of open-air Paleolithic localities found thus far. The Levalloisian lithic industry of the Middle Paleolithic constitutes the most frequent assemblage type, with the distribution of these sites expanding across the largest part of the area surveyed (Conard et al., 2004). Most of these open-air localities, however, lack clear stratigraphic contexts.

The surveys in the Ma'aloula–Jaba'deen region have also shown that most rockshelters and caves along the Oligocene cliff line have been eroded down to bedrock. There are, however, two fortunate exceptions (Conard, 2002). In May, 1999 the survey team discovered stratified deposits at Baaz Rockshelter and has conducted three seasons of excavation since then. The team first viewed Kaus Kozah Cave in October, 2000 and began investigations there in October, 2004. Both of these sites have provided multiple find horizons dating from the Epipaleolithic and Neolithic. Together, these two sites have yielded important results about settlement at the time of transition from a foraging economy to one based on agriculture and sedentism (Conard, 2002).

GEOLOGICAL SETTING

The survey region around Ma'aloula (Figs. 2 & 3) is situated in the Palmyrides Mountains near the Anti-Lebanon orogenic zone (Ponikarov et al., 1963; Ponikarov, 1967). Tectonically, it is located in the southwestern portion of the Nabk Anticline along its northwestern flank (Ponikarov, 1964).

Flints, which provided the raw material for artifacts made by people during the Paleolithic, are readily available from primary and secondary deposits in many areas within the survey region. Occasional beds of flint outcrop in the Upper Cretaceous limestones and sandstones of the Anti-Lebanon Mountains and the Nabk Anticline, which flank the region to the northwest and southeast, respectively. Thin lenses of flints are widespread in the Paleogene limestones and marls of the survey region, while occasional secondary flint can be obtained from the Neogene conglomerates, marls and sandstones. Quaternary deposits containing rounded cobbles of flint blanket the wadis, forming a relatively thin cover atop the Paleogene, and to a lesser extent the Neogene, bedrock.

Near the base of the prominent cliff line that runs through the region, artesian springs, such as those near Jaba'deen and Ma'aloula, represent perennial sources of water that likely encouraged Paleolithic settlement in the region.

METHODS

For our initial geological study, we chose routes along the main drainages that transect the highlands and lowlands, including Wadi Ma'aloula, Wadi George Jaffa and Wadi Jaba'deen (Fig. 2). Other mapping routes focused on the areas formed by the Paleogene and Neogene rocks that create the higher topographic relief. Geological, geomorphological and paleopedological observations were made at more than 300 points and document the stratigraphic sequence, lithology and facies.

The geomorphological map (Fig. 3) was constructed by the survey team in the field using the existing geological and topographical maps as a basis. The team made hundreds of observations in the field concerning the regional geomorphology and spot checked critical locations to confirm boundaries of the various units. The team conducted survey mostly on foot, but also used an automobile to record data at many of the remote points.

The coarse nature of the majority of sediments in the survey region limited the preservation of fauna and flora. However, we collected palynological samples at three separate localities (Fig. 2) and recovered gastropods from a fine-grained, lacustrine deposit in the upper reaches of Wadi Ma'aloula. Despite the presence of numerous exposures of Pleistocene sediments, the very coarse nature of these deposits generally hinders the environmental interpretations based on sedimentary and pedological studies. Similarly, sediments of this nature are also inappropriate for paleomagnetic studies.

Further environmental information from the excavations at Baaz Rockshelter and Kaus Kozah Cave provided significant data for the Epipaleolithic and Neolithic of the region (Conard, 2002). These periods correspond to the end of the Late Pleistocene and Holocene. Combining the geological, geomorphological and palynological studies with the archaeological investigations, we were able to use the archaeological finds from open-air localities as rough chronostratigraphic markers for sediment and landforms that were otherwise undatable.

RESULTS

In the following sections we present the results of the five different focal points of the survey in detail, including: a) geomorphological characteristics; b) Quaternary stratigraphy; c) distribution of the archaeological sites; d) paleogeographic reconstructions, and; e) palynological results.

A. Geomorphological Characteristics

Based on observations made in the field, we subdivided the survey area into seven zones (Fig. 4). A description of the general characteristics of each of the zones follows, along with the approximate range of elevations at which these features were typically observed. They are listed in order of increasing altitude starting in the southeast and moving towards the northwest.

1) Lowland fans composed of Middle and Late Quaternary proluvial conglomerates tilted towards the southeast at an angle of 3–4º. Small wadis dissect the surface of the fans to create irregularities in the topography with relief of up to 10–15 m. Altitude: ca. 1100–1300 m.

2) Lowland hills formed of Middle Quaternary conglomerates and Eocene marls and limestones. These oval-shaped hills contain dispersed flints in lenses and continuous layers up to 30–40 cm thick. The flint varies from dark to light brown in color. Slopes tilt at 7–8º with ridges of 20–30 m in relative height. Altitude: ca. 1300–1450 m.

3) Colluvial slope at the base of the cliff line, covered by Late Pleistocene–Holocene colluvium. The angle of the slope ranges from 15–25º. Scattered blocks of slumped limestone are more common in the northeastern portion of this topographic zone and are especially characteristic of the area near Ma'aloula. Altitude ranges from 1450–1550 m.

4) The Paleogene cliff consists of hard, massive Oligocene limestone and forms nearly vertical walls 50–70 m in height, fractured by sub-vertical small faults which promoted the formation of caves, rockshelters and niches. The Oligocene limestone does not contain flint, and its highest altitude is 1550–1600 m.

5) Resistant Oligocene limestone forms a cuesta developed from southwest to northeast, and its northwestern slope is partially covered by Neogene stratum. The limestone dips to the northwest at 15–20º. Altitude: ca. 1550–1600 m.

6) Highland hills formed by Pliocene conglomerates are observed as a belt northwest of the Oligocene cuesta. Erosion has created a highly dissected topography in the bedrock and is represented by incised Pliocene conglomerates, siltstones and marls. The depth of erosion reaches as much as 70–80 m. The inclination of the eroded slope does not exceed 15–17º. Altitude is in the range of 1600–1700 m.

7) Highland plateau formed on Pliocene conglomerates with a 3–4 m layer of calcrete at the top tilting slightly downward towards the northwest. The inclination of the surface is around 3–5º to the northwest in accordance with the general dip of the Pliocene conglomerates. The calcrete serves as a hardpan that hinders erosion. The highland plateau is cut by several prominent, deep wadis. Altitude is from 1600–1650 m.

B. Quaternary Stratigraphy

The Quaternary subdivisions used here are those of the international stratigraphic scale: the Neogene-Quaternary boundary is 1.8 Ma, the Lower Pleistocene ranges from 1.8–0.8 Ma, the Middle Pleistocene from 0.8–0.13 Ma, the Upper Pleistocene from 0.13–0.01 Ma, and the Holocene spans the last 0.01 Ma. Ponikarov et al. (1969) correlated the lower boundary of the Quaternary in Syria with the base of the Calabrian stage or its continental equivalents. According to Gibard et al. (2004), the

Calabrian stage represents the period from 1.8 to 1.0 Ma. In the Ma'aloula survey region, Middle Pleistocene, Upper Pleistocene and Holocene deposits can be recognized on the basis of geomorphological and archaeological data, with additional evidence provided by the palynological analysis.

The Middle Pleistocene is represented by proluvium (Fairbridge, 1968; Gary et al., 1972) that is widespread to the southeast of the Ma'aloula–Jaba'deen cliff line. The proluvium is a poorly bedded and poorly sorted conglomerate with clasts of pebbles, gravels and boulders in a carbonate, coarse sandy matrix. It contains both angular and rounded pieces of local materials (limestone, marl and flint) and occasionally thin lenses of sandy silt with pebbles and gravel. The proluvial conglomerate formed during phases of highly seasonal, intense precipitation and consequent surface erosion along wadi systems. This poorly sorted, aggradating debris was deposited over large areas during the Quaternary.

The thickness of the proluvial conglomerates ranges from a few meters up to at least 20-25 m, increasing in the southeastern part of the area studied. The age of the conglomerates cannot be younger than Middle Quaternary because many open-air Middle Paleolithic sites are located on their surface. The conglomerates are present on the slopes of wadi valleys and are often eroded by the wadis. For example, Wadi Ma'aloula has cut 35–40 m into the conglomerates and the underlying Paleogene rocks. Smaller wadis do not create such deep erosional systems.

At the top of the proluvial conglomerates a 0.5–1 m thick horizon of calcrete creates a resistant crust that hinders agricultural activities. Intense evaporation of soil moisture near the surface during dry seasons resulted in the precipitation of carbonate from saturated groundwater, leading to the formation of calcrete on the surface. In modern trenches that penetrate through the calcrete crust, the underlying carbonate material appears loose, and the conglomerates are not strongly cemented.

The Upper Pleistocene and Holocene geological accumulations include colluvium, proluvium and lacustrine deposits. The colluvium covers the base of the steep slope below the resistant cliffs of

Oligocene limestone (Krasheninnikov et al., 1996). The colluvium consists of unsorted, poorly cemented debris with angular pieces of marl and limestone. Very large blocks of limestone (>100 m^3) rest precariously on the slope of the colluvium. The colluvial thickness varies from less than 1 m at the top of the slope and increases to 5–6 m or more at its base. The age of the colluvium can be assigned to the Upper Pleistocene and Holocene based on the Epipaleolithic and Neolithic finds on the colluvial surface near Baaz Rockshelter and other sites. Moreover, scattered finds of Upper Paleolithic artifacts on the colluvial surface can be considered as an argument for an Upper Pleistocene age for some of the colluvial sediments.

Young proluvial deposits, 4–5 m thick, form the lower terraces along Wadi Jaba'deen, Wadi Ma'aloula and Wadi George Jaffa. The young proluvium fills the bottom of small wadis, but does not form terraces. Lithologically, this deposit is similar to the proluvium of the Middle Pleistocene, but it is less cemented and more silty.

A 2–3 m thick exposure of lacustrine sediment in the upper reaches of Wadi Ma'aloula above the Oligocene cliff consists of clayey carbonate silt and contains mollusks (Fig. 2: P2). *In situ* stone artifacts attributed to the Upper Paleolithic suggest an Upper Pleistocene age for these lake sediments. A calcrete horizon of 0.8–1.0 m thickness overlies the silt. An analysis of the mollusks indicates the presence of three families of terrestrial gastropods. Two forms each of the genera Pupillidae and Succinidae were identified, as was one form of the genera Helicidae (pers. comm. A. L. Tchepalyga). Many of the gastropods are juveniles. The identified genera typically inhabit rocky, grass-covered slopes and are characteristic of an open landscape in a semiarid climate. The presence of these gastropods provides evidence that slope washing occurred along the valley of Wadi Ma'aloula, depositing the shells into a small, shallow lake that followed the contours of the wadi in the area just above the cliff line.

C. Distribution of the Archaeological Sites

The survey resulted in the discovery of 618 new archaeological sites, the vast majority of which were Paleolithic open-air occurrences (Fig. 5). The sites were characterized according to the density of lithic artifacts within a radius of 5 m (Tab. 1). A low density rating indicated less than 1 find/10 m^2, while a medium density site had from 1-5 finds/10 m^2 and a high density scatter contained more than 5 finds/10 m^2. Although the absolute number of sites of all find densities shows the predominance of Levalloisian Middle Paleolithic sites, the number of sites normalized over time shows the dominance of Upper Paleolithic and Epipaleolithic occupations (Figs. 6 & 7).

The sites were frequently observed as continuous scatters on the land surface, where a site was defined as continuous if it extended beyond a radius of 100 m. The spatial continuity of many of the sites over large areas, combined with the fact that many of the sites appear to be palimpsests, make it more difficult to interpret the specific types of sites present. At this early point in the analysis, it appears that quarry sites are common near outcrops of raw materials, and that increases in find density seem to correlate with increases in the general availability of raw material. We hope to glean further information from the lithic artifacts about the sites as the detailed analysis progresses.

Faunal remains, while not preserved at the open-air sites, are present at the stratified sites including Baaz Rockshelter and Kaus Kozah Cave. In all, the cave sites and rockshelters made only small contribution to the absolute numbers of sites, while Neolithic (i.e., post-Epipaleolithic) sites with ceramic or diagnostic lithic artifacts were also less frequent than Paleolithic sites.

The open-air sites are widely represented in different geomorphological and geological positions. It must be emphasized that certain regularities exist between the age of Paleolithic finds and their geomorphological setting. The 76 Lower and 255 Middle Paleolithic sites are mostly distributed on the highland plateau, highland and lowland hills, and lowland fans. While the highland plateau is built upon the slightly tilted Neogene stratum, the lowland area formed on the Middle Pleistocene conglomerates and denudated Paleogene bedrock. Both of these geomorphological zones were formed before the Late Pleistocene. Therefore, surface erosion and reworking of artifacts in these topographic zones were not dramatic, but rather, represent a gradual process. As a result, a high percentage of chipped flint at the open-air sites shows good preservation.

In the highland and lowland hills, the density of archaeological finds is often higher on the surfaces that are composed of Middle Pleistocene conglomerates. However, the 3–4 m thick calcrete crust at the top of the Pliocene highland plateau protects it from erosion and results in fewer flint scatters on its surface. At the bottom of the wadis, younger artifacts are more characteristic, although older archaeological material is frequently found there as well. The latter circumstance could be explained by the re-deposition of artifacts.

A more complicated distribution of archaeological sites can be observed in the highland hills. Here, the Middle Paleolithic sites along the lower slopes are not strongly reworked because the lower slopes formed during the early Late Pleistocene. For instance, a high concentration of Middle Paleolithic artifacts has been observed on the lower slopes of Wadi George Jaffa.

The frequency of Middle Paleolithic artifacts in the highland hills is reflected in part by the abundance of flints in this geomorphic zone. A significant amount of raw material derives from the upper part of the Pliocene conglomerates that are rich in secondary flints deposited in connection with the denudation of the Paleogene and Upper Cretaceous strata. These sites are also located close to water sources such as wadis or springs. The localities with older stone assemblages are often associated with a higher topographic position on the highland plateau and its slopes.

In the Late Pleistocene, stronger seasonal fluctuations of moisture may have contributed to an association between the Upper Paleolithic localities and their proximity to drainage systems. The occurrence of the Upper Paleolithic and Epipaleolithic finds along the cliff line (Conard et al., 2004) is connected with relatively recent erosion on their slopes. Thus, older stone material cannot be preserved there. The Epipaleolithic and Neolithic are well represented in rockshelters and caves like Baaz and Kaus Kozah, but the central survey area preserves relatively few indications of Neolithic and later archaeological settlement. The Jeiroud Basin, however, documents clear indications of Neolithic settlement including open-air scatters and at least one tell.

D. Paleogeographic Reconstructions

The paleogeographic reconstructions in Figs. 8 & 9 illustrate how the geologic history of the region influenced the development of the landscape and the availability of flint. Profiles I and II (Fig. 8), depict the primary sources of Upper Cretaceous and Paleogene flint layers and their inferred distribution during the Pliocene. These diagrams help to explain the presence of flint raw material in certain areas but its lack in other areas. Clearly, the distribution of flint artifacts co-varies with the availability of flint raw material. For example, one area of the Anti-Lebanon Mountains (Sector A) is devoid of the units that contain Upper Cretaceous and Eocene flints, whereas Sector B, located to the northeast, shows an area where flint layers and concretions occur frequently. In Sector C in the Palmyrides, flints derived from Eocene and Upper Cretaceous (Campanian, Maestrichtian) rocks are also well represented. (Ponikarov et al., 1963).

Fig. 9 illustrates the geologic development of the Palmyrides and Anti-Lebanon Mountains from the Paleogene (Fig. 9a), through the Neogene (Fig. 9b) (Ponikarov et al., 1969; Krasheninnikov et al., 1996). At the beginning of the Quaternary uplifting occurred, and, as a result, the Neogene molasse was dislocated and eroded. The Middle Quaternary is characterized by the formation of proluvial deposits (Fig. 9c). Drainage systems were more active than at present, resulting in the accumulation of very coarse conglomerates. At that time, the wide passes in the Oligocene cliff line were formed in Wadi Ma'aloula, Wadi Jaba'deen and Wadi George Jaffa, among others. During the Late Pleistocene and Holocene, cutting of relief increased (Fig. 9d). This resulted in the formation of the dissected highland hills and the cutting down of wadis, especially Wadi Ma'aloula, with its narrow canyons that incise the Paleogene cliff. A small lake that collected seasonal water existed in the upper reaches of Wadi Ma'aloula until a protective limestone dam was undercut.

E. Palynological Results

The survey area is situated in a transitional zone between the Syrian Desert and the Mediterranean vegetation zone. In sub-fossil pollen spectra determined in the Damascus region, the prevalence of herbs (up to 90%) with a predominance of Chenopodiaceae indicates a semi desert-steppe landscape (Devyatkin & Dodonov, 2000). Despite the presence of many exposures of sediment in the survey region, only three stratigraphic sections have been successfully tested for pollen.

The first profile (P1) is a brown paleosol in the upper part of the proluvial fan on the right flank of Wadi George Jaffa (Fig. 2). Here, a brown paleosol separates two generations of proluvial deposits. The B-horizon of the paleosol, 1.0 m in thickness, consists of loam with small amounts of gravel. The soil exhibits characteristic iron and manganese staining and contains very soft carbonate concretions. In the upper part of the soil the identification of a few pollen grains of Chenopodiaceae and Herbetum mixtum document the presence of a steppic landscape at the time of deposition.

The second profile (P2) is located in a small wadi above the canyon in Ma'aloula (Fig. 2). Lacustrine silts with shell inclusions fill the valley with a visible thickness of 2–3 m. At a depth of 1.25 m, pollen of Asteraceae and Cichoriaceae predominate in the silt, with a significant quantity of grains of Caryophyllaceae, Brassicaceae, Chenopodiaceae, and rarely of *Pterocarya*, *Carpinus* and Oleaceae. The pollen spectrum at 1.0 m in depth is characterized by an increase in the presence of trees. Herbs and small shrubs predominate in this steppe phytocenosis. Pollen grains of *Pinus*, *Alnus*, *Tilia* and *Rhus* are recorded, and Brassicaceae, Cyperaceae, Poaceae and *Thalictrum* predominate in the herb group. This pollen spectrum attests to a relative increase in moisture within a landscape that was predominantly steppic. At a depth of 0.75 m, tree pollen was not recognized, while Cichoriaceae, Brassicaceae and Chenopodiaceae predominate. The latter changes can be associated with aridization.

If we exclude the possibility of re-deposition of pollen grains, the presence of *Tilia* and *Pterocarya* can be interpreted as evidence of sedimentation in a small lake during at least the early Late Pleistocene. According to Leroi-Gourhan (1980), this pollen signal has not been recognized in Syria after 35 ka.

The third profile (P3) consists of a 6 m-thick outcrop of conglomerates near the Damascus Highway (Fig. 2). These conglomerates form a widespread, proluvial terrace. Three out of ten samples (depth 5.8, 5.2 and 2.0 m) included sufficient quantities of pollen to calculate the percentage content (Fig. 10). In general, the pollen of herbs and small shrubs prevails (75–80%) pointing to the development of an open steppe landscape. At 5.8 m depth, pollen grains of Brassicaceae (20%), *Thalictrum* (26%) and Herbetum mixtum (41%) predominate. At a depth of 5.2 m, the analysis identified Leguminosae (68%), Cichoriaceae (4%), Chenopodiaceae (5%), Herbetum mixtum (15%), as well as rare grains of *Pinus*, *Olea* and *Jasminum*. In the spore-pollen spectrum from 2.0 m depth, we recorded pollen grains of Asteraceae (14%), Brassicaceae (48%), Chenopodiaceae (4%) and *Thalictrum* (6%). The content of tree pollen became more diverse with the presence of *Pinus*, *Carpinus*, *Morus*, Juglandaceae, Cornaceae and Ericales, indicating a moister paleo-climate, although the steppe remained as the dominant landscape. Considering the pollen spectra from conglomerates in comparison with the palynological data of the Late Pleistocene (van Zeist & Bottema, 1982; Leroi-Gourhan, 1980), we propose that the conglomerates formed during the late Middle to Late Pleistocene.

CONCLUSIONS

By the early Middle Pleistocene, people settled in the Ma'aloula area. An analysis of the distribution of the Paleolithic and Neolithic sites shows that human activity varied not only with the prevailing environmental conditions, but also with the technological and economic systems employed. In the Ma'aloula region, the abundance and easy accessibility of local raw material, as well as the rich seasonal outflow of water and permanent springs, provided good conditions for Paleolithic settlement.

During the Pleistocene, the relief of the region formed during two phases associated with the Middle and Late Pleistocene. The Middle Pleistocene was characterized by relatively intense seasonal moisture, as indicated by the deposition of proluvium. As a result, conglomeratic fans formed to the southeast of the Oligocene cliff line. In the Late Pleistocene, general aridization increased. Regional uplifting and erosional processes resulted in further dissection of the highland area and in the cutting down of wadis.

The environmental data obtained from three pollen profiles indicate an expansion of alternating steppe and desert-steppe vegetation in the Ma'aloula area from the late Middle Pleistocene through the Holocene. The herb pollen supports that an arid climate dominated the greater part of the Late Pleistocene. The spread of forest took place only during relatively brief intervals in response to increased precipitation. However, establishing the specific timing of these climatic fluctuations will require more reliable dating.

The distribution of archaeological sites indicates similar patterns of settlement during the Lower and Middle Paleolithic. However, the amount of diagnostic Lower Paleolithic material is significantly lower than that of the nearly ubiquitous, Levalloisian Middle Paleolithic (Conard et al., 2004). Acheulean handaxes are present at 13 localities, but in each case only one handaxe was recovered (Conard, 2003). The Upper Paleolithic is also well represented in most of the survey zones, but more work is needed to distinguish this group from earlier and later laminar assemblage types.

The Epipaleolithic is well established in rockshelters and caves, as documented at Baaz Rockshelter and Kaus Kozah Cave. The survey results also demonstrate that Epipaleolithic sites existed in a variety of geographic settings. Even at the highest reaches of our survey, at 2350 m on a peak of the Anti-Lebanon Mountains, Epipaleolithic finds were recovered. In contrast to the older periods, Epipaleolithic occurrences seem to depend less upon the presence of flint raw material and water sources and instead focus upon good vantage points or sheltered locations.

Neolithic and later archaeological periods are poorly represented in the central survey area, although Neolithic finds were documented at Baaz Rockshelter and Kaus Kozah Cave. The Neolithic is accompanied by a shift from the Ma'aloula region into the lowland areas of the Jeiroud Basin, where, as in the more southerly Damascus Basin, Neolithic artifact scatters and tells indicate a different system of settlement that reflects new economic and social systems.

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TABLES & FIGURES

Table 1. Summary of sites by cultural group and artifact density. These sites are present at 381 localities documented during four field seasons from 1999-2004. A locality may contain more than one cultural group.

Figure 1. Map of Syria showing the location of the Ma'aloula regional survey (after Wolfart, 1966: Tab. 4).

Figure 2. Map depicting the ca. 100 km^2 area of the central survey region showing names of villages and wadis in the immediate vicinity of Ma'aloula and Jaba'deen. The location of three pollen profiles (P1-P3) are also shown.

Figure 3. Geomorphological map of the Ma'aloula region showing the entire area surveyed and names of villages and land features.

Figure 4. Schematic geological and geomorphological profile across the Ma'aloula region.

Figure 5. Map of the spatial distribution of the 618 Paleolithic sites discovered during the Ma'aloula regional survey.

Figure 6. Graph depicting the absolute number of sites from different archaeological periods recorded during the Ma'aloula regional survey.

Figure 7. Plot showing the number of sites, normalized to time in thousands of years, that were recorded during the Ma'aloula regional survey.

Figure 8. Schematic geological profiles I and II depicting the primary sources of flint from Upper Cretaceous (K_2) and Paleogene (P) layers and its inferred distribution during the Pliocene epoch (N_2) in the al-Majar depression. The map inset corresponds to the same area shown in Figure 3. In the Anti-Lebanon Mountains, Sector A is in an area where the units that contain Upper Cretaceous and Eocene flints are not well represented, whereas Sector B shows an area where flint layers and concretions occur frequently. In Sector C in the Palmyrides, flints derived from Eocene and Upper Cretaceous (Campanian, Maestrichtian) rocks are well represented.

Figure 9. Paleogeological profiles of the Ma'aloula area showing the development of the regional geology during the a) Paleogene (P); b) Neogene (N); c) Middle Quaternary (Q_2); and, d) Late Quaternary–Holocene (Q_{3-4}).

Figure 10. Pollen profile from the 6.0 m section, P2, (#98 of year 2000) where Middle Pleistocene conglomerates outcrop along the edge of a proluvial terrace. The location of this section is depicted in Fig. 2.

TABLE 1

Cultural group	**Low Density Sites**	**Medium Density Sites**	**High Density Sites**	**Total number of sites**
Lower Paleolithic	25 (30%)	36 (47%)	15 (23%)	76
Handaxes	13* (100%)	0	0	13
Middle Paleolithic (Levallois)	70 (27%)	140 (55%)	45 (18%)	255
Middle Paleolithic (non-Levallois)	4 (24%)	11 (65%)	2 (11%)	17
Upper Paleolithic	34 (24%)	86 (60%)	24 (16%)	144
Upper or Epipaleolithic	6 (86%)	1 (14%)	0	7
Epipaleolithic	17 (38%)	23 (51%)	5 (11%)	45
Post-Epipaleolithic (with ceramic)	6 (67%)	0	3 (33%)	9
Indeterminate	40 (77%)	11 (21%)	1 (2%)	52
TOTAL	215 (31%)	308 (51%)	95 (18%)	618

*No site contained more than one handaxe.

FIGURE 1

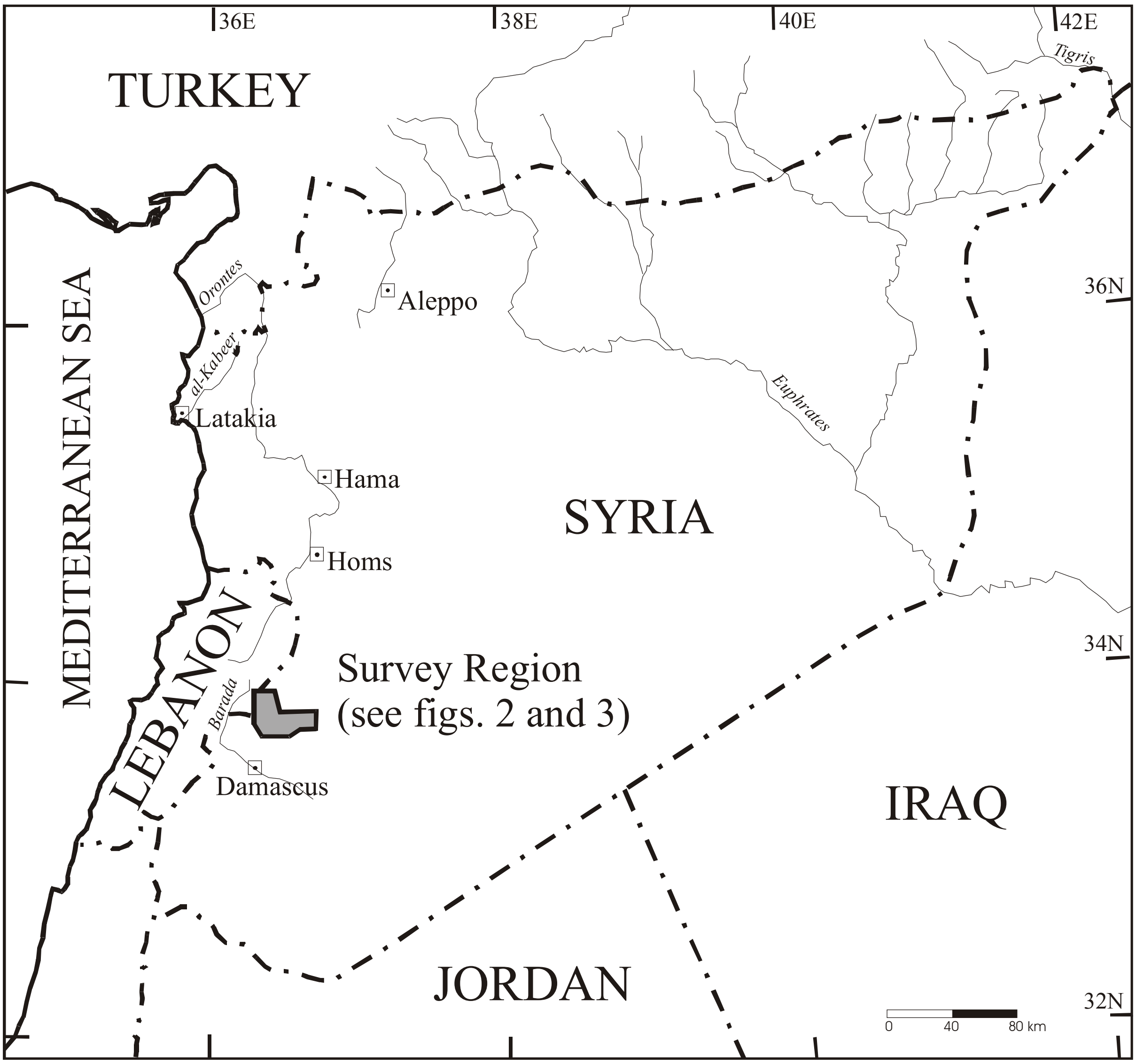
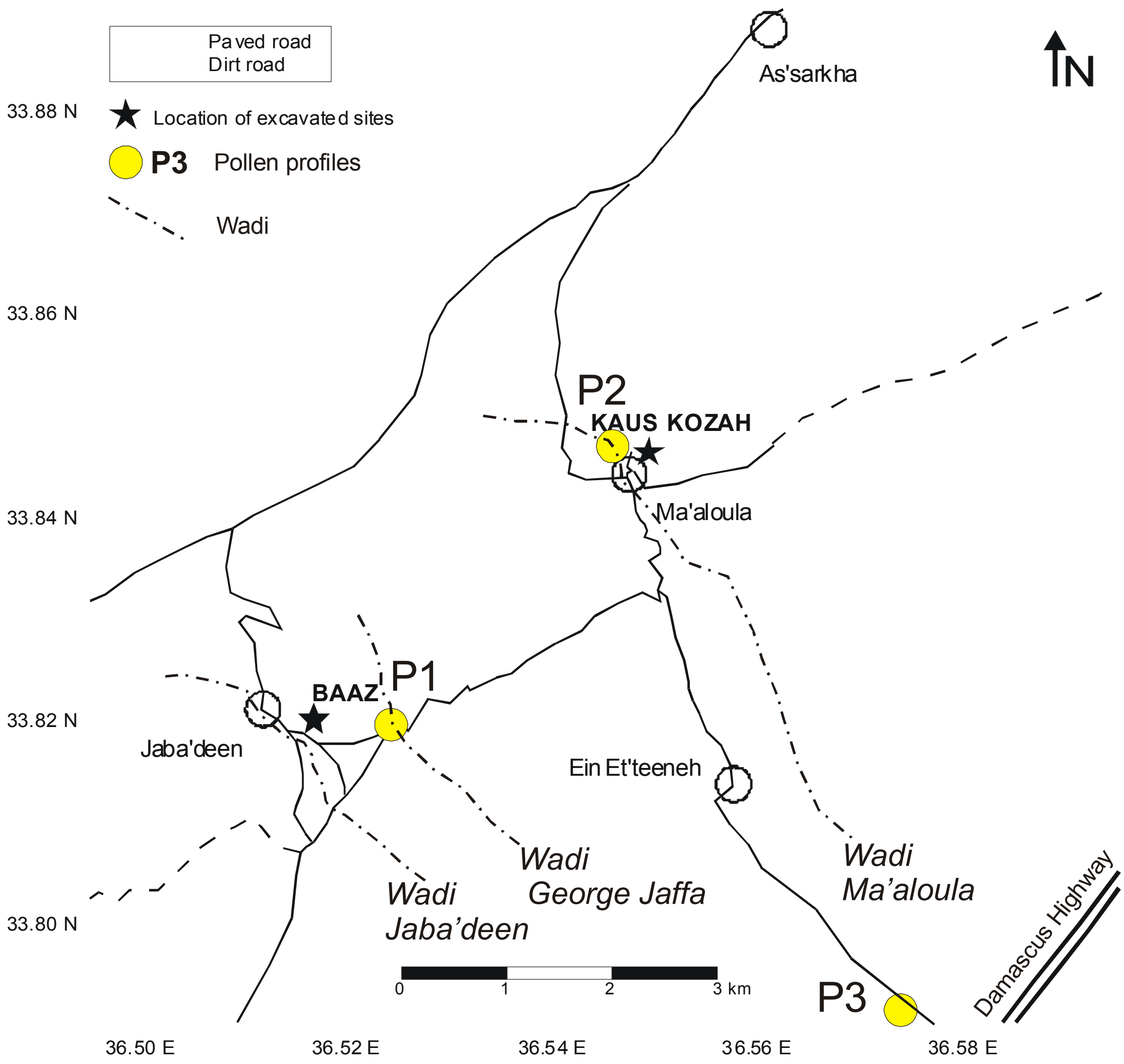

36E
38E
40E
42E
TURKEY
Tigris
36N
34N
32N
MEDITERRANEAN SEA
Orontes
al-Kabeer
Aleppo
Latakia
Euphrates
Hama
SYRIA
Homs
LEBANON
Survey Region
(see figs. 2 and 3)
Barada
Damascus
IRAQ
JORDAN
0
40
80 km

FIGURE 2


Paved road
Dirt road
Location of excavated sites
P3 Pollen profiles
Wadi
As'sarkha
N
33.88 N
33.86 N
33.84 N
33.82 N
33.80 N
P2
KAUS KOZAH
Ma'aloula
P1
BAAZ
Jaba'deen
Ein Et'teeneh
Wadi George Jaffa
Wadi Jaba'deen
Wadi Ma'aloula
Damascus Highway
0
1
2
3 km
P3
36.50 E
36.52 E
36.54 E
36.56 E
36.58 E

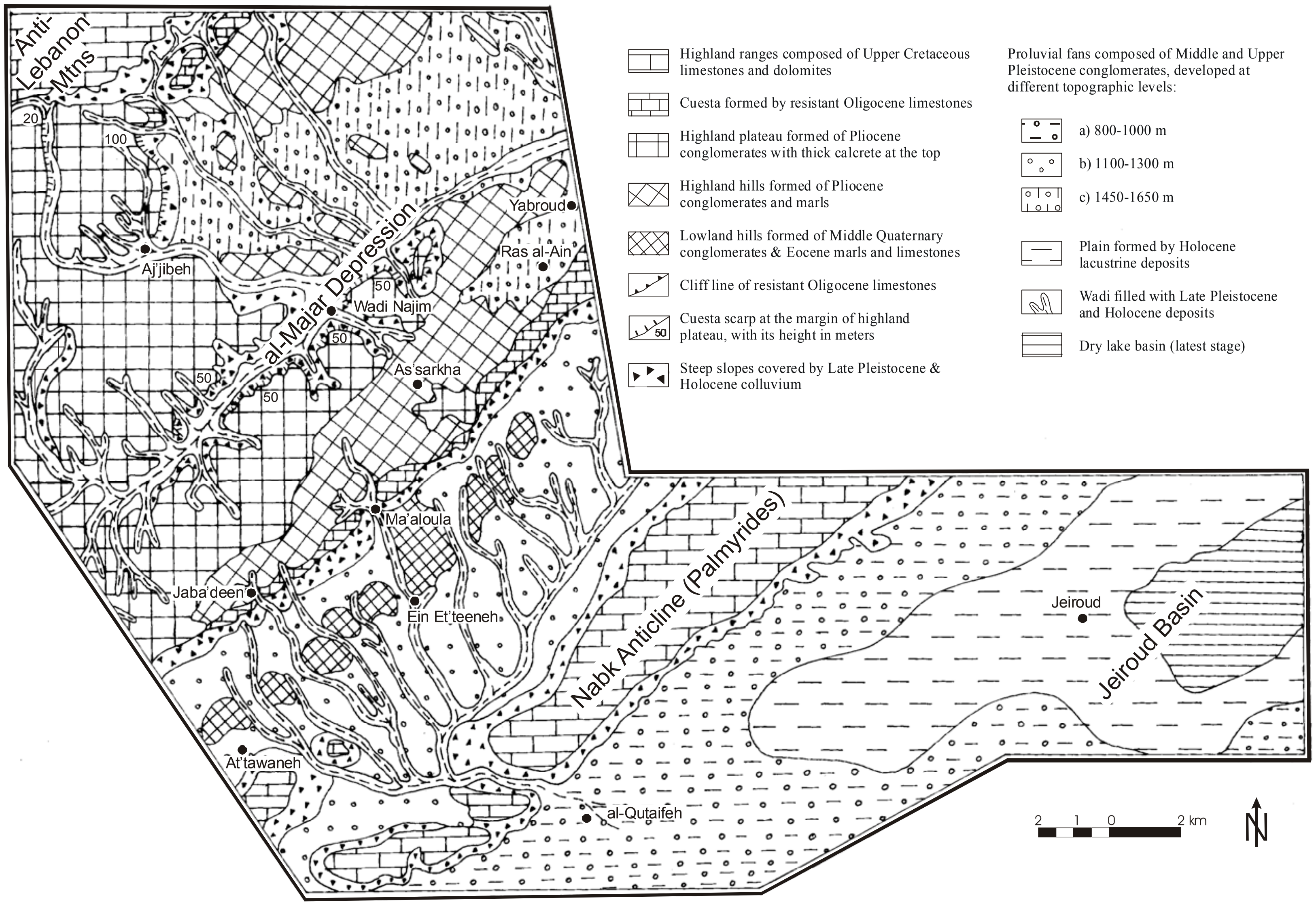

Anti-Lebanon Mtns
20
100
Aj'jibeh
al-Majar Depression
50
Wadi Najim
Yabroud
Ras al-Ain
As'sarkha
Ma'aloula
Jaba'deen
Ein Et'teeneh
At'tawaneh
al-Qutaifeh
Nabk Anticline (Palmyrides)
Jeiroud
Jeiroud Basin
2 1 0 2 km
N
Highland ranges composed of Upper Cretaceous limestones and dolomites
Cuesta formed by resistant Oligocene limestones
Highland plateau formed of Pliocene conglomerates with thick calcrete at the top
Highland hills formed of Pliocene conglomerates and marls
Lowland hills formed of Middle Quaternary conglomerates & Eocene marls and limestones
Cliff line of resistant Oligocene limestones
Cuesta scarp at the margin of highland plateau, with its height in meters
Steep slopes covered by Late Pleistocene & Holocene colluvium
Proluvial fans composed of Middle and Upper Pleistocene conglomerates, developed at different topographic levels:
a) 800-1000 m
b) 1100-1300 m
c) 1450-1650 m
Plain formed by Holocene lacustrine deposits
Wadi filled with Late Pleistocene and Holocene deposits
Dry lake basin (latest stage)

FIGURE 3

FIGURE 4

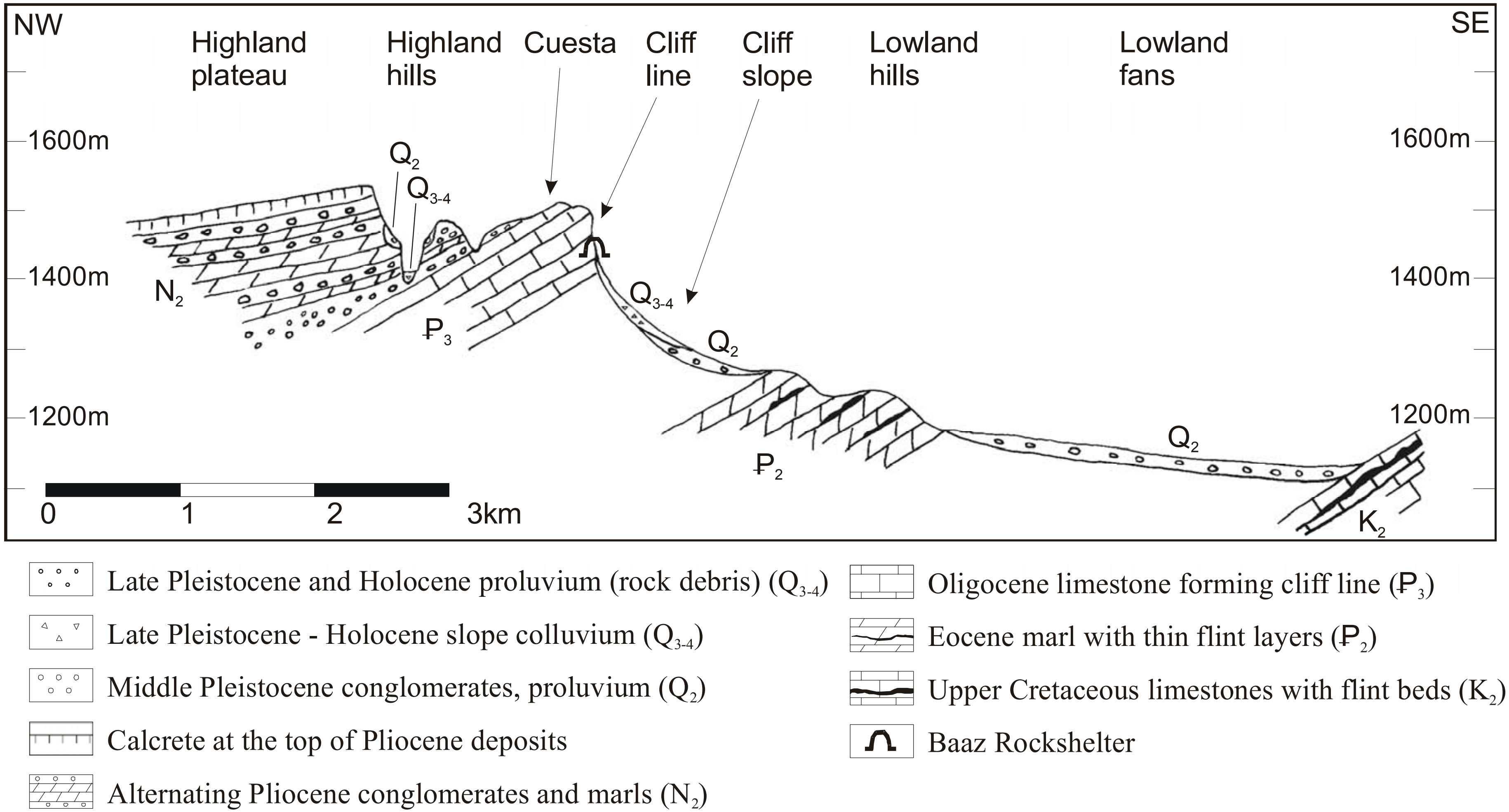

NW
SE
Highland plateau
Highland hills
Cuesta
Cliff line
Cliff slope
Lowland hills
Lowland fans
1600m
1400m
1200m
1600m
1400m
1200m
Q2
Q3-4
N2
P3
Q3-4
Q2
P2
Q2
K2
0
1
2
3km
Late Pleistocene and Holocene proluvium (rock debris) (Q3-4)
Late Pleistocene - Holocene slope colluvium (Q3-4)
Middle Pleistocene conglomerates, proluvium (Q2)
Calcrete at the top of Pliocene deposits
Alternating Pliocene conglomerates and marls (N2)
Oligocene limestone forming cliff line (P3)
Eocene marl with thin flint layers (P2)
Upper Cretaceous limestones with flint beds (K2)
Baaz Rockshelter

FIGURE 5

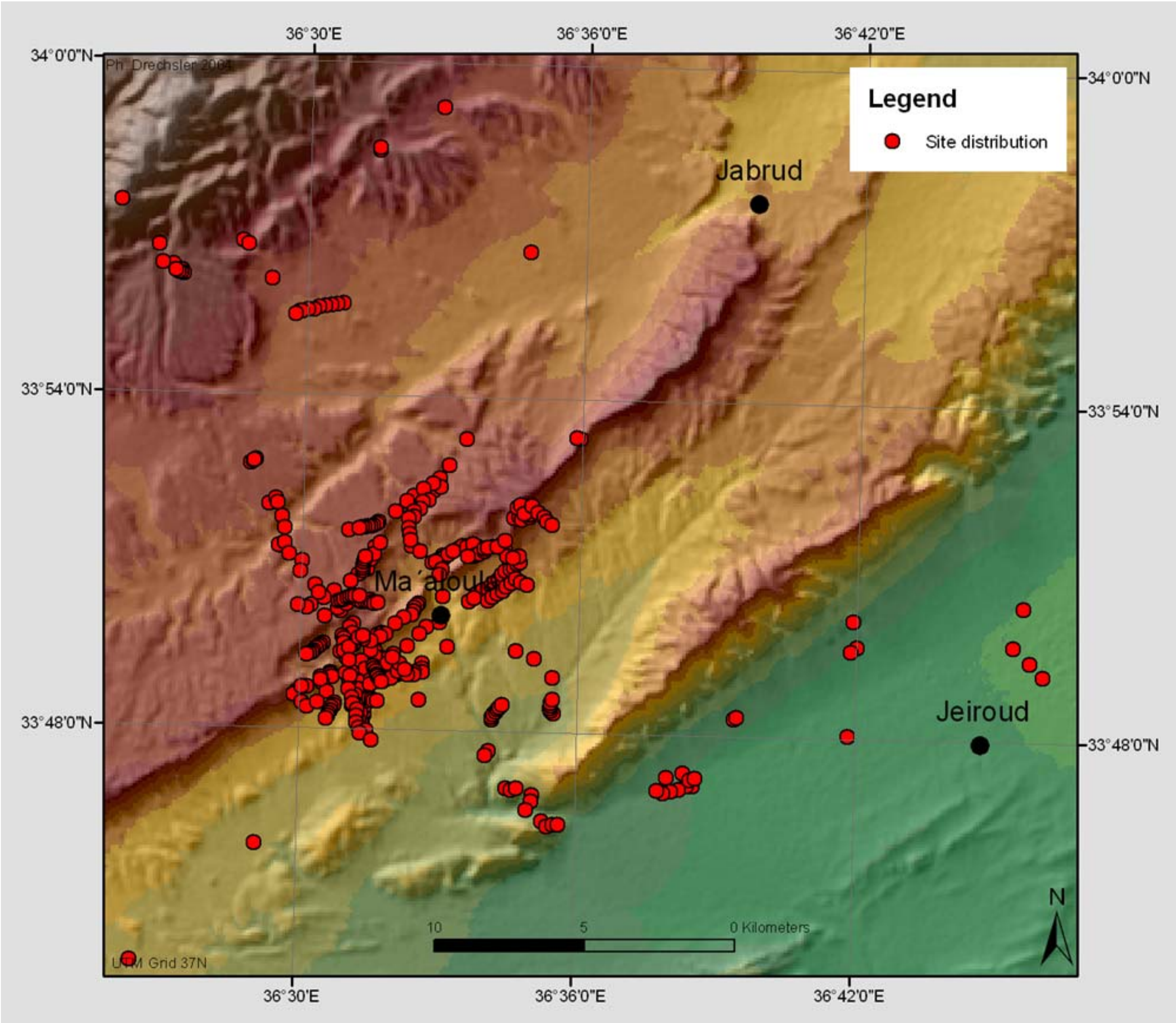

36°30'E
36°36'0"E
36°42'0"E
34°0'0"N
33°54'0"N
33°48'0"N
Ph. Drechsler 2007
Legend
Site distribution
Jabrud
Ma´aloula
Jeiroud
10
5
0 Kilometers
N
UTM Grid 37N

FIGURE 6

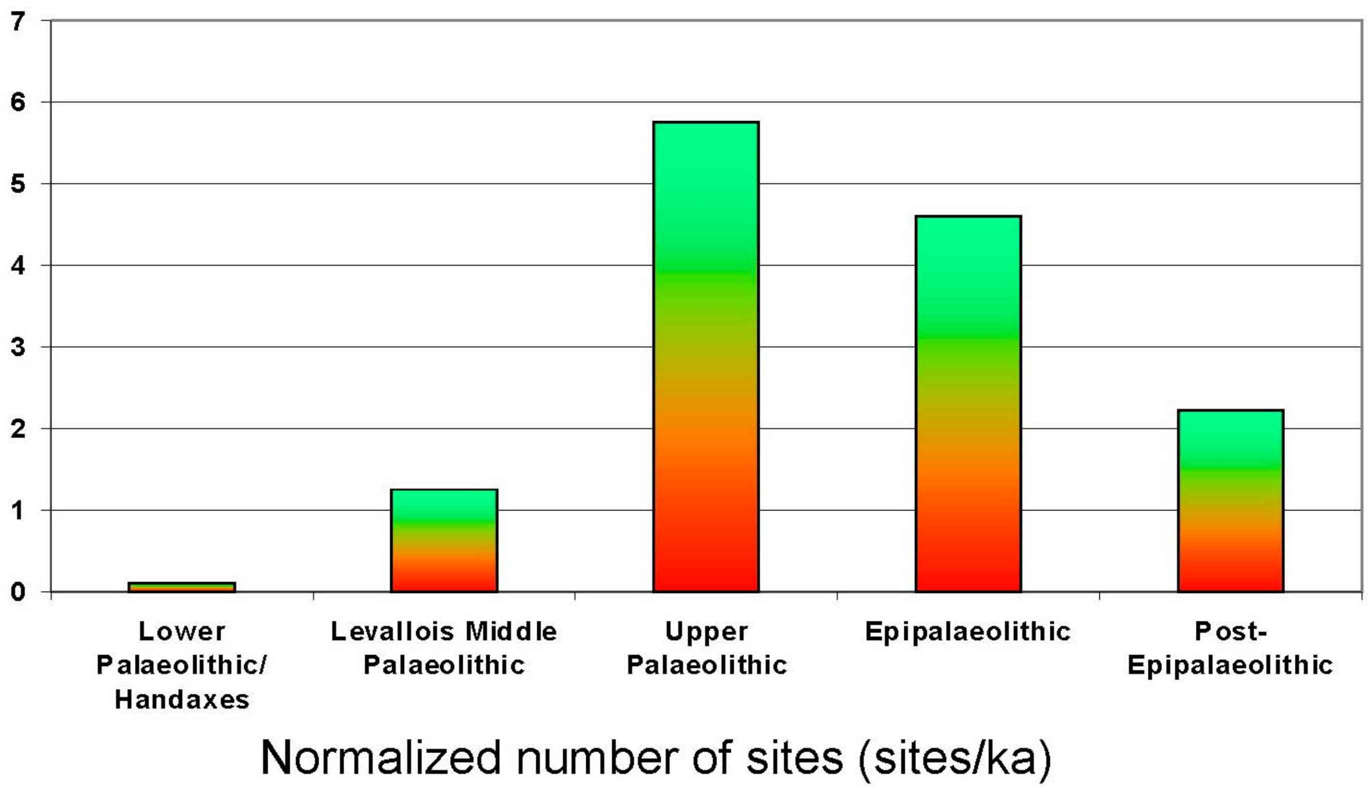

7
6
5
4
3
2
1
0
Lower Palaeolithic/ Handaxes
Levallois Middle Palaeolithic
Upper Palaeolithic
Epipalaeolithic
Post-Epipalaeolithic
Normalized number of sites (sites/ka)

FIGURE 7

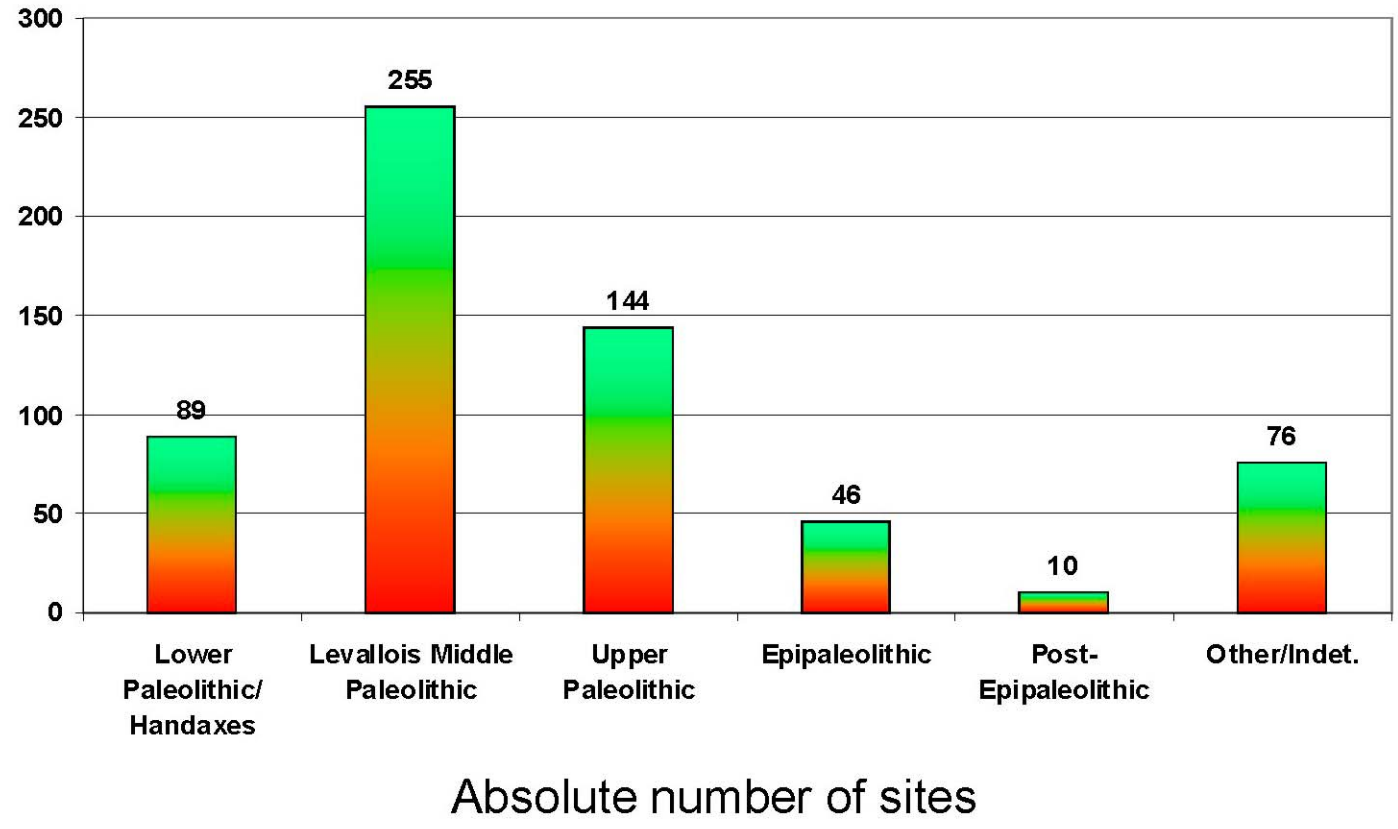

300
250
200
150
100
50
0
89
255
144
46
10
76
Lower Paleolithic/ Handaxes
Levallois Middle Paleolithic
Upper Paleolithic
Epipaleolithic
Post-Epipaleolithic
Other/Indet.
Absolute number of sites

FIGURE 8

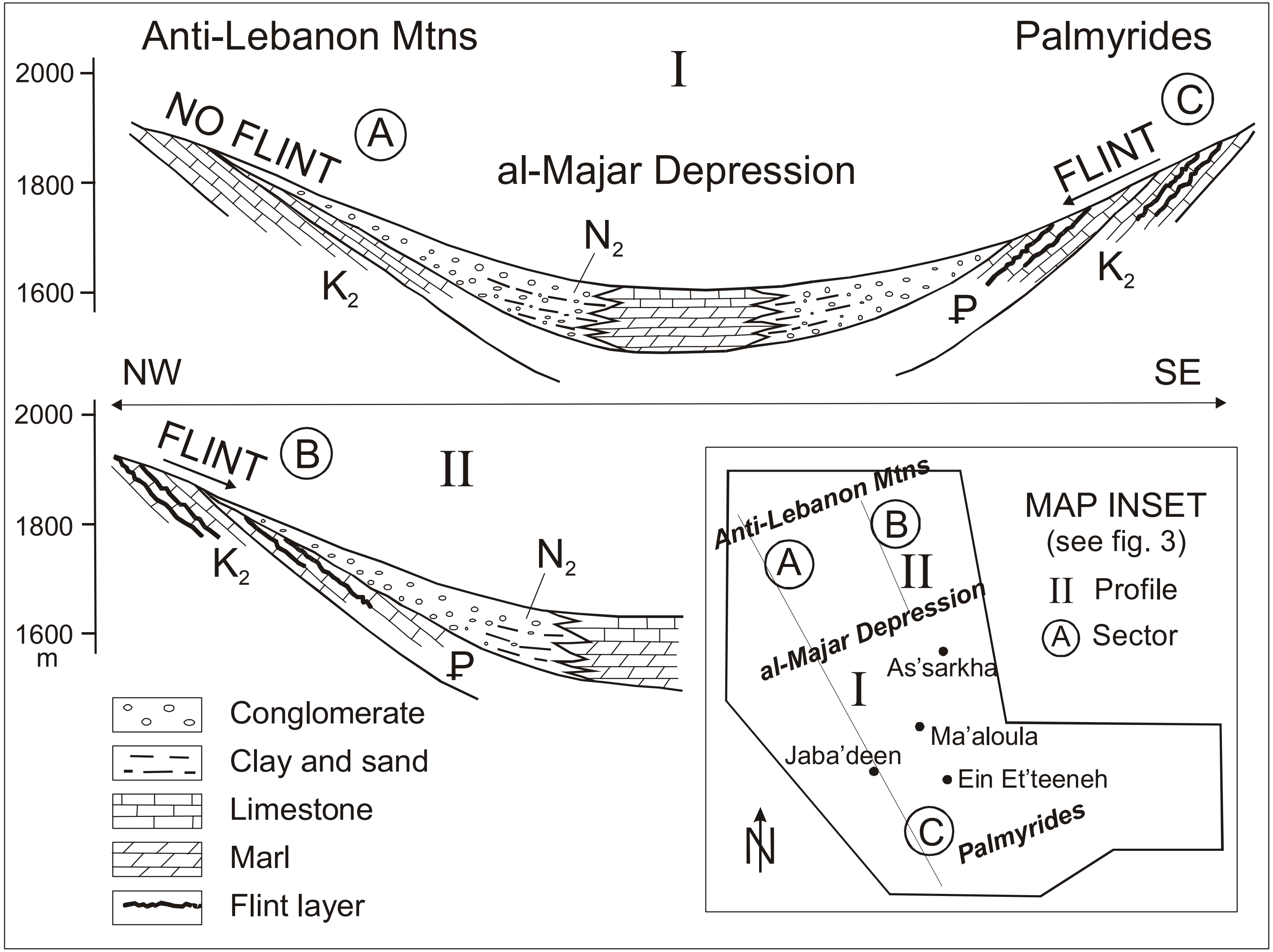

Anti-Lebanon Mtns
Palmyrides
I
al-Majar Depression
NO FLINT
A
C
FLINT
N2
K2
P
2000
1800
1600
m
NW
SE
II
B
Conglomerate
Clay and sand
Limestone
Marl
Flint layer
MAP INSET
(see fig. 3)
II Profile
A Sector
Anti-Lebanon Mtns
al-Majar Depression
As'sarkha
Ma'aloula
Jaba'deen
Ein Et'teeneh
Palmyrides
N

FIGURE 9

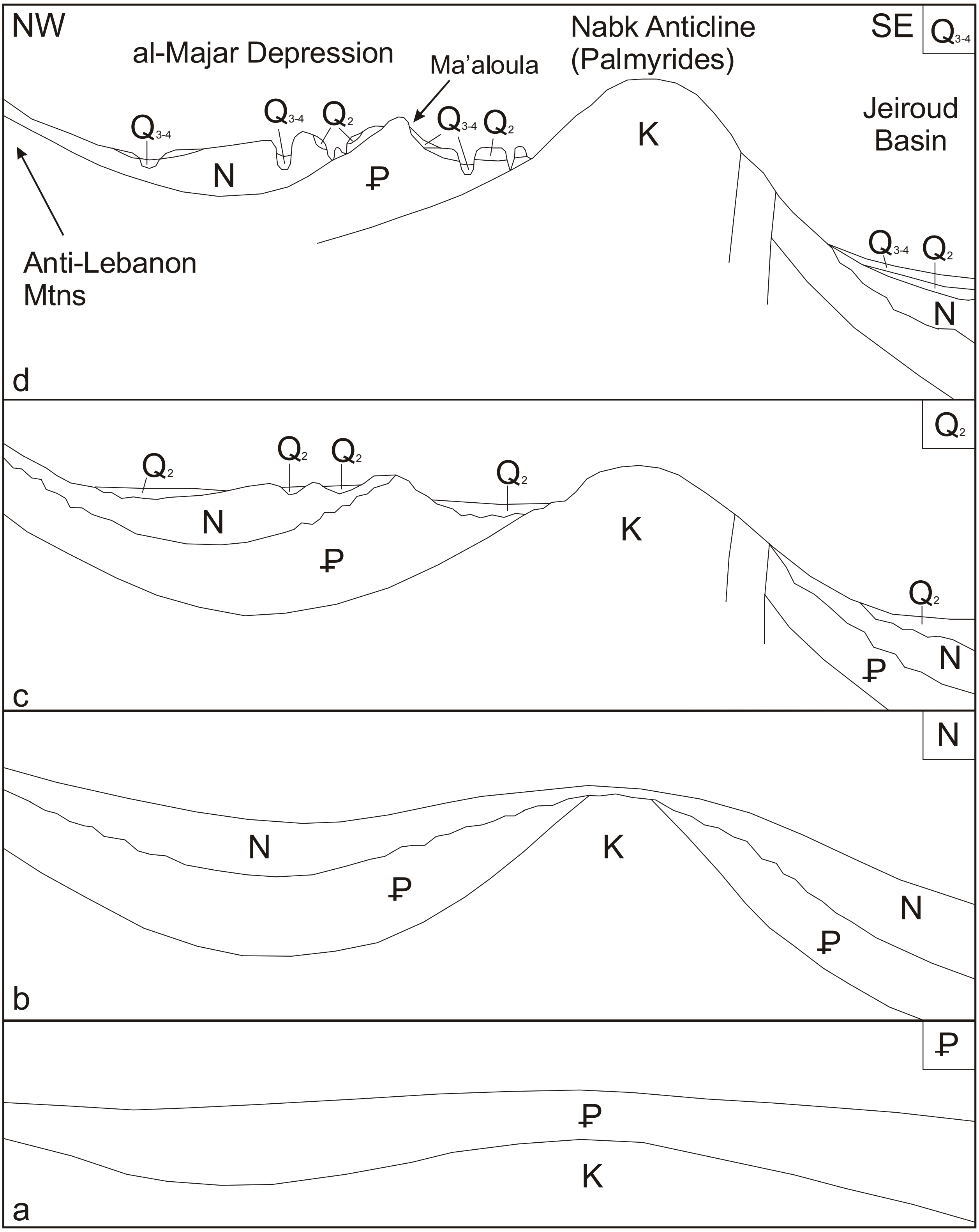
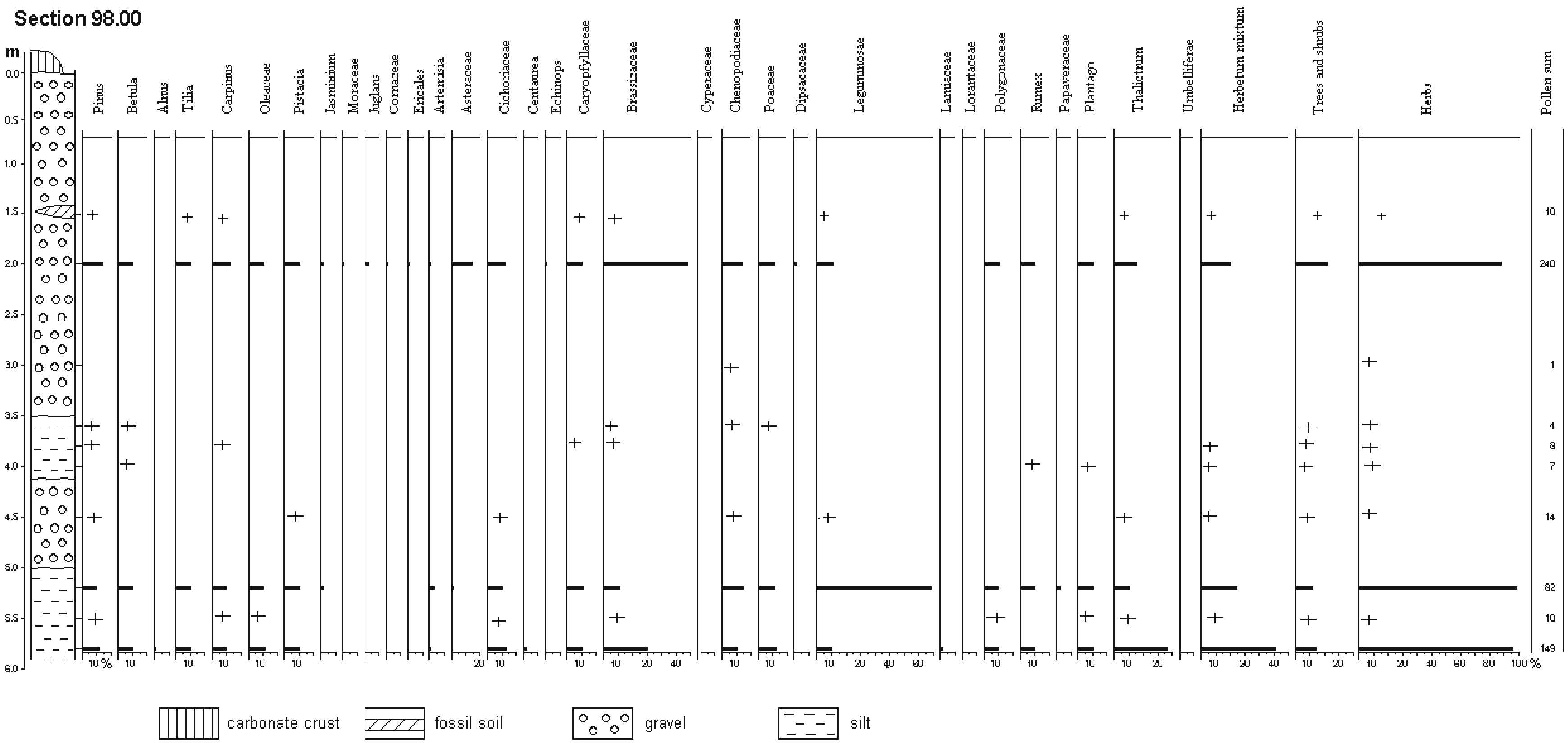

NW
al-Majar Depression
Ma'aloula
Nabk Anticline
(Palmyrides)
SE
Q3-4
Jeiroud
Basin
Anti-Lebanon
Mtns
Q3-4
Q2
N
₽
K
d
Q2
c
N
b
₽
a

FIGURE 10


Section 98.00
m
Pinus
Betula
Alnus
Tilia
Carpinus
Oleaceae
Pistacia
Jasminum
Moraceae
Juglans
Cornaceae
Ericales
Artemisia
Asteraceae
Cichoriaceae
Centaurea
Echinops
Caryopfyllaceae
Brassicaceae
Cyperaceae
Chenopodiaceae
Poaceae
Dipsacaceae
Leguminosae
Lamiaceae
Lorantaceae
Polygonaceae
Rumex
Papaveraceae
Plantago
Thalictrum
Umbelliferae
Herbetum mixtum
Trees and shrubs
Herbs
Pollen sum
carbonate crust
fossil soil
gravel
silt