SURFICIAL PROCESSES AND PLEISTOCENE ARCHAEOLOGY: CONTEXT, LANDSCAPE EVOLUTION AND CLIMATE CHANGE

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Abstract

Surficial processes inferred from Pleistocene sedimentary sequences can provide a record of events leading to archaeological site formation as well as landscape evolution. In northeastern Africa, Palaeolithic artifacts are found within sedimentary deposits that seem to reflect surficial processes linked to changing climate and environmental settings. These include Acheulian, Middle Palaeolithic, and Late Palaeolithic occurrences in the Western Desert and Nile Valley of Egypt, and their site-specific sedimentary contexts. In the western interior region of North America, records of landscape evolution dating to the last glacial-interglacial transition and the Pleistocene-Holocene boundary can be related to settings contemporaneous with late Pleistocene human populations. Stratigraphic sequences provide evidence that can be utilised to examine the relationships between human adaptations, surficial processes, and landscape evolution.

Introduction

Sedimentary deposits containing Palaeolithic artifacts offer information connected with Pleistocene surficial processes on at least two scales: 1) discrete events that provide information on landscapes and site formational contexts, and 2) landscape evolution that can be correlated with climate and environmental change. Sedimentary sequences can be used to infer surficial processes that reflect specific depositional events and local palaeoenvironments. Variations in stratigraphic sequences also have the potential of being related to climate change. Thus, the examination of stratigraphic successions provides information pertinent to interpreting the human past in terms of formation processes on a site-specific scale,
as well as human adaptation and landscape evolution on broader regional-to-continental scales that may ultimately be related to global climate change (Hill 2005). In this paper, sedimentologic, stratigraphic, landform, and geochronologic data are used to evaluate Middle and Late Pleistocene contexts associated with the presence of human populations in northeast Africa (the Sahara and the Nile Valley) and the western interior of North America (the Upper Missouri Basin and Southern High Plains) (Figure 2-1).

Applications of geoarchaeological concepts and methodologies to examine aspects of Quaternary landscape change rely on the use of landform mapping, sedimentology and stratigraphy, and geochronology (Brown et al. 2003; Butzer 1982; Gregory 2000; Karlstrom 2005; Mayer 2005; Miall 1996, 2000; Posamentier and Allen 1999; Rapp and Hill 2006; Sely 2000; Waters 2000). At a minimum these involve the documentation and description in the field of sedimentary deposits and their vertical and lateral variations, along with their relationships to archaeological occurrences. Additionally, it sometimes proves very useful to obtain textural and compositional information from laboratory studies. These methods provide a way to use sediments, erosional surfaces, and soils found in stratigraphic successions to infer surficial processes of erosion, deposition and landscape stability. Although changes in lithostratigraphic facies reflect variations in surficial processes that can be used to examine site formation and spatial distributions or longer-term landscape evolution, connecting these variations to global climate change requires correlation. Correlation of discrete sedimentological events or broader-scale patterns of landscape evolution can be undertaken by using geochronological methods such as uranium-series and radiocarbon dating of the deposits and relating them to independently developed measures of global climate change, such as marine and ice stable isotope curves. The basis of this kind of geoarchaeological study is the examination, analysis, and interpretation of stratigraphic sequences.

Middle and Late Landscape Evolution in the Eastern Sahara and Nile Valley

Introduction

Southern Egypt contains a record of landscape evolution within stratigraphic sequences that reflect local changes in environments. In some instances these appear to be related to patterns of continental- and global-scale climate. An understanding of the conditions under which stratigraphic sequences have been produced provides information pertinent to evaluating site-specific formational
events, local and regional landscapes, and temporal correlation on a variety of scales.

From the perspective of hominid behavioural and biological evolution, the Middle and Late Pleistocene are connected with the patterns of artifactual change within the Palaeolithic and the fossil evidence for changes from archaic forms of the genus Homo (e.g., late forms of Homo erectus/ergaster or H. heidelbergensis) to anatomically modern Homo sapiens (Wendorf et al. 1994; Tryon and McBrearty 2002; White et al. 2003). Biologically modern Homo sapiens forms appear to have emerged during the Middle Pleistocene (McDougall et al. 2005).

Artifacts dating to the Middle Pleistocene (from about 800 000-130 000 years ago) represent two taxonomic sets: Lower Palaeolithic Acheulian assemblages (characterised by the presence of hand axes, or bifaces), and Middle Palaeolithic or Middle Stone Age assemblages. The Late Pleistocene (the last glacial cycle, from about 130 000 to 10 000 years ago) in northeast Africa contains Middle Palaeolithic and Late Palaeolithic artifact assemblages that are both likely connected with Homo sapiens. Here, stratigraphic successions that can be related to Palaeolithic archaeological assemblages in southern Egypt are considered from the perspective of landscape evolution by examining the implications of two aspects of Pleistocene surficial processes: 1) sedimentary events, and 2) potential correlations with climate fluctuations.

Sedimentary sequences in southern Egypt at Bir Tarfawi and Wadi Kubbaniya contain Palaeolithic artifacts (Figure 2-2). The Bir Tarfawi region, within the Western Desert in south-central Egypt, contains deposits that can be directly linked to Acheulian and Middle Palaeolithic artifact occurrences (Wendorf and Schild 1980; Hill and Wendorf 1991; Wendorf et al. 1993; Hill 1993a, 2001c, 2002b). At Wadi Kubbaniya, a tributary of the Nile River located northwest of Aswan, the sedimentary sequence can be linked to some Middle Palaeolithic occurrences and a significant set of Late Palaeolithic assemblages (Hill and Schild 1986; Wendorf et al. 1989; Hill 1989). Together, Bir Tarfawi and Wadi Kubbaniya provide evidence of Pleistocene surficial processes and adaptive responses of hominids associated with Acheulian, Middle Palaeolithic and Late Palaeolithic artifacts that can be examined in terms of the site-specific depositional contexts and long-term Pleistocene climate change.

**Surficial Processes and Sedimentary Sequences in the Egyptian Western Desert**

Sedimentary deposits related to Acheulian and Middle Palaeolithic (or "Mousterian") occurrences from the eastern Sahara provide information that can be used to evaluate landscape settings, site formation (taphonomic) processes, and palaeoclimate chronologies associated with Middle and Late Pleistocene hominids.
The sedimentologic and stratigraphic evidence appears to show changing landscape conditions in the Sahara since the Middle Pleistocene that can be linked to the presence of hominids that used Palaeolithic artifacts. In terms of landscape evolution, the evidence for wetter, pluvial conditions is in the form of sheet wash, paludal, and lacustrine deposits, while intervals when more arid conditions prevailed are represented by aeolian sediments and erosional boundaries within the stratigraphic sequences.

Middle Pleistocene strata associated with Acheulian artifacts consist mostly of carbonates and coarse siliciclastics (mostly sands). The carbonates (micrites and limestones) are interpreted to indicate the presence of wet climates that resulted in higher ground water levels, spring mounds and lakes. Deposits dominated by clastics are interpreted to reflect shore, beach, or basin-margin facies. The clastics have been protected from erosion by the deposition of younger carbonates as a consequence of ground water rise or transgression events in basins.

Some of the sediment remnants associated with Acheulian artifacts show signs of erosion by wind; deflational processes have affected both the sedimentary matrix and the artifactual record. Where a sedimentary sequence has been preserved, the patterns of deposition and erosion primarily reflect a single pluvial event and subsequent erosional activity that can be linked to arid conditions. Changes in the Acheulian landscape, therefore, seem to have been largely driven by climate fluctuations that have contributed to the preservation, transformation, and destruction of the Middle Pleistocene artifactual record.

Sedimentologic contexts containing Acheulian hand axes provide information pertaining to the physical landscapes available to the Middle Pleistocene hominids in this region. The deposits suggest the episodic presence of ponds or small lakes during wet ("pluvial") climate intervals. These Acheulian contexts can be used to suggest some of the geological processes that could have formed the surviving, observable record. From the geochronological perspectives of taphonomy and site integrity, some Acheulian sites appear to have not been significantly affected by post-depositional processes (Hill 2001c). At other sites, however, there appear to have been modifications of the patterns originally produced by hominid activity. For instance, vertical displacement of artifacts may be implied by the trace fossil horizons indicative of bioturbation.

Modifications to the original Acheulian artifact assemblages at some sites are indicated by evidence for wind erosion. At one locality (designated site BS-14) estimated to date from about 600 000-500 000 years ago, wind erosion appears to have removed the surrounding sedimentary matrix, resulting in dense concentrations of artifacts. Deflation also seems to have led to the destruction of smaller artifacts (such as debitage), changing the original character of the assemblage. The artifact assemblages recovered from deposits not affected by
deflation contain a much higher percentage of smaller artifacts relative to larger Acheulian artifacts (hand axes) when compared to the surface collection affected by deflation. The wind removed the sandy matrix and left the larger artifacts in lag position mantling the remnant of a fossil groundwater pond.

The deposits with Acheulian artifacts are overlain by carbonates deposited in a groundwater-fed pond. The carbonate reflects a change in local surficial processes that can be linked to a wetter climate. The carbonate protected the underlying sediments from erosion, whereas along the margins of the basin, where there was no protective carbonate, wind could easily erode the sandy deposits. The surficial processes that occurred after the deposition of the artifacts affect the interpretation of Palaeolithic hominin behaviour; the presence of higher proportions of smaller artifacts in the undeflated deposits implies that hand axes were being used and resharpened at the site and also suggests that these Acheulian artifacts are in primary context.

The sedimentary sequences associated with the Middle Palaeolithic at Bir Tarfawi contain evidence for multiple pluvial-arid cycles, as well as in situ artifact assemblages. They provide information relevant to understanding changing landscape conditions, as well as the surficial processes that have influenced the pattern of the Middle Palaeolithic artifactual record. These deposits are the products of discrete events (for instance site or intra-site spatial distributions of artifacts or depositional episodes), as well as broader-scale temporal patterns (such as diachronic variation in artifactual assemblages or climatic fluctuations).

The spatial and size fraction analyses of artifacts and associated sediments provide data useful in evaluating site formation events associated with both hominin behaviour and surficial processes that contribute to the archaeological record. For instance, understanding the surficial processes that have affected a Typical Mousterian site at Bir Tarfawi, designated as E-87-3, is critical for interpreting the landscape context and the spatial patterning of artifacts (Hill 1993c, 2001d). Figure 2-3 shows the lithostratigraphy of the site. The Mousterian artifacts were recovered in clastic-dominated strata on a surface composed of sandy mudstone plates, underlying sandy muds. The landscape at the time hominids deposited the artifacts appears to have been the surface of a pan or seasonally-dry lake. Limestones below the artifact-bearing clastic deposits have uranium-series ages of around 172 000-118 000 years ago (Table 2-1). The carbonates imply that the basin contained a larger more permanent lake before the hominids were present. As with the Acheulian localities, the stratigraphy and geochronology of this Mousterian (Middle Palaeolithic) site indicates the presence of pluvial conditions in the Sahara during the Pleistocene. Because of the large standard deviation associated with the ages of the deposits (Table 2-1), it is difficult to directly relate the patterns of landscape evolution reflected by this sequence with global stable isotope climate records.
Besides information on the landscape, the surficial processes thought to have been active at the site provide two alternative interpretations of the events leading to the spatial distribution of the Mousterian artifacts (Figure 2-4). The spatial patterning could be the result solely of the original hominid behaviour, or the combined result of human activity and geological site-formational processes. Evidence supporting these alternatives includes the arrangement and size of the artifacts and the sedimentologic context. Statistical analyses by Hietala and Applegate (1993) led to the conclusion that the artifact distribution was not altered by post-depositional events. However, the size fractions of the sediments (medium and fine sands and muds) indicate a medium-to-low energy environment for transportation and deposition that could be connected with local rainfall or fluctuating groundwater levels. Some clustering of the artifacts may have been caused by a short, intense episode of flooding at the end of a dry season leading to the movement and redeposition of smaller artifacts (Figure 2-4). In this instance it may not be possible to determine whether the spatial distribution of artifacts reflects both human activity, as well as post-depositional movement, but only that the geological context suggests the possibility of re-arrangement of the original pattern formed by hominid behaviour.

The examination of surficial processes at a nearby Middle Palaeolithic site, designated as E-87-2, also provides information on both landscape evolution and the interpretation of spatial patterning of artifacts. The site contained an artifact assemblage composed of over 50 000 stone artifacts (mostly debitage), within sandy deposits (Hill 1993b). Uranium series ages range from 302 000-195 000 years ago, with the sample with the smallest standard deviation having an age of about 220 000 years ago (Table 2-1).

The surficial processes active at this site can be inferred from the spatial patterning of artifacts and the character of the sediments. The artifact assemblage was recovered from within sands that are interpreted to reflect the beach and shore facies of a shallow lake (Figure 2-5). The spatial patterns of different artifact size-sets can be interpreted by relating them to potential surficial processes connected to transport and depositional facies within the basin (Morton 2004). The distribution of artifacts appeared to indicate some size-sorting (Figure 2-6). The larger, heavier artifacts do not seem to have been moved very far from their point of initial deposition, while the smaller, lighter artifacts appear to have been eroded and redeposited in a position slightly closer to the centre of the basin. The spatial patterning of artifacts could be the result of the original hominid behaviour along the edge of a lake combined with shore processes that preferentially moved the smaller artifacts (Figure 2-6).

The lithostratigraphy of sedimentary sequences containing Middle Palaeolithic artifacts also provides information pertaining to broader-scale processes linked to
landscape evolution in northeast Africa. A stratigraphic sequence associated with Middle Palaeolithic assemblages from the north area of Bir Tarfawi provides an example (Figure 2-7). Uranium-series ages on ostrich eggshell ranging from 137 000-122 000 years ago suggest that the sequence at least partially reflects pluvial climate conditions that can be correlated with the transition to or the early part of the Last Interglacial in the global isotope records (Table 2-1).

The variation in lateral sedimentary facies provides information related to depositional environments at the time of the Middle Palaeolithic presence. For example, it is possible to correlate beach and shore margin deposits dominated by coarse clastics (sands) at one stratigraphic section with deeper water deposits characterised by high amounts of carbonate (marls) and muds (silts and clays) at another section (Figure 2-7). Vertical variations in lithology, in contrast, provide information on changing depositional conditions and thus variation in surficial processes over time at a specific locality. For instance, a lithostratigraphic sequence consisting of coarse clastics overlain by carbonates and muds suggests a transgressive lake event, associated with rising groundwater or increased local effective moisture. A change from strata containing high amounts of carbonates and muds to overlying deposits chiefly composed of coarser clastics could imply a regression event, connected with reduced moisture levels and increased local aridity. Thus lithofacies changes within sedimentary successions can provide synchronic information on environmental settings as well as diachronic information relevant to landscape evolution.

**Surficial Processes and Sedimentary Sequences in the Nile Valley**

A framework for evaluating landscape evolution in part of the Nile Valley can be developed by examining the record of Late Pleistocene surficial processes at Wadi Kubbaniya. The stratigraphic succession consists mainly of Late Pleistocene sediments containing Middle and Late Palaeolithic artifact assemblages. In the case of Wadi Kubbaniya, Pleistocene landscape evolution appears to be the result of sedimentological events instigated by local environmental conditions (wadi and aeolian activity and pedogenesis) and processes connected to the Nile River (fluvial deposition resulting from climatic conditions in the upper sections of the Nile basin) (Figure 2-2) (Hill 1989).

The petrographic properties of sediments, along with vertical and lateral stratigraphic variation, from Wadi Kubbaniya were used to document and compare sediments associated with Acheulian, Middle Palaeolithic, and Late Palaeolithic artifacts in the Nile Valley (Hill and Schild 1986; Hill 1989). The presence of Acheulian and Middle Palaeolithic artifacts in the Nile Valley deposits is used to infer that these deposits date to the Middle or early Late Pleistocene. Sedimentary deposits with Middle Palaeolithic artifacts are older than about 40 000 BP, while
younger Pleistocene deposits are associated with Late Palaeolithic artifacts (Bluszcz and Pazdur 1989; Haas 1989). Detailed petrographic studies of the Wadi Kubbaniya sediments illustrate two of the most useful applications of geoarchaeological methods: the description of lithostratigraphic units, and the interpretation of surficial processes and palaeoenvironmental contexts associated with prehistoric humans.

The textural and compositional characteristics used to study the Nile Valley sediments included particle size, clay mineralogy, organic content and carbonate content (Hill and Schild 1986; Hill 1989). Based on sediment particle size analyses, there are two groups of deposits at Wadi Kubbaniya. One group is characterised by the presence of larger-sized sedimentary particles. It likely reflects surficial processes associated with wadi wash, sand sheet, and sand dunes. Another group, dominated by silts and clays, seems to be the result of Nilotic river and lake depositional environments. Clay mineralogy also provided clues to environmental change. For instance, vertisol at Wadi Kubbaniya contain higher amounts of secondary chlorite. The relative amounts of organics and carbonates were also used to interpret environmental conditions associated with the Palaeolithic in the Nile Valley. Sediments associated with floodplain environments, for example, can have higher carbonate values, as can pond and lacustrine deposits. Sand-dominated units generally do not have high organic or carbonate values, unless affected by post-depositional soil-forming processes. The Late Pleistocene stratigraphic sequences at Wadi Kubbaniya are the product of various types of depositional contexts that reflect the development of the local landscape and the role it sometimes played in influencing Middle and Late Palaeolithic prehistoric humans. In this instance, artifact assemblages typically are associated with aeolian sands that interfere with Nilotic silts, apparently demonstrating that Palaeolithic humans were actively utilising landscapes that were episodically flooded by fluvial processes.

Late Pleistocene Contexts from North America

Introduction

The Pleistocene landforms and stratigraphy of North America, like the landscapes of the Sahara and Nile Valley, are the products of episodic changes in local and regional environmental conditions. Some of these changes can be linked to global-scale glacial/interglacial climates. In North America, an interdisciplinary approach has also been used to address a diverse array of archaeological issues such as developing geoarchaeological models used to predict the location of Pleistocene archaeological sites, documenting landscape evolution and past physical environments, and evaluating site formation and taphonomic contexts. In
the western interior region of the Rocky Mountains and Great Plains the last climate cycle from non-glacial to full glacial and back to non-glacial conditions resulted in dramatic changes in landscapes and biotic habitats.

The oldest clearly defined artifact types in North America are Clovis and Folsom fluted points (Holliday 2000). Human populations using Clovis artifacts existed as part of a Rancholabrean biota that included mammoth (*Mammuthus*), while Folsom artifacts have been recovered with extinct forms of bison (*Bison antiguus*). Plano-type (non-fluted) point forms are generally assigned to latest Glacial and post-Glacial palaeoenvironmental contexts. Age relationships between regional geological events and artifact assemblages have been determined using radiocarbon measurements and/or stratigraphic relationships. For example, the averages from Great Plains Clovis sites range from about 11 600-10 800 BP (all ages in this paper are uncalibrated). Based on this age range, Clovis can therefore be partly correlated with the last part of the late Glacial Interstadial and the beginning of the Younger Dryas reflected in the global isotope record. Sedimentary sequences for the southern margin of the Laurentide ice sheet in the Upper Missouri basin and on the Southern High Plains provide data relevant to understanding the environmental conditions from before the Last Glacial Maximum (the Middle Wisconsinan non-glacial) to the end of the Pleistocene (the Younger Dryas-Preboreal boundary).

### Surficial Processes and Sedimentary Sequences on the Great Plains and Rocky Mountains

The character of the Late Pleistocene Laurentide southwestern margin is considered here in relation to the eastern margin of the Cordilleran ice sheet and the availability of landscapes along the eastern front of the Rocky Mountains and on the Great Plains for migration and habitation. An examination of landscape dynamics along the eastern front of the Rocky Mountains and Late Pleistocene environmental conditions on the Great Plains can be undertaken by developing a time-space framework based on stratigraphic sequences and related landforms (Hill 2006).

Some evidence suggests that the southern position for the Laurentide continental ice was at the Lethbridge moraine in southwest Alberta, within the Saskatchewan River drainage, while other evidence indicates a more southerly limit along the Missouri River in northern Montana (Fullerton et al. 2004a, 2004b). The difference is significant in terms of the presence of available land for biotic communities and the timing of glaciation. A more southerly ice margin advance to about the present-day location of the Missouri River appears to be supported by Late Wisconsin luminescence ages on lake deposits above and below Laurentide till within the Missouri drainage near Great Falls, Montana (Hill and Feathers
2002). The advance and melting of the Laurentide glacier resulted in changes in the Saskatchewan and Missouri River drainages; proglacial (ice-marginal) lakes that developed along the margin help to constrain the deglaciation chronology of the region.

The Missouri River drainage contains evidence of interaction between mountain and continental glaciers and other areas where the space between them was always ice-free. In Montana, lakes formed between the mountain valley glaciers and the Laurentide continental ice margin. The pattern of ice retreat along the southwest margin of the Laurentide Ice Sheet is useful for understanding the availability of inhabitable post-glacial landscapes. Glacial Lake Great Falls was formed when the Laurentide ice Sheet blocked the drainage of the Missouri River (Montagne 1972; Hill and Valppu 1997; Hill 2000; Hill and Feathers 2002; Feathers and Hill 2003; Reynolds and Brandt 2005). Lacustrine silts and overlying sands adjacent to Holter Lake indicate the youngest stage of Glacial Lake Great Falls has an age of around 17,000-13,000 OSL BP indicating that the ice extended to and blocked the Missouri River during the last part of the Pleistocene (Figure 2-8) (Hill and Feathers 2002; Feathers and Hill 2003).

Vertebrate remains provide information on Middle and Late Wisconsin landscapes close to the glacial margins (Hill 2001a, 2001b, 2006) (Figure 2-8). The stratigraphy along Indian Creek in the Elkhorn Mountains contains both the late Pleistocene Glacier Peak and middle Holocene Mount Mazama tephras, along with faunal remains and a series of artifact assemblages (Albanese and Frison 1995). The nearby MacHaffie site contains a Folsom artifact component associated with a bone collagen age on bison of 10,390 BP (Table 2-1) (Davis et al. 2002). The uppermost deposits at Blacktail Cave contained large mammal remains dated from 11,240-10,270 BP (Hill 2001a). In the Sun River area near Augusta, along the eastern front of the Rocky Mountains, mammoth fossils were found embedded in organic-rich (swamp and paludal) deposits dated to about 11,500 BP (Marsters et al. 1969). The sediments containing the mammoth fossils were deposited after the melting of the Sun River lobe alpine-valley glacier and are buried by alluvial deposits that contain the Mazama tephra. In the Marias River Valley the late Quaternary stratigraphic record includes two tephras correlated with the Glacier Peak and Mazama, at the Elwell section. Deposits between the two tephras contain palaeosols. A fragment of mammal bone with an age of 11,170 BP recovered near the oldest tephra and above Laurentide till helps to constrain erosional and depositional processes connected with the Late Pleistocene landscape evolution of this region (Hill 2002a, 2006).

Physiographic features and stratigraphic sequences in the lower Yellowstone River basin also provide information on late Pleistocene surficial processes and landscape evolution. Surficial processes include intervals of aeolian deposition and
periods of increased landscape stability resulting in the development of soils. Some pedogenic (soil-forming) features consist of secondary carbonates (possibly associated with arid climates), while other palaeosols are characterised by well-developed A horizons (potentially the result of wetter or cooler climates). Two late Quaternary stratigraphic sequences illustrate this pattern.

The South Fork of Deer Creek flows into the Yellowstone Valley from the north. Upland silts overlie bedrock and contain buried A horizons and secondary carbonates. The silts contain the remains of a mammoth (*Mammuthus columbi*). Radiocarbon ages from this mammoth indicate the silts were deposited around 12 330 to 11 500 BP, followed by the soil-forming episodes (Table 2-1) (Hill and Davis 1998; Hill 2003, 2006). The deposits provide information relating to landscapes that were contemporary with human groups using Clovis. Fossil pollen recovered from the silts demonstrates the presence of both arboreal and nonarboreal vegetation (Huber and Hill 2003). The pollen assemblage contains *Pinus*, *Betula*, and *Salix* and open-ground herbaceous plants. This may mean that the mammoth habitat in this region at about the time when Clovis artifacts were used was an open coniferous deciduous parkland. This landscape could have been a northern variant of gallery woodland and parkland or savannah landscapes that have been proposed to have been present in the Southern High Plains during the Late Pleistocene (Hill and Wendorf 1998), or it may reflect landscape contexts similar to the Southern Rocky Mountains at about 10 200 BP where conifer stands may have been separated by steppe (Mayer et al. 2005).

The sequence can be interpreted in terms of prevailing surficial processes and the dynamics of landscape evolution. The mammoth-bearing silts seem to be aeolian deposits; these can be correlated with the Aggie Brown Member of the Oahe Formation (Hill 2003). The overlying palaeosols reflect intervals of landscape stability. Elsewhere, these have been related to moist-cool late Pleistocene and early Holocene climates, and increasingly arid middle Holocene (“Altithermal”) conditions (Karlstrom 2005; Mayer et al. 2005; Rawling et al. 2003; Waters 2000). Palaeosols that formed under moist-cool climates may be the local equivalent of the regional Leonard Palaeosol and Brady buried soil (Albanese and Frison 1995). These are stratigraphic contexts that preserve the landscapes associated with a Late Pleistocene human presence.

Stratigraphic sequences south of the Yellowstone River also contain aeolian silts and palaeosols (Figures 2-8 and 2-9). Buried A horizons developed within aeolian silts at OTL (Oscar T. Lewis) Ridge, south of Glendive, Montana, and have radiocarbon ages of 11 415 to 9 330 BP (Table 2-1) (Hill 2003, 2006). The stratigraphic sequence indicates intervals of aeolian deposition interrupted by episodic intervals of increased pedogenesis linked to landscape stability (e.g. Waters 2000). The radiocarbon ages from materials within the palaeosols are approximately contemporaneous with data suggesting climate conditions wetter
than present elsewhere in the western interior of North America (e.g. Karlstrom 2005). The OTL upland lithostratigraphic sequences can also be correlated with the Aggie Brown Member of the Oahe Formation and other regional late Pleistocene-early Holocene deposits that are contemporary with Clovis and Folsom artifacts.

In contrast to the Yellowstone basin sections which reflect Late Pleistocene upland contexts, surficial processes have been examined in valley fill stratigraphic sequences in the Southern High Plains. This region has been extensively studied using geoarchaeological approaches (Haynes 1975; Holliday 1995). At Blackwater Draw and Mustang Draw (Figure 2-10), for example, stratigraphic sequences reflect landscape conditions contemporaneous with Clovis and Folsom archaeological occurrences and can be correlated with broader-scale climate change (Hill and Meltzer 1986, 1987; Hill and Wendorf 1998). At Blackwater Draw, between Portales and Clovis, New Mexico, stratigraphic sequences contain Clovis and Folsom artifacts and fossils of extinct Rancholabrean fauna. One locality, the Barrow Pit section, contains a late Quaternary sequence (Haynes 1975). Two radiocarbon ages indicate the oldest deposits date to the late Pleistocene (Table 2-1). Mudstones (sils and clays) dated to about 15 770 BP seem to reflect the presence of episodic transgressions and regressions in a lacustrine environment. These conditions appear to have prevailed after the Last Glacial Maximum during a wet climate interval designated as the Tahokia pluvial. The mudstones are overlain by calcareous sandy silts dated to about 10 600 BP (Table 2-1). These silts may correlate locally with diatomites associated with Folsom artifacts. They may reflect regional landscape contexts that can be correlated with the Younger Dryas. Pollen data from the Barrow Pit section have been interpreted as indicating a mosaic vegetative landscape with spruce-pine parkland and grassland savannas (Hill and Wendorf 1998). A somewhat similar landscape consisting of steppe separated by conifer stands has been dated to the end of the Younger Dryas (10 200 BP) in the Southern Rocky Mountains (Mayer et al. 2005).

Mustang Draw, north of Midland, Texas, also contains a late Quaternary stratigraphic record that provides information on the types of surficial processes and landscapes on the Great Plains (Hill and Meltzer 1986, 1987). The lowest deposits at one locality consist of calcareous sandy gravels (zone 1) (Figures 2-10 to 2-12). A silty sand (zone 2) overlies the gravel. These sediments may represent surficial processes associated with spring and fluvial activity within the draw. Lacustrine deposits (zones 3 a-g), dating from about 10 130 to younger than 8 260 BP (Table 2-1), seem to indicate a shift associated with the end of the Younger Dryas and the early part of the Holocene. There is substantial facies variation within this set of lacustrine deposits. There are sediments dominated by clastics (sils and clays), as well as cienaga and diatomaceous sediments. Thus
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valley fill in Mustang Draw suggests surficial processes shifted from fluvial activity to lacustrine deposition close to the end of the Pleistocene.

Conclusion

Studies of stratigraphic sequences provide a means to examine surficial processes linked to archaeological site formation and local environmental contexts and also provide information relevant to landscape evolution and climate change. In Egyptian northeast Africa, the adaptive patterns of hominids that made and used Palaeolithic artifacts can be more fully understood through the study of erosional and depositional surficial processes. This same type of approach is also crucial in attempts to expand and test our understanding of the connections between physical and biological environments in western North America during the Late Pleistocene. Evaluation of the stratigraphic record provides a means of understanding site context and formation processes, as well as the connections between landscape evolution and climate on the human time-scale.

Acknowledgements

This paper was prepared for the DIG 2005 conference. I would like to express my thanks to the organisers of the conference, especially Lucy Wilson and Pam Dickinson. This research was partially funded by the National Science Foundation, Sigma Xi, the Geological Society of America, and the Institute for the Study of Earth and Man, Southern Methodist University.

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Figure 2.1: Map showing general location of regions in northeast Africa and the western interior of North America.
Figure 2-2: Pleistocene sedimentary sequences in northeastern Africa. Bir Tarfawi, situated in the eastern Sahara Desert, contains Middle and Late Pleistocene sediments containing Acheulian and Middle Palaeolithic artifacts. Middle and Late Palaeolithic artifacts are associated with the stratigraphic sequences at Wadi Kubbaniya, a tributary of the Nile River.
Figure 2-4: Spatial distribution of artifacts at a Typical Mousterian site (E-87-3). The concentrations of artifacts may be the result of surficial deposits after the presence of hominid activities at the site. The smallest artifacts consist of debitage. The artifacts are associated with a playa or seasonal lake.
Processes:

Laterally depositional basins. These sediments appear to primarily reflect lake margin, shore zone, and...

Figure 2-5: Stratigraphic sequence at a Middle Paleolithic site (E-8-2). The artifacts were recovered...
Figure 2-6: Spatial distribution of three sizes of artifact types at a Middle Palaeolithic site (E-87-2). Cores represent the largest artifacts while debitage consists of small artifacts. The highest number of smaller artifacts is on the southeast part of the site, closer to the centre of the basin.
Figure 2-7: Composite stratigraphic section from middle Paleozoic locality at northern Ft. Laramie. The sequence at

contents shown from close to the center of the depositional basin; these facies consist of fine clastics and carbonates.

Trench 16/74 consists of sheetlike and basin margin lithofacies, primarily dominated by coarse clastics. Trench 14/74
Figure 2-8: Late Pleistocene localities from the Upper Missouri Basin (Montana, U.S.A.).
Figure 2.9: Landscape context within the drainage basin of the Yellowstone River.

- South Fork of Deer Creek
  - Mammoth Loess Under Buried Soil
    - 12,330-11,500 B.P.
- OTL Ridge
  - Buried Soils in Loess
    - 11,415-9,330 B.P.

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Figure 2-10: Late Pleistocene localities from the Southern High Plains (New Mexico and Texas, U.S.A.).
Figure 2.11: Late Quaternary stratigraphic section from Mustang Draw. Zones 1 and 2 are sedimentary intervals in the Pleistocene interval that correspond with depositional processes associated with lacustrine facies.

Depositional processes associated with lacustrine facies reflect fluviatile processes within the draw during the Late Pleistocene. Zone 3 primarily reflects lower energy depositional processes within the draw during the Late Pleistocene. Zones 1 and 2 are sedimentary intervals in the Pleistocene interval that correspond with depositional processes associated with lacustrine facies.
## Chapter Two

**Table 2-1: Geochronometric measurements mentioned in the text.**

<table>
<thead>
<tr>
<th>Method</th>
<th>Age</th>
<th>Specimen Number</th>
<th>Location</th>
<th>Notes</th>
</tr>
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<tbody>
<tr>
<td><strong>Egypt-Tarfali</strong></td>
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<td></td>
<td></td>
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<tr>
<td>U-Series</td>
<td>220,000 +/- 230,000</td>
<td>87BF-26</td>
<td>E-87-2, Bed 6</td>
<td>Carbonate</td>
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<tr>
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<td>87BF-39</td>
<td>E-87-3, Bed 1</td>
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<td>Trench 1 at E-87-3, Bed 1</td>
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<tr>
<td>U-Series</td>
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<td>87BF-44</td>
<td>BT-14, Bed 1d</td>
<td>Eggshell, Bed 1d</td>
</tr>
<tr>
<td>U-Series</td>
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<tr>
<td>U-Series</td>
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<tr>
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<td>BT-14, Bed 1d</td>
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<td><strong>North America</strong></td>
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<tr>
<td>Radiocarbon</td>
<td>10,600 +/- 300, 10,000 +/- 320</td>
<td>A-499</td>
<td>Blackwater Draw, Barrow, Pit Unit D2</td>
<td>Lake mudstone (carbonate)</td>
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<td>A-669B</td>
<td>Blackwater Draw, Barrow, Pit Unit D2</td>
<td>Anodonta shells</td>
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<tr>
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<tr>
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<td>MacHaffie</td>
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<td>MacHaffie</td>
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<td>Blacktail</td>
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<tr>
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<td>Sun River</td>
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<td>Beta-31200</td>
<td>Marias</td>
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<td>Deer Creek</td>
<td>XAD-gelatin, KOH collagen</td>
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<tr>
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</tr>
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<td>Whiter Bear Creek</td>
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</tr>
</tbody>
</table>

*Table 2-1: Geochronometric measurements mentioned in the text.*
Reconstructing Human-Landscape Interactions

Edited by

Lucy Wilson, Pam Dickinson and Jason Jeandron

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