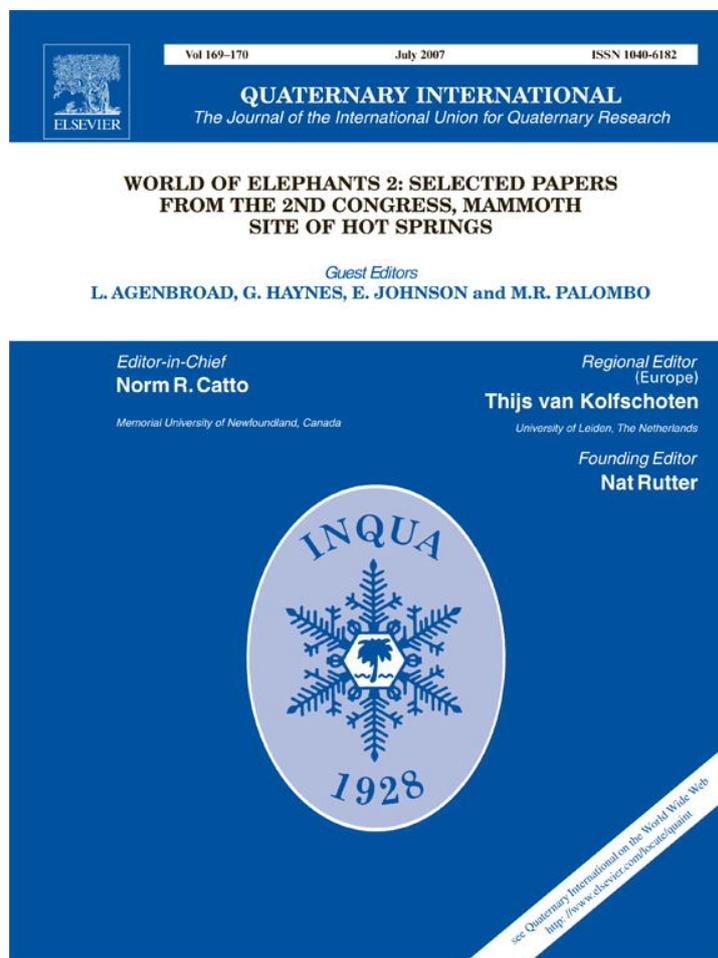


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# The age and taphonomy of mammoths at Lovewell Reservoir, Jewell County, Kansas, USA

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## Abstract

Remains of five mammoths have been excavated along the north shore of Lovewell Reservoir on White Rock Creek, Jewell County, Kansas. Two additional mammoths have been recorded as surface finds. These seven mammoths are clustered within a distance of 2 km and are contained within sediments dating to the transition from terminal mid Wisconsin to Last Glacial Maximum. This density of single adult mammoth death sites is uncommon elsewhere on the central Great Plains of North America. Radiocarbon ages from bone and decalcified organic carbon indicate the mammoths date between about 18,000 and 21,000 rcybp. A discussion of the stratigraphy, ages and taphonomy for the five excavated mammoth localities is presented including new taphonomic data collected from the Lovewell Mammoth Site (14JW306) during the 2004 excavation. New data indicate that the Lovewell Mammoth Site contains three mammoths where as previously only one mammoth was reported [Holen, S.R., 2006. Taphonomy of two last glacial maximum mammoth sites in the central Great Plains of North America: a preliminary report on La Sena and Lovewell. *Quaternary International* 142–143, 30–43]. Results presented here support the earlier taphonomic interpretation that humans were present on the central Great Plains during the Last Glacial Maximum.

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## 1. Introduction

Research at Lovewell Reservoir in north-central Kansas, USA, has documented the presence of seven mammoths, all of which date to the Last Glacial Maximum (LGM) and terminal mid Wisconsin. These mammoths were investigated over a 35-year span beginning in 1969, with the last excavation and surface survey in 2004. Work in 1969 and 1979 represents a scientific salvage response to chance discoveries of mammoth remains. Beginning in 1989, the author undertook test excavations to determine the stratigraphic origin of late Wisconsin-age Clovis lithic artifacts found on the beach at the Eckles Clovis Site, 14JW4. Since that time the fieldwork has been more systematically geared toward the development of a stratigraphic and temporal framework for paleontological and archeological sites along the north shore of the reservoir and the discovery and excavation of new sites. A total of seven mammoths occur along a 2-km segment of the northern shoreline (Fig. 1). This density of single adult

mammoth death sites is a unique record for the central Great Plains and offers an opportunity to evaluate both stratigraphy and mammoth taphonomy at several locales. Five excavated mammoth sites will be discussed here and these include three excavated mammoths at the Lovewell Mammoth Site (14JW306), one mammoth at the April Fools' Site (14JW101) and one mammoth tusk at site 14JW310.

The first goal of this article is to provide a physiographic and geologic setting for late Pleistocene fauna recovered from the Lovewell Reservoir. The second is to present stratigraphic and taphonomic data for the five mammoth deposits. Finally, new data recovered from the 2004 excavation at the Lovewell Mammoth site are presented and implications for understanding human occupations on the Central Great Plains during the LGM are explored.

## 2. Physiographic, geologic, and paleontological setting

Lovewell Reservoir is located on White Rock Creek, a tributary of the Republican River in north-central Kansas, USA. The White Rock Creek valley ranges from 1.5 to

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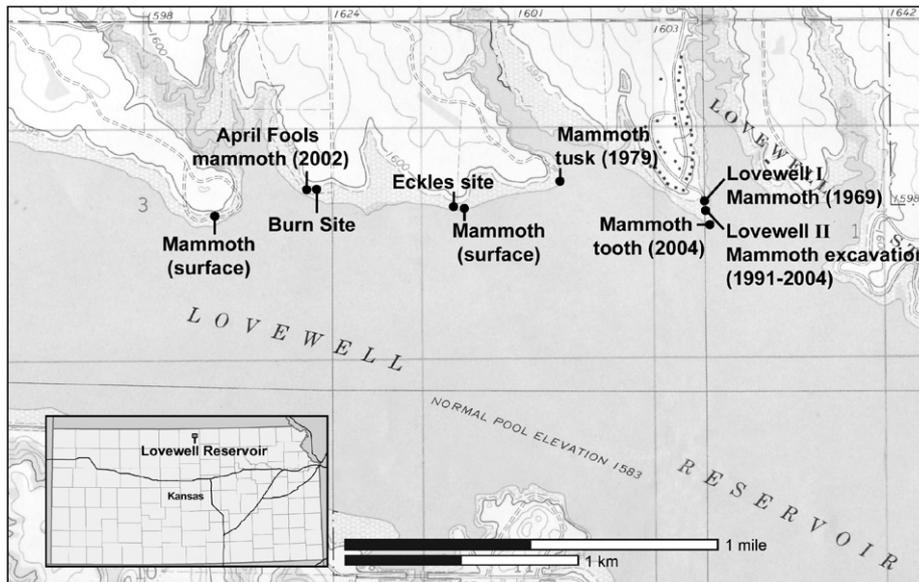


Fig. 1. Map of north shore of Lovewell Reservoir showing the location of seven mammoth localities, the Eckles Site, and the Burn Site.

2.0 km wide with approximately 60 m of relief (Mandel, 2002). The valley was dammed by the US Bureau of Reclamation in the mid 1950s to form Lovewell Reservoir, primarily for the purpose of irrigation. Since that time the fluctuating lake levels have eroded the north shoreline exposing a rich Wisconsin paleontological and archeological record.

White Rock Creek is situated in the Smoky Hills physiographic subprovince of Fenneman's (1931) Great Plains Physiographic Province (Mandel, 2002). The surrounding area is made up of a wide belt of hills formed by the dissection of Cretaceous bedrock (Schoewe, 1949; Merriam, 1963). Thin, chalky limestone beds that alternate with thicker beds of gray, chalky shale tops the higher areas, while the lower sections rise from softer eroding shale. This causes the region to take on a rolling landscape with limestone overhangs, which appear as flat-topped buttes and mesas (Mandel, 2002; Merriam, 1963).

North-central Kansas has a late Pleistocene stratigraphic framework that includes Illinoian and Wisconsinan loesses. These deposits are regional in extent, and hence provide marker units to which more localized and younger fluvial and colluvial units can be stratigraphically related. Mandel (2002) provides a stratigraphic and temporal outline of the local deposits including three types of loess present in the White Rock Creek valley: Loveland Loess, Gilman Canyon Formation, and Peoria Loess. The Loveland Loess consists of yellowish-brown or reddish-brown silt that was deposited from ca. 135,000 to 140,000 years ago (Forman et al., 1992). In many locations throughout the Midwest, the Sangamon Geosol is developed in the upper portion of the Loveland Loess. Constraining TL and radiocarbon ages indicate that the period of pedogenesis for the Sangamon Geosol extended from about 120,000 to 55,000 years ago (Mandel and Bettis, 2001). The Gilman Canyon Formation

is dark, noncalcareous silt that has been modified by pedogenesis. Radiocarbon and TL ages from the Gilman Canyon Formation range from about 40,000 rcybp at its base to 20,000 rcybp at the top (May and Souders, 1988; Johnson, 1993; Martin, 1993; Mandel and Bettis, 2001). The Peoria Formation is typically light yellowish tan-colored silt. Initial deposition of the Peoria Formation began around 21,000–20,000 rcybp and ended around 12,000 rcybp (May and Holen, 1993; Mandel, 2002). Alluvial terrace sequences are present along White Rock Creek that are equivalent in age with Gilman Canyon and Peoria loess.

A geomorphic study of the Burn Site, located just east of the April Fools' Mammoth (Fig. 1) identified Gilman Canyon Formation and Peoria Loess deposits from which extinct fauna is eroding (Mandel, 2002). Charcoal from a naturally burned area in the base of Peoria Loess at Section 1, about 80 m east of the April Fools' Mammoth, was radiocarbon dated to  $20,420 \pm 400$  rcybp (Tx-8484). At Section 2, about 20 m east of the mammoth, decalcified organic carbon from the upper 10 cm of the buried Gilman Canyon soil was radiocarbon dated to  $20,510 \pm 310$  rcybp (Tx-8479). Both of these ages are consistent with ages derived elsewhere for the terminal Gilman Canyon Formation and initial Peoria loess deposition (Martin, 1993; May and Holen, 1993; Mandel, 2002) and provide a local chronologic marker for this transition at Lovewell Reservoir (Fig. 2).

Faunal remains of extinct species dating to the mid to late Wisconsin have been recovered from primarily surface contexts with a few excavated individual specimens along the north shore of Lovewell Reservoir between 1989 and 2004. These species are collectively termed the Lovewell Local Fauna (Holen et al., 1995). The diverse mammalian fauna includes mammoth (*Mammuthus columbi*), bison

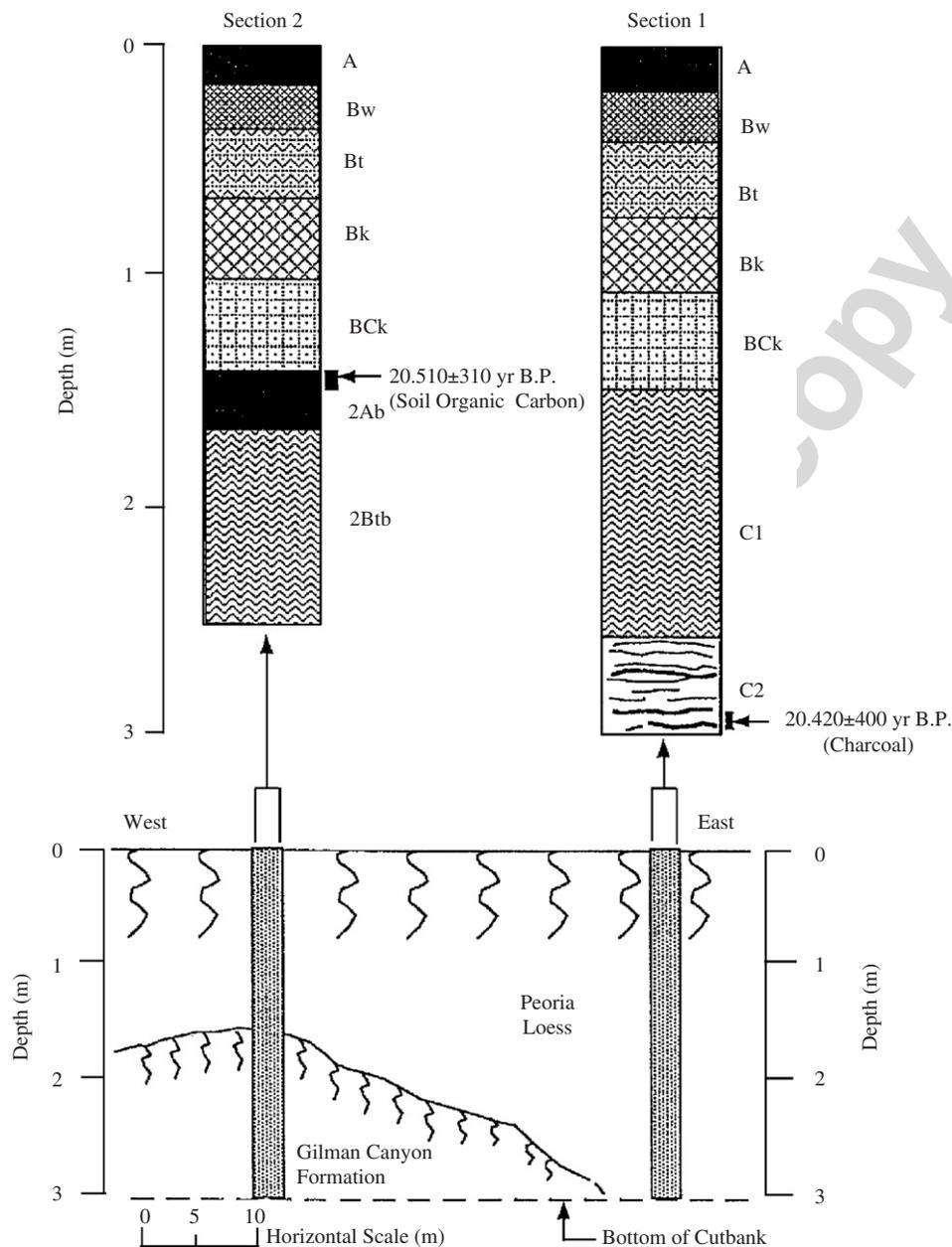


Fig. 2. Composite stratigraphic section at the Burn Site (after Mandel, 2002).

(*Bison* cf. *Bison bison antiquus*), camel (*Camelops hesternus*), dire wolf (*Canis dirus*), horse (*Equus* sp.; both large and small), llama (*Hemiauchenia macrocephala*), and sloth (*Megalonyx jeffersonii*). Smaller mammals include mouse (*Peromyscus* sp.), Plains pocket gopher (*Geomys bursarius*), Pocket mouse (*Perognathus* sp.), Prairie dog (*Cynomys* sp.), 13-lined ground squirrel (*Spermophilus tridecemlineatus*), and vole (*Microtus* sp.). Reptiles include toad (*Bufo* sp.), Blue Racer snake (*Coluber constrictor*), Hognose snake (*Heterodon* sp.), and Garter snake (*Thamnophis* sp.). Indeterminate fish and indeterminate passerine bird remains were also recovered. All of these species were recovered from test pits in the top 50 cm of in situ Gilman Canyon Formation alluvial point bar deposits except for

the bison, dire wolf, llama, mammoth, and sloth faunal elements. A horse metapodial excavated from 30 cm deep in the Gilman Canyon Formation point bar deposit was dated to  $22,770 \pm 810$  rcybp (CAMS 17406). Test excavations at the Eckles Clovis archeological site, 14JW4, were designed to locate the origin of lithic Clovis artifacts found on the beach, however, the age of the Gilman Canyon point bar deposits indicates that the artifacts originated much higher in the section (Holen, 1998, 2001).

Llama faunal elements were excavated from a similar stratigraphic position at Pawnee Point near the westernmost surface mammoth (Logan et al., 1991). Some llama elements excavated and reported by Logan et al. (1991) from the late Pleistocene deposits at the westernmost

mammoth locality also exhibit spiral fractures, but the cause of fracture patterns is not reported.

The majority of ungulate limb elements found at Lovewell Reservoir are from surface finds and thus lack the context of the excavated mammoths. Some surface-collected limb bone elements from large ungulates exhibit spiral fractures, however, these fracture types are often caused by natural processes like carnivores and trampling on ungulate bone (Haynes, 1983). One lateral segment of a large spirally fractured Pleistocene bison or camel humerus was found on the surface near the westernmost mammoth locality. This humerus exhibits a very distinctive percussion notch ca. 2.5 cm in diameter thought to have been caused by hammerstone percussion. Several other spirally fractured lateral segments from a large ungulate limb bone were found nearby on the surface. The estimated age of these elements is 12,000–23,000 rcybp based on the age of the eroded deposits and the presence of a calcium carbonate concretion of the type that is only found on late Pleistocene bone. Thus, there is a suggestion of human involvement with large Pleistocene ungulates at Lovewell but that evidence is not as convincing as the evidence for human breakage of mammoth limb bones because most of the ungulate bone is from the surface.

### 3. The April fools' mammoth

In 2002, the April Fools' Mammoth site (14JW101) was discovered on the north shore of Lovewell Reservoir immediately west of the previously discussed Burn Site. At this location, alluvium and loess are exposed in a 100 m-long cutbank. The loess mantles a high alluvial terrace of White Rock Creek. Lithostratigraphic units exposed in the cutbank include Gilman Canyon Formation, Peoria loess, and alluvial gravels and silts that are equivalent in age with the Peoria loess (Holen and Talley, 2003). The matrix surrounding the April Fools' Mammoth was alluvial fill consisting of compact gravels and dense silt. Based on the dated stratigraphic sections at the Burn site immediately to the east, and the fact that the April Fools' Mammoth is in a channel fill inset into the Gilman Canyon Formation, the age of the mammoth is considered to be about 18,000–20,000 rcybp.

This site contains an in situ mammoth deposit that was exposed near the base of the cutbank and test excavations totaling 6 m<sup>2</sup> recovered a restricted concentration of faunal material. This includes two complete molars and 164 molar fragments, 183 tusk fragments, five skull fragments, 47 rib fragments, nine limb bone fragments, one cuneiform and one calcaneum. Several rib fragments exhibiting dry bone fractures could be refit. A total of 693 bone fragments were collected of which 657 could be identified as mammoth with the remainder probably representing mammoth elements too fragmentary to identify. The excavated elements, with the exception of molars and podials, are very fragmentary and in poor condition. The mammoth was a young adult, in the range of 20–26 years old, based

on the wear pattern on two-second molars (M-2s) using the criteria of Laws (1966) for the identification of African elephant ages from tooth eruption and wear.

There are numerous dry bone fractures on both bone and tusk fragments indicating that the mammoth lay exposed on the point bar for a lengthy period of time allowing the bone to weather and disintegrate. The geomorphic context indicates that after the bones weathered extensively they were size-graded with the largest items moving downstream being molars and the calcaneum and cuneiform. These and smaller elements were washed downstream a short distance to the southeast over the end of a point bar where they were found in a heavy concentration (Fig. 3). Based on the direction of flow in the paleo-channel that contains the April Fools' Mammoth, larger bone elements may be situated some unknown distance to the northwest, farther back into the cutbank.

Faunal elements were also collected in 2002 on the beach near the in situ April Fools' Mammoth remains. Thirty of the 33 faunal elements (91%) collected from the surface are mammoth elements. The only identifiable spiral fracture is situated on a segment of mammoth limb bone found near the in situ deposits. The three remaining elements are identified as horse (*Equus* sp.). Additional mammoth faunal elements were found on the beach surface at the site in 2004 although none were found in situ in the



Fig. 3. April Fools' Mammoth site (14JW101), concentration of mammoth molars, tusk fragments and rib fragments deposited at the edge of a LGM point bar deposit.

cutbank. This indicates a few additional elements are eroding from the site as the bank recedes. No evidence of human modification of the bone or any other cultural association was observed at the April Fools' Mammoth site.

#### 4. The mammoth tusk site, 14JW310

In 1979, a large adult mammoth tusk was excavated from beach deposits at Lovewell Reservoir (Fig. 1) by Bureau of Reclamation and Kansas State Historical Society archeologists. The age of the tusk was thought to be late Illinoian, in excess of 100,000 years, based on the red silt that encased the tusk (Kenyon, 1979). The red silty deposit along the north shore of the reservoir is now known to be part of the Gilman Canyon Formation. Based on the radiocarbon age obtained from the top of the Gilman Canyon Formation soil at the Burn site, this tusk is older than ca. 20,500 rcybp and may be as old as ca. 40,000 rcybp.

The tusk is 3.15 m in length and 0.23 m in diameter at the base indicating it was derived from a large adult mammoth. The stratigraphic position in fine-grained alluvium suggests that the tusk had not moved far from the death site. Only one small fragmentary mammoth bone element was encountered during the excavation. Additional elements may have been present beneath the cutbank or may have been destroyed by cutbank erosion. The 1979 excavation was a quick salvage operation and attempts to locate additional mammoth elements were not undertaken.

#### 5. The Lovewell Mammoth site, 14JW306

Three mammoths are located along a low peninsula that extends southward from the north shore of the reservoir for about 225 m (Fig. 4). These three mammoths are designated Lovewell Mammoths I–III based on their date of discovery. The peninsula appears to be a remnant terrace fill primarily comprised of Wisconsin-age fine-grained alluvium, consisting of redeposited Peoria loess toward the south, and late mid Wisconsin Gilman Canyon Formation red alluvium on the broader beach to the north (Holen et al., 2005).

Controlled surface survey and collection of faunal remains throughout the peninsula in 2002 and 2004 documented the presence of five surface concentrations of bone (Fig. 4). Three of the surface concentrations are associated with the three mammoth locales on the peninsula. Other late Pleistocene fauna identified in these surface collections include isolated elements from bison, horse, and camel.

##### 5.1. Lovewell mammoth I

The first mammoth at Lovewell Reservoir was discovered in 1969 when a local resident found a mammoth skull eroding out of fine-grained alluvial deposits on the beach

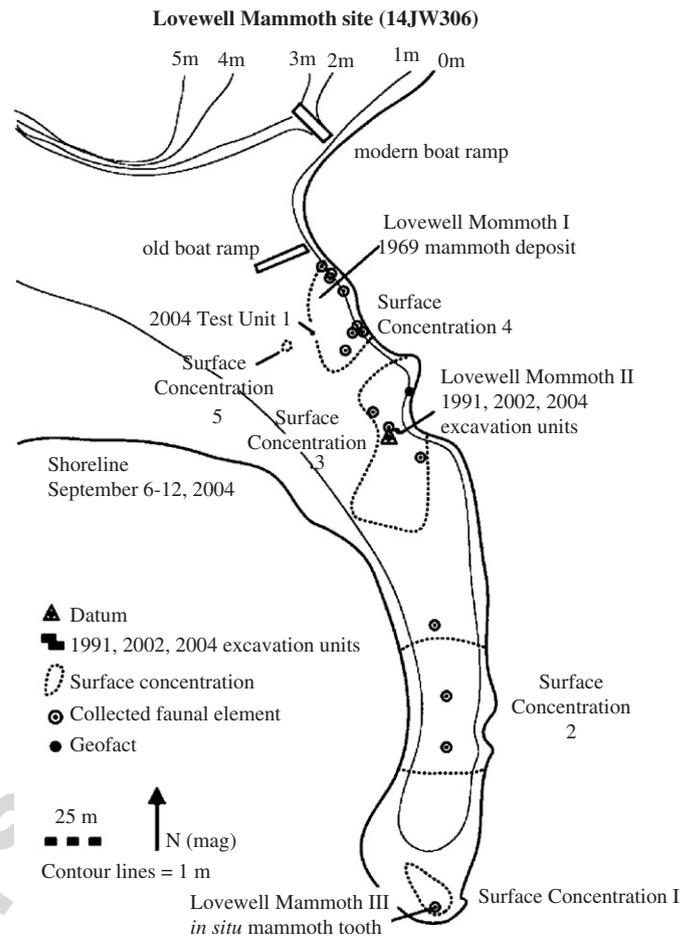


Fig. 4. Lovewell Mammoth site (14JW306) peninsula, showing location of three mammoth localities, and various surface concentrations.

during a very low lake level (Holen, 1997, 2006). Tom Witty and Tom Barr, archeologists at the Kansas State Historical Society, were called in to investigate the find. Photographs and interviews with the excavators indicate the presence of a complete, or nearly complete skull, tusks, limb bones and ribs. It appears that the mammoth excavated in 1969 represented the complete or nearly complete skeleton of an adult *Mammuthus cf. columbi* situated in a tight concentration in fine-grained red silts. Witty and Barr noted the presence of numerous spiral fractures on the bones and that the bone appeared to be "stacked". Furthermore, the nearly complete skull was inverted and rotated 180° back towards the body. Tom Barr had recently worked on the Domebo Mammoth Site, a Clovis mammoth kill and processing site in Oklahoma (Leonhardy, 1966), and was familiar with mammoth sites. Barr thought the mammoth at Lovewell had been processed by humans based on the inverted skull, the spirally fractured bone, and the stacked bone. This interpretation changed when the consulting geologist told the excavators, based on the reddish color of sediment at the site, that the fill containing the mammoth was in the Loveland loess of Illinoian age and that it was older than

100,000 years. Upon receiving this news the archeologists left the site and did not collect the mammoth bone, because they thought it was too old for human association in North America. A local school class then cast and collected some of the bone that was unfortunately discarded many years later. The remainder of the mammoth was soon covered by the reservoir where it remained for 22 years.

Archeological test excavations in 1989 and a radiocarbon age from the Eckles Clovis site (14JW4) located 800 m west of the Lovewell Mammoth indicated that much of the terrace fill along the north shore of the reservoir was not Illinoian in age. This discovery brought into question the age of the fill that contained the 1969 mammoth remains because the earlier excavation appeared to have been conducted in a stratigraphically equivalent terrace fill as the 1989 excavation.

For the first time since 1969, a drought in 1991 exposed the peninsula where the mammoth was excavated. Surface survey identified mammoth bone spread over a wide area on the beach with one area that contained a very heavy concentration of small fragments. Based on the very general location of the mammoth recorded on the original site form and photographs from the 1969 excavation, the 1991 location with in situ mammoth bone was initially thought to be the location of the 1969 mammoth site (now known as Lovewell Mammoth I) and was reported as such by Holen (1996, 1997, 2006). Three square meters excavated in this concentration in 1991 produced numerous pieces of spirally fractured and flaked adult mammoth limb bone extending into in situ gray silt beach deposits. Human association with the mammoth was indicated by impacted and flaked limb bone and the presence of one highly polished bone artifact. The presence of Clovis lithic artifacts at the nearby Eckles Site also suggested that this mammoth might represent a Clovis archeological site ca. 11,000 rcybp (Holen, 1993). A radiocarbon age of  $18,250 \pm 90$  rcybp (CAMS-15636) was later obtained from a limb bone fragment exhibiting an impact notch. This age indicated that the mammoth was about 7000 years older than the proposed Clovis designation.

The peninsula containing the Lovewell Mammoth site was covered by the reservoir from 1991 to 2002, when another drought lowered the lake level enough to expose the mammoth deposit. Excavation of an additional  $10\text{ m}^2$  at the location of the 1991 fieldwork yielded additional evidence of impacted and flaked adult mammoth limb bone (Holen, 2005a, 2006). The bone was contained in a shallow erosional gully and had been redeposited slightly down-slope in a very fine-grained alluvium during the late Pleistocene. During the 2002 fieldwork, heavy rain and a rising reservoir prevented completion of the excavation.

In 2002, one in situ mammoth rib fragment was excavated from red silts 80 m north of the 1991 and 2002 excavation. A second rib fragment was found on the surface next to the in situ rib. These ribs were discovered because a surface layer of loose modern alluvial silt had been eroded away down to in situ red silts that were not

exposed in 1991. Later, in 2005, a radiocarbon age of  $20,430 \pm 300$  rcybp (CAMS-112739) was obtained from collagen from this in situ rib indicating the red silt is part of the Gilman Canyon Formation, not Loveland loess. Red alluvium surrounding the Lovewell Mammoth I location is similar in color with Loveland loess present in the eastern Great Plains that predates the Sangamon Interglacial. Gilman Canyon Formation deposits had not been identified locally in 1969 and the similarity in color between Loveland loess and the Gilman Canyon Formation was the reason that the geologist misidentified the age of the deposit in 1969. The mammoth tested in 1991 and excavated more extensively in 2002 and 2004 is in terrace fill comprised of Peoria loess that post-dates the Gilman Canyon Formation (i.e.,  $\leq 20,000$  rcybp) and, therefore, is not the same mammoth as the one excavated in 1969 (Lovewell Mammoth I). In order to separate and discuss these two mammoth excavations in the future, the mammoth excavated in 1969 will be termed the Lovewell Mammoth I and the mammoth excavated in 1991–2004 will be called the Lovewell Mammoth II.

### 5.2. *Lovewell Mammoth II (1991–2004)*

Taphonomic analysis Lovewell Mammoth II provides tantalizing clues regarding the earliest inhabitants of the central Great Plains. A total of 695 pieces of mammoth bone were recovered in situ with several hundred additional pieces recovered from water screening during the 1991, 2002, and 2004 excavations. Differences in sediment color, texture, and content during excavation suggests the mammoth remains were deposited in a narrow shallow gully (Fig. 5). A geomorphic analysis of the site depositional setting conducted by David May (Holen et al., 2005) determined that two very fine-grained alluvial deposits are present, one forming the primary terrace fill and the second forming the gully fill. The primary deposit is a silt loam to



Fig. 5. 14JW306, mammoth bone in base of narrow gully (unit D1, base of level 6, 30 cm below datum).

silty clay loam that forms the beveled terrace that is exposed as the south part of a peninsula during low water levels at the reservoir. The second deposit consists of a silt loam that represents a shallow paleo-gully. The mammoth elements appear to be in the upper portion of this secondary alluvial deposit. Both the deposits are late Wisconsin in age indicating the gully did not form during the Holocene.

Construction of the reservoir resulted in the erosion of less than one meter of fill from over the Lovewell II mammoth based on the presence of a line of pre-reservoir postholes across the peninsula. Modern fence-line postholes are excavated no more than 1 m deep. This evidence is supported by the presence of light to moderate root etching on the mammoth bone indicating it was relatively near the ground surface. Compression from soil loading is not considered to be a factor in bone breakage at the Lovewell Mammoth II site based on the shallow buried in pre-reservoir sediments. Mammoth bone at the La Sena Mammoth Site (Holen, 2006) was buried under 3.5 m of loess and the only breakage due to soil loading was present on two complete ribs. These ribs exhibited dry bone fractures oriented 90° to the long axis of the bone. The separate pieces of these ribs were still articulated as would be expected of elements broken in situ. Sediment loading is therefore not considered to be an important factor in the breakage of mammoth limb bones in fine-grained silt deposits in the central Great Plains at depths of up to 3.5 m.

Villa (2005, p. 17), a leading European archaeologist/taphonomist, conducted an independent taphonomic analysis of mammoth bone collected in 2002 and described the overall condition,

All bones are in a good state of preservation and exhibit no evidence of pre-depositional weathering by exposure to the elements. Edges are fresh to slightly abraded (cf. post-burial water action at the site). I have seen no cutmarks and no gnaw marks (i.e., no ragged edges, no grooves, no scooping of cancellous bone, no tooth punctures or tooth pits). Bones are very robust, not brittle and resistant to breakage.

Villa's description of the condition of the 2002 bone applies to the specimens recovered in 2004 as well.

Three radiocarbon dates have been determined for bone samples from the Lovewell Mammoth (Holen, 2005b). A radiocarbon date on bone collagen from a spirally fractured mammoth limb bone fragment recovered in situ in 1991, returned an age of  $18,250 \pm 90$  rcybp (CAMS-15636). A second date of  $19,530 \pm 80$  rcybp (UCIAMS-11211) was obtained from mammoth cortical bone excavated in 2002. Both samples, processed by the laboratory of Thomas Stafford in Colorado, USA, contained high-quality collagen for radiocarbon dating. The  $19,530 \pm 80$  rcybp age is the single best age for the site because it was run on highly purified collagen obtained by more rigorous laboratory methods developed by Stafford

over the ten year period between 1995 and 2005 when the respective dates were run. The discrepancy between these two ages is best interpreted as being the result of improved collagen extraction techniques by the Stafford Laboratory. These two radiocarbon ages are consistent with the stratigraphic position of the Lovewell Mammoth in LGM terrace fill and other radiocarbon ages from similar stratigraphic positions along the north shore of the reservoir. A third date of  $16,110 \pm 280$  rcybp (CAMS-112738) was reported by Holen (2005b). This radiocarbon sample was processed at the University of Alaska-Fairbanks, using a methodology similar to Stafford's. This age is now rejected because the nitrogen content of the bone was zero which indicates no collagen existed in the sample and that an accurate age could not be obtained from this element. The bone chemistry was apparently not completed before the sample was sent to Lawrence Livermore Laboratory for radiocarbon dating and was not reported to the author until after the abstract containing the radiocarbon age was submitted (Holen, 2005b). The lack of collagen in this limb bone segment suggests differential collagen preservation among the faunal elements in this assemblage, a factor that is not uncommon in late Pleistocene faunal assemblages.

The Lovewell Mammoth II is about 8000 radiocarbon years older than the well-documented Clovis occupations dating between 11,500 and 10,750 rcybp. Although impacted and flaked mammoth limb bone and a bone artifact were recovered from the Lovewell Mammoth II location and although the initial interpretation of the site as a mammoth processing site was correct (Holen, 1993) it was not of Clovis age.

The bone artifact, illustrated in Holen (2006, Fig. 16), is highly modified and polished and it is not possible to identify the original element from which it was produced. The bone artifact is identified as such based on the high degree of modification of the original element, the high polish, and the snap fracture with additional polish produced after the snap. It is also identified as an artifact based on the similarity to items variously termed bone rods, foreshafts, projectile points and pry bars found in Clovis sites at many locations in North America and in Upper Paleolithic sites in central Europe and Siberia.

Villa (2005) identified bone flakes from the 2002 excavation that have characteristics consistent with percussion flaking akin to that observed on lithic artifacts. These characteristics include a striking platform, bulb of percussion, ripple marks, a curved ventral surface, and a hinge or feather termination. While Villa (2005, p. 18) could not positively state that the 2002 Lovewell Mammoth flaked bone specimens were themselves used as tools, she did state that the flake scars were "apparently due to percussion flaking of their fractured edges, following the primary fracture". Holen (2006) also noted the presence of cone flakes in the Lovewell Mammoth bone assemblage. Cone flakes result from dynamic loading of force against the cortical surface of a bone and are produced in concentric

rings around the point of impact. Holen (2006) recently evaluated the modified bone specimens from the Lovewell Mammoth site against three hypotheses to explain their presence. He concluded, as did Villa (2005), that scavenging and trampling cannot account for the observed taphonomic characteristics, and that human modification is the most likely explanation. Spirally fractured bone, bone flakes, cone flakes, and flaked bone that further support the interpretation of the human association with the Lovewell Mammoth II were recovered during the 2004 excavation.

### 5.3. *The 2004 excavation at the Lovewell Mammoth II*

In 2004, the locale was revisited when the reservoir level was intentionally lowered for dam maintenance. The 2004 fieldwork completed the excavation of mammoth remains in the shallow gully down to the water table of the reservoir. Examples of spirally fractured and flaked adult mammoth bone were recovered and there appears to be additional mammoth bone in situ in the gully fill farther to the north for an unknown distance extending below the current water table. The area 80 m to the north of the 2004 excavation, where the 1969 mammoth was excavated from the Gilman Canyon Formation red silts, was again covered with a layer of modern disturbed silts. Shovel skimming did not produce any additional mammoth elements in the area of the Lovewell Mammoth I.

The 2004 excavation produced adult mammoth disarticulated faunal elements. Data generated from all excavated materials from 1991, 2002, and 2004 indicate a minimum number of one individual because there are no duplicate faunal elements that would suggest two or more individuals. Element size also suggests that all came from the same individual. Weathering and root etching on all of the excavated elements are also similar, which also supports the single death event hypothesis. Elements include fragments of a femur and tibia from the appendicular part of the mammoth and ribs, vertebra, illium, scapula, and skull fragments from the axial portion of the mammoth. The presence of numerous spirally fractured limb elements indicates that the mammoth bone was heavily fractured while the bone was still very fresh. Cortical bone is generally in good condition with some root etching. Weathering of the bone before burial is very light to non-existent indicating a relatively rapid deposition. This evidence also supports the single individual hypothesis because if more than one individual were washed into this shallow gully from different locations one would expect to see differential weathering.

The mammoth bone recovered in 2004 is contained in a shallow gully that is oriented with the gully head to the southeast. The gully becomes deeper to the northwest with a maximum depth of 60 cm below the modern terrace surface at the northern wall of the excavation and dipped below the 2004 water table. Larger elements like ribs and the longer limb bone segments are generally oriented with

the long axis situated southeast/northwest. This trend indicates they have been transported at least a short distance down the gully. This transport occurred in a low energy situation as evidenced by the very fine-grained matrix around the bone deposit. Transport within the gully could not have caused the fracturing and flaking observed on the bone because the narrow short paleo-gully lacked the streamflow velocity to develop a high-energy regime and also lacked the cobbles or boulders required to impact the mammoth bone. Also, the fact that the mammoth bone fragments are not size sorted and include a wide variety of skeletal elements suggests that the bone was not transported over a long distance before coming to rest in the paleo-gully.

Two bone fragments (Catalog #s D1-087a and D1-093) recovered from unit D1 retain particularly good evidence of being culturally modified. Catalog # D1-087a is a bone flake with a platform, bulb of percussion, and feather termination (Fig. 6). When oriented with the striking platform up, the distal end and right lateral margin have low-angled edges while the left lateral margin is blunt with a 90° edge. If this piece were a stone artifact, it could be classified as a naturally backed flake.

Catalog # D1-093 is a bone flake with a bulb of percussion, lines of force, and a feather termination that was subsequently flaked from two directions. Two smaller bone flakes that refit to D1-093 were found in place still adhering to the larger bone's surface. When the main bone fragment is oriented with the original bulb of percussion up, there are four flake scars on the left half of the cortical (i.e., dorsal) surface that are oriented longitudinally and one flake scar that enters from the right margin and is oriented laterally (Fig. 6). The two refit flakes are shown in the dorsal view of Fig. 6. If these three objects were stone, they could be classified as a core with two refitted flakes that failed to initially detach during reduction.

Two thick lateral limb bone segments (Catalog #s: E0-047, and E0-051) that retain good evidence of being culturally modified were recovered from unit E0. These two specimens exhibit impact scars indicating breakage of thick cortical bone when it was still very fresh.

Catalog # E0-047 is a lateral cortical limb bone segment exhibiting numerous spiral fracture planes. Morphologically the piece is wedge shaped, with a beveled end opposite a squared butt end (Fig. 7). The interior surface has preserved the hinge termination of an impact scar that was created when the bone was initially broken open. The dorsal surface has a flake scar with a hinge termination that is oriented perpendicular to the long axis of the bone fragment.

Catalog # E0-051 is a lateral cortical limb bone segment. The piece has a conical scar caused by an impact fracture, two adjacent flake scars at one end, and a single, small flake scar at the opposite end—all located on the interior surface (Fig. 7). The two adjacent flake scars are oriented longitudinally, have hinge terminations, and are slightly expanding. The right scar has a clear ripple mark across the

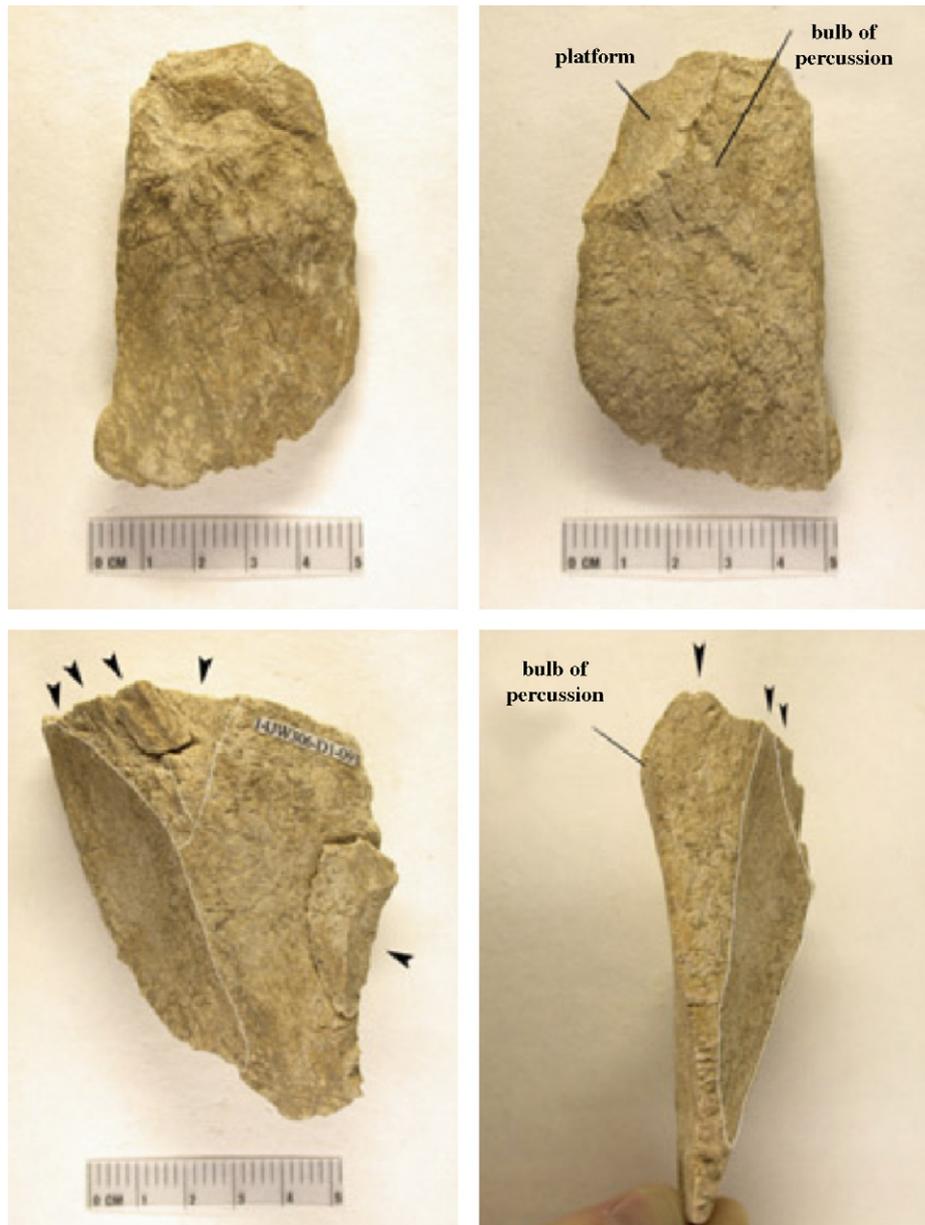


Fig. 6. Lovewell Mammoth II, top row D1-087a dorsal (left) and ventral (right) surfaces. Bottom row, D1-093 dorsal surface (left) and profile (right) views.

midsection. The small, single flake scar has a subtle ripple mark near the proximal end, and a step termination. The semi-circular notch where the point of impact occurred that created the cone flake is 52 mm across. Impact flake scars such as this are produced during the initial impact that spirally fractures a complete bone.

Two other specimens (Cat. # E0-031 and E0-042) from unit E0, exhibit evidence of bone flaking based on negative flake scars.

Catalog # E0-031 is a bone fragment with two flake scars preserved on its cortical surface (Fig. 8). Both flake scars originate from the same edge and retain negative bulbs of percussion. When the piece is oriented with the flake scars at the top, the left flake scar has a feather termination and the right scar has a termination that feathers into a slight hinge.

Catalog # E0-042 is identified as a mammoth ilium fragment (Fig. 8). This piece has two intersecting spiral fractures and a large flake scar on a cortical surface that has a maximum width of 132.5 mm. The flake scar is very well defined with a negative bulb of percussion, a wide expanding margin, and a feather-hinge termination. There is also the subtle indication of an erailleur flake that detached below and to the left of the point of impact. The point of impact is very well defined by a distinct notch that has an internal diameter of about 10 mm and expands across the surface of the bone for a maximum of 25 mm. There is a smaller, less distinct notch to the right of the point of impact that measures about 10 mm across but is not associated with a flake removal.

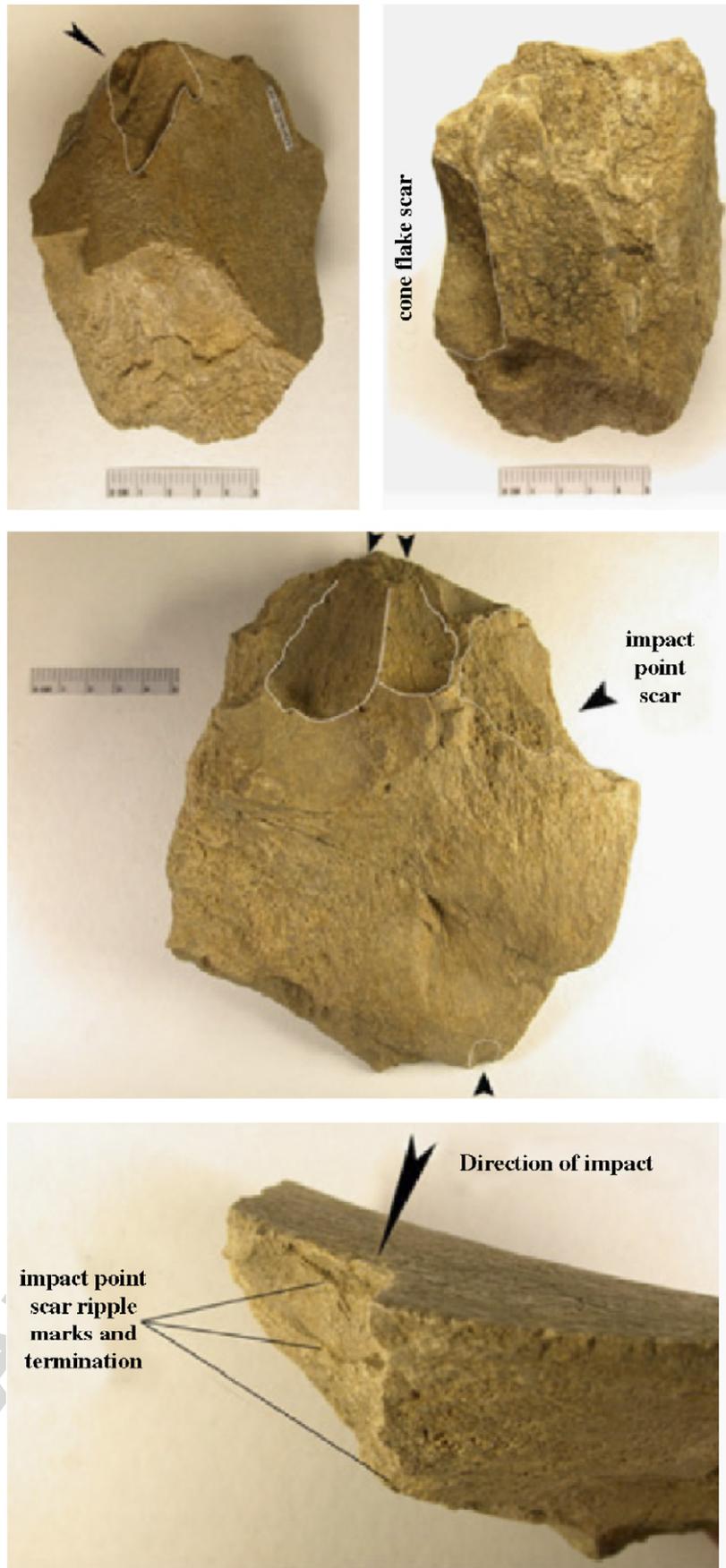


Fig. 7. Lovewell Mammoth II, top row E0-047 dorsal (left) and ventral (right). Middle row E0-051 dorsal view and arrows indicate direction of blows and flake scars are outlined in white Last row E0-051 side view.



Fig. 8. Lovewell Mammoth II, Cat. # E0-031 dorsal (cortical) surface (left); EO-42 illium fragment with flake scar (right).

These flaked bone fragments add important data to understanding the Lovewell Mammoth II taphonomy. As discussed by Holen (2006) and Villa (2005), carnivore scavenging and trampling do not adequately explain the spiral breakage and flaking patterns observed on the bone. The additional evidence recovered in 2004 strengthens the interpretation that humans were responsible for breaking and flaking the Lovewell Mammoth bone during the LGM.

#### 5.4. *Lovewell Mammoth III*

A third mammoth was also discovered in 2002 at the southern end of the peninsula about 220 m south of the Lovewell Mammoth II location (Fig. 4). The find consisted of mammoth molar plates located on the terrace surface. In 2004, an additional mammoth molar and plates from a second molar were excavated from the same fine-grained terrace deposit that contains the mammoth excavated between 1991 and 2004. The complete mammoth molar is from an adult but the exact age of the mammoth at death cannot be determined because of the poor condition of the tooth. This terrace deposit is an alluvial equivalent of the Peoria Formation. Based on the similar stratigraphic position of the mammoth excavated in 1991–2004, the age of the molars is ca. 18,000–19,000 rcybp. No other mammoth bone fragments were observed in the vicinity.

## 6. Conclusion

The density of late Pleistocene fauna, especially mammoths, along the north shore of Lovewell Reservoir indicates this is one of the most important localities on the central Great Plains for the study of faunas from the transitional period between late mid Wisconsin to the LGM.

During the last 35 years the excavation of five mammoth localities, and the presence of two additional mammoths from surface finds, within a 2-km segment of the north shore of Lovewell Reservoir, appears to be the highest concentration of single mammoth death sites in the central Great Plains of North America. The reason for this density

of Wisconsin-age fauna appears to be twofold. First, the erosion of Lovewell Reservoir into the extensive alluvial deposits exposes new faunal evidence each year. However, this does not completely explain the observed density of fauna because other reservoirs in the central Great Plains that are eroding into Wisconsin-age alluvial deposits do not produce this high number of mammoths and other extinct fauna. Therefore, it is proposed that the White Rock Creek valley ecological setting was conducive to supporting a large and diverse fauna. White Rock Creek is a spring-fed creek that flowed continuously and supported lush vegetation even during the relatively dry LGM. The presence of numerous channel deposits containing small gravel along the north shore indicates that White Rock Creek was a dynamic stream with a significant flow that would attract large numbers of megafauna.

Taphonomic differences between the five mammoth localities are striking. The Lovewell Mammoth I excavated in 1969 consisted of the nearly complete skeleton of an adult mammoth in fine-grained Gilman Canyon alluvium. The tight concentration of the skull, tusks, and post-cranial elements and the generally good condition of the bone indicates that the skeleton was covered by alluvium soon after death and was not significantly redeposited by streamflow. The presence of numerous spirally fractured elements, the “stacked” appearance of some elements, and the position of the skull and tusks noted by the original excavators strongly suggests humans were responsible for the observed taphonomic patterns at ca. 20,430 rcybp.

Quite different taphonomic situations are present at other excavated localities. The April Fools’ Mammoth died on a point bar consisting of small gravels, sand and silt. The mammoth apparently was exposed to the elements on the surface for a significant period because rib and tusk fragments exhibit dry bone fractures and the molars were separated from encasing bone. Subsequently, a flood moved these elements downstream and concentrated them over the end of the point bar deposit. The discovery of a single large tusk in fine-grained sediments is more difficult to explain. However, the fact that the tusk was salvaged from a cutbank indicates the remainder of the mammoth

may have been contained nearby in the terrace fill and not discovered, or had previously eroded away. The fact that archeologists from the Kansas State Historical Society thought the site was over 100,000 years and that there was no chance of human association probably also hastened the excavation, similar to their abandonment of the Lovewell Mammoth I excavation 10 years earlier.

There are currently two alternative explanations to account for the taphonomy of the Lovewell Mammoth II excavated in 1991–2004. First, the mammoth died near the headward cut of a shallow gully and the bones were subsequently fractured and flaked by humans. Continued headward cutting of the gully then redistributed the faunal elements a short distance down slope into the paleo-gully. Alternatively, the mammoth may have died, or was killed by humans, at or near the head of an already formed gully and the bones were purposely discarded into the gully after they were processed. In either case, the faunal elements have moved only a short distance in the gully based on orientation of the longer fragments and the lack of size sorting. Unfortunately, the original surface surrounding the paleo-gully has been removed by erosion, leaving only the base of the gully behind, and thus the evidence required to resolve these alternatives is not available.

Evidence of diagnostic breakage patterns and flake scars indicates that the Lovewell Mammoth II elements were fractured by hammerstone blows to the cortical surface. Most often the fractured elements consist of heavy, thick cortical limb bone. Impact fractures are identified by a diagnostic expanding cone of percussion. These percussion cones often exhibit step fractures and sometimes hinge fractures. Cone flakes produced around the point of impact are also present. Mammoth elements excavated during the 1991, 2002, and 2004 excavations exhibit this same pattern of breakage. After the cortical bone was impacted and spirally fractured, some pieces were flaked. Individual flakes and flake scars are present. However, in some cases a more complex pattern of multiple flake scars is present. A thick cortical bone biface was excavated in 2002 (Holen, 2006, Fig. 15) and a bone flake with five flake scars produced from two different directions was excavated in 2004. No hammerstones were found in association with the Lovewell II mammoth, only the evidence left by hammerstone blows including negative bulbs of percussion and bone flakes formed by percussion.

Modern studies of elephant bone taphonomy at single elephant kill and natural death sites in southern Africa has not documented this type of impact fracturing and bone flaking on single adult elephant skeletons (Crader, 1983; Haynes, 1991; Holen, 2006). These patterns of impact fractures and bone flaking are exactly like the patterns produced by Upper Paleolithic populations in central Europe and Siberia (Mochanov, 1977; Valoch, 1980, 1982), and by Clovis peoples at the end of the Pleistocene in North America (Holen, 2006; Morlan, 2003). Therefore, these breakage patterns observed on the Lovewell Mammoth II remains are interpreted as evidence of human

breakage and flaking of mammoth limb bone that occurred about 19,500 rcybp. Humans may have fractured the mammoth limb bone to acquire raw material for the production of bone tools like foreshafts and shaft wrenches, which are well known from Upper Paleolithic and Clovis sites.

Monitoring of the erosion along the north shoreline of Lovewell Reservoir continues and additional late Pleistocene fauna is collected on a yearly basis. Further excavation is planned at the Lovewell Mammoth Site if the reservoir is lowered enough to expose the lower part of the gully containing the Lovewell Mammoth II.

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### References

- Crader, D., 1983. Recent single-carcass bone scatters and the problem of "butchery" sites in the archaeological record. In: Clutton-Brock, J., Grigson, C. (Eds.), *Animals and Archaeology, Hunters and Their Prey*, vol. 1. BAR International Series no. 163, Oxford, pp. 107–141.
- Fenneman, N.M., 1931. *Physiography of Western United States*. McGraw-Hill, New York.
- Forman, S.L., Bettis III, E.A., Kemmis, T.L., Miller, B.B., 1992. Chronological evidence for multiple periods of loess deposition during the Pleistocene in Missouri and Mississippi River Valleys, United States—implications for the activity of the Laurentide Ice Sheet. *Paleogeography, Paleoclimatology, and Paleoecology* 93, 71–83.
- Haynes, G., 1983. Frequencies of spiral and green-bone fractures on ungulate limb bones in modern surface assemblages. *American Antiquity* 48, 102–114.
- Haynes, G., 1991. *Mammoths, Mastodons, and Elephants: Biology, Behavior and the Fossil Record*. Cambridge University Press, London.
- Holen, S.R., 1993. The Lovewell Mammoth: a late Wisconsinan man/mammoth association in north-central Kansas. Paper presented at the Flint Hills Conference, Wichita, Kansas.
- Holen, S.R., 1996. The Lovewell Mammoth: A late Wisconsinan site in north-central Kansas. *Current Research in the Pleistocene* 13, 69–70.
- Holen, S.R., 1997. The Lovewell Mammoth: A late Wisconsinan mammoth processing site in north-central Kansas. Nebraska Archaeological Survey Technical Report 97-01. University of Nebraska State Museum, Lincoln.
- Holen, S.R., 1998. The Eckles Site, 14JW4: A Clovis assemblage from Lovewell Reservoir, Jewell County, Kansas. Nebraska Archaeological Survey Technical Report 98-03. University of Nebraska State Museum, Lincoln.

- Holen, S.R., 2001. Clovis mobility and lithic procurement on the central Great Plains of North America. Ph.D. Dissertation, University of Kansas.
- Holen, S.R., 2005a. The 2002 excavation of the Lovewell Mammoth Site, 14JW306. Denver Museum of Nature & Science Technical Report 2005-03.
- Holen, S.R., 2005b. The age and taphonomy of mammoths at Lovewell Reservoir, Jewell County, Kansas, USA. In: Agenbroad, L.D., Symington, R.L. (Eds.), Short Papers and Abstracts, Second World of Elephants Congress, Hot Springs, South Dakota, pp. 67.
- Holen, S.R., 2006. Taphonomy of two last glacial maximum mammoth sites in the central Great Plains of North America: a preliminary report on La Sena and Lovewell. *Quaternary International* 142–143, 30–43.
- Holen, S.R., Talley, R.H., 2003. The April Fools' Mammoth Site (14JW101) Lovewell Reservoir, Jewell County, Kansas. Denver Museum of Nature & Science, Archaeological Series Technical Report 2002-03.
- Holen, S.R., Corner, R.G., Mandel, R.D., 1995. A late Farmdalian-Woodfordian fauna from Lovewell Reservoir, Jewell County, Kansas. *Current Research in the Pleistocene* 12, 98–99.
- Holen, S.R., Muniz, M.P., May, D.W., 2005. The 2004 excavation of the Lovewell Mammoth Site (14JW306), Lovewell Reservoir, Jewell County, Kansas. Denver Museum of Nature & Science, Technical Report 2005-09.
- Johnson, W.C., 1993. Surficial geology and stratigraphy of Phillips County, Kansas, with emphasis on the Quaternary Period. Kansas Geological Survey Technical Series 1.
- Kenyon, J.L., 1979. Investigation of mammoth tusk exposed by water erosion of banks of Lovewell Reservoir, Jewell County, Kansas. Report prepared by the Bureau of Reclamation, Lower Missouri Regional Office, for the Kansas State Historical Society.
- Laws, R.M., 1966. Age criteria for the African elephant *Loxodonta a. Africana*. *East African Wildlife Journal* 4, 1–37.
- Leonhardy, F.C. (Ed.), 1966. Domebo: A Paleo-Indian Mammoth Kill in the Prairie-Plains. Contributions of the Museum of the Great Plains I, Lawton, OK.
- Logan, B., Martin, L.D., Neas, J.F., 1991. Late Pleistocene *Hemiauchenia* from north central Kansas. *Current Research in the Pleistocene* 8, 97–99.
- Mandel, R.D., 2002. Geomorphology of the north shore of Lovewell Reservoir, north-central Kansas: implications for archaeological and paleontological research. Nebraska Archaeological Survey Technical Report 2002-01. University of Nebraska State Museum, University of Nebraska-Lincoln.
- Mandel, R.D., Bettis, III, E.A., 2001. Late Quaternary Landscape Evolution in the South Fork of the Big Nemaha River Valley, Southeastern Nebraska and Northeastern Kansas. Guidebook No. 11. Conservation and Survey Division, Institute of Agriculture and Natural Resources, University of Nebraska-Lincoln.
- May, D.W., Holen, S.R., 1993. Radiocarbon ages for soils and charcoal in late-Wisconsinan loess in south-central Nebraska. *Quaternary Research* 39, 55–58.
- May, D.W., Souders, V.L., 1988. Radiocarbon ages of the Gilman Canyon Formation in Dawson County, Nebraska. *Nebraska Academy of Sciences Proceedings*, pp. 47–48.
- Martin, C.W., 1993. Radiocarbon ages of late Pleistocene loess stratigraphy of Nebraska and Kansas, central Great Plains. *Quaternary Science Review* 12, 179–188.
- Merriam, D.F., 1963. The Geologic History of Kansas. Bulletin 162, State Geological Survey of Kansas, Lawrence.
- Mochanov, Y.A., 1977. Drevneishie Etapy Zaselennia Chelovekom Serevo-vostochnoi Azii (The earliest stages of human occupation of northeastern Asia). Nauka, Novosibirsk.
- Morlan, R.E., 2003. Current perspectives on the Pleistocene archaeology of eastern Beringia. *Quaternary Research* 60, 123–132.
- Schoewe, W.H., 1949. The geography of Kansas, pt. 2, physical geography. *Kansas Academy of Science Transactions* 52, 261–333.
- Valoch, K., 1980. Knochenartefakte aus dem Micoquien (Schicht 7C) in der Kulna-Höhle im Märischen Karst. *Acta Musei Moraviae* 65, 7–18.
- Valoch, K., 1982. Die Beingeräte von Predmosti in Mähren (Tschechoslowakei). *Anthropologie* 20, 57–69.
- Villa, P., 2005. Appendix A, Taphonomy of the Lovewell Mammoth Site. Denver Museum of Nature and Science, Technical Report 2003-05.