CLOVIS AND THE AMERICAN MASTODON AT BIG BONE LICK, KENTUCKY

Kenneth B. Tankersley, Michael R. Waters, and Thomas W. Stafford, Jr.

Contemporaneity of people and the American mastodon (Mammut americanum) at Big Bone Lick, Kentucky, has been extensively debated for more than two hundred years. Newly interpreted stratigraphic excavations and direct AMS 14C measurements on mastodon bones from Big Bone Lick, Kentucky, indicate that the megafauna are a palimpsest of fossils spanning at least 1,200 calendar years (11,020 ± 30 to 12,210 ± 35 RC yr B.P.). The radiocarbon evidence indicates that mastodonts and Clovis people overlapped in time; however, other than one fossil with a possible cut mark and Clovis artifacts that are physically associated with but dispersed within the bone-bearing deposits, there is no incontrovertible evidence that humans hunted Mammut americanum at the site.

La contemporaneidad de los seres humanos y el mastodonte americano (Mammut americanum) en Big Bone Lick, Kentucky, ha sido extensamente debatida por más de doscientos años. Tanto las excavaciones estratigráficas recién interpretadas como las determinaciones directas de AMS 14 C llevadas a cabo en los huesos de mastodonte procedentes de Big Bone Lick, Kentucky, indican que la megafauna es un palimpsesto de fósiles que abarcan por lo menos unos 1200 años civiles (11,020 ± 30 to 12,210 ± 35 RC años a.p.). A la vez, las pruebas de radiocarbono indican que los mastodontes y la gente Clovis traslaparon en el tiempo. Sin embargo, aparte de un solo fósil de colocación problemática y los artefactos Clovis físicamente asociados pero dispersados dentro de las capas que contienen restos óseos, no hay evidencias incontrovertibles que los seres humanos cazaban a los Mammut americanum en el sitio.

Big Bone Lick, often referred to as the birthplace of American paleontology, is located less than 2 km from the Ohio River in Boone County, Kentucky. It is one of the largest and most reliable salt springs in eastern North America where brine discharges to the surface near the confluence of Big Bone Lick Creek and Gum Branch under hydrostatic pressure through fault planes and bedrock fractures in the limestone and shale of the Ordovician-age Cincinnatian Series (Stout et al. 1932:15; Tankersley 1985; Figure 1). During the late Pleistocene, saline springs and the surrounding salt licks attracted a faunal community including Botherium bombifrons (Helmeted Musk Ox or Harlan’s Musk Ox), Bison antiquus (Late Pleistocene Bison), Cervalces scotti (Stag Moose), Equus complicatus (Complex-tooth Horse), Paramylodon harlani (Harlan’s Ground Sloth), Mammutus sp. (Mammoth), Megalonyx jeffersonii (Jefferson’s Ground Sloth), Rangifer tarandus (Caribou), Mammut americanum (the American mastodon), and the people who hunted and scavenged them (Tankersley 1985, 1986, 1987, 1992a).

In this paper we first present a brief overview of the discovery and investigations of Big Bone Lick. This is followed by a summary of the University of Cincinnati’s 1981 investigations and a discussion of new radiocarbon dates for the site.

Historical Background

The mastodon remains and salt springs at Big Bone Lick had been known and used for centuries by native peoples of the Ohio valley. Europeans first saw the site in 1729 (Jillson 1936). Following this,

Kenneth B. Tankersley ▪ Department of Anthropology, University of Cincinnati, OH 45221 (tankerkh@uc.edu)
Michael R. Waters ▪ Center for the Study of the First Americans, Departments of Anthropology and Geography, Texas A&M University, College Station, TX 77843-4352 (mwaters@tamu.edu)
Thomas W. Stafford, Jr. ▪ Stafford Research Laboratories, 200 Acadia Avenue, Lafayette, CO 80026 (twstafford@stafford-research.com)

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Big Bone Lick was periodically visited through the mid-eighteenth century. In 1765 the American Philosophical Society sponsored the first structured excavations.

A year later, a second excavation was conducted on behalf of Benjamin Franklin and Lord Shelborn of London, England, which resulted in the collection of a substantial number of mastodon fossils. After a detailed examination of the specimens, Franklin and Shelborn presented the first paleontological report on the site to the Royal Society of London in 1767. They concluded that an extinct elephant-like creature lived at a time when the climate was different from the present and that this creature was extinct before the arrival of the Shawnee (Jillson 1936). Celebrated anatomist William Hunter (1768) disagreed with Franklin and Shelborn, and believed that it was much more likely that the Shawnee hunted the mastodon into extinction (Peale 1802).

Thomas Jefferson also believed that indigenous people hunted mastodons based on Algonquian oral history, which describes how their ancestors hunted and killed mastodons at Big Bone Lick (Jefferson 1801). In 1795, Jefferson instructed William Henry Harrison to go to Big Bone Lick and collect an assemblage of mastodon bones. Harrison went to the site and conducted a massive excavation of the ground around the salt springs. In 1797, Jefferson sent some of the mastodon fossils to Georges Dagobert Cuvier for examination (Adams 1879). Cuvier (1796, 1800, 1806a, 1806b) used the fossils as evidence of past catastrophic climatic change.

Between 1803 and 1806, William Goforth, a medical doctor from Cincinnati, collected more than five metric tons of fossils at the site for Benjamin Franklin and the American Philosophical Society. Goforth described the stratigraphic context, stating that the mastodon bones occurred on the surface of a gravel layer at a depth of 11 feet, below layers of blue clay containing bones of smaller, more-modern animals such as deer, elk, bison, and bear. Goforth also argued that the
tons of mastodon bones, including 22 tusks, were collected and dispersed to universities, museums, and scientific institutions in New England and Great Britain (Cooper et al. 1831). In 1841, Charles Lyell (1845), the father of modern geology, examined the Quaternary deposits of Big Bone Lick and placed them into the newly defined Pleistocene and Recent Epochs. Excavations continued at Big Bone Lick after the American Civil War, but by then the mastodon-bearing deposits had been greatly depleted by nearly a century and a half of intensive excavation. In 1898, however, a local artifact collector found a fluted biface in possible association with mastodon remains (Figure 2f).

Little work occurred at Big Bone Lick during the twentieth century. Around 1930, another Clovis fluted biface was found eroding from the late Pleistocene deposits (Figure 2c). Thirty years later, C. Bertrand Schultz became intrigued by the discovery of artifacts in physical association with mastodon remains at Big Bone Lick. Motivated by this interest, Schultz headed an interdisciplinary team conducting excavations at the site from 1962 to 1966 with the goal of understanding the association between humans and mastodons. They exposed the remains of numerous mastodons as well as a Clovis fluted biface (Figure 2a). A radiocarbon date of 10,600 ± 259 RC yr B.P. (W-1358), calibrated to 12,160 – 12,840 cal yr B.P., was obtained from a sample of wood excavated in close proximity to a mastodon tusk in gray, silty clay (Levin et al. 1965:374). A second radiocarbon date of < 200 RC yr B.P. (W-1357) was obtained from the same stratum as the Clovis-age sample. Given that the mastodon bones could not be reliably dated in the 1960s and a more recent radiocarbon date and artifact were obtained from the same stratum, contemporaneity between mastodon and Clovis artifacts at the site remained ambiguous. Little work was pursued at the site after this time.

The 1981 Investigations

In 1981, Tankersley, working under the auspices of the University of Cincinnati, conducted a geoarchaeological survey of Big Bone Lick to locate strata that contained both mastodon remains and Clovis artifacts. Fieldwork included hand excavation of eight 1-m² units (Figure 3, locations H, M, N, R, T, U, V, and W) in terrace and floodplain
cut-bank exposures along Big Bone Lick Creek and Gum Branch (Figure 3). Sediments were removed in 1 cm levels and water screened through .64 and .25 mm mesh screens to recover artifacts and vertebrate fossils for radiocarbon assays. Additionally, 15 columns of sediment approximately 3 to 10 m long were extracted using a portable 6 cm diameter split-spoon drill rig (Figure 3, locations A, B, C, D, E, F, G, I, J, K, L, O, P, Q, and S). These data were used to define the late Quaternary stratigraphy of the Big Bone Lick area. The location of diagnostic artifacts and fossil bone, along with radiocarbon dates help to provide chronological control (Tankersley 1985, 1987, 1992a).

Quaternary Stratigraphy

Four late Quaternary geomorphic surfaces were mapped along Big Bone Creek (Figure 1). There is a high-level fluvial deposit, two late Pleistocene terraces (T–2 and T–1), and a Holocene floodplain (Figure 4:T–0). Similar geomorphic surfaces are found in the neighboring drainage basins that are tributaries to the glaciated Ohio River Valley (Gray 1984; Tankersley et al. 1983). The sediments associated with these surfaces were separated into four units that are labeled 1, 2, 3, and 4, from oldest to youngest. These sediments are lithologically similar and are sometimes difficult to distinguish (c.f. Swadley 1969).
Pre-late glacial fluvial deposits (Unit 1) occur on ridge tops at elevations > 200 m above sea level (Potter 2007). These deposits are up to seven meters thick and composed of deeply weathered, yellowish brown clayey silt and sand with abundant rounded to subangular pebbles and cobbles of chert, quartz, and limonitic concretions. There are no chronometric dates from these sediments and faunal remains are absent.

Terrace 2 (Figure 4:T-2) lies approximately 152-m above sea level. The sediments underlying T-2 vary from one to four meters thick and are composed of light gray to brownish gray clay, clayey silt, and gravelly clay (Unit 2). Within these sediments are heavily mineralized, black to gray, disarticulated bones of *Bootherium bombifrons* (Helmeted Musk Ox or Harlan’s Musk Ox), *Equus complicatus* (Complex-tooth Horse), and *Mammuthus* sp. (Mammoth). A fragment of wood from this unit yielded a radiocarbon date of 17,200 ± 600 RC yr B.P. (W-1617; Table 1). The fine-grained sediments of Unit 2 were deposited within a lacustrine environment when outwash filled the adjacent Ohio River Valley and dammed tributary drainages such as Big Bone Creek (Goldthwait 1959; Tankersley et al. 1983). At that time the tributary valleys became large lakes. The lake filling the Big Bone Valley was later drained and the creek downcut created T-2.

Terrace 1 (Figure 4:T-1) lies 146 m above sea level. It is underlain by a weathered yellowish gray to yellowish brown clayey gravel, silty gravel, and silty clay (Unit 3) deposited by alluvial processes. Disarticulated remains of *Bison antiquus* (Bison), *Rangifer tarandus* (Caribou), and *Mammuthus americanum* (Mastodon) occur within the basal gravels of this unit. In most places, Unit 2 rests unconformably on Unit 3, which extends beneath the T-1 terrace (Figure 5).

Mastodon fossils in Unit 3 occur in three conditions—pristine, broken, and abraded. Mastodon fossils and Clovis artifacts were found together in Unit 3. Both the artifacts and mastodon bones were found at the contact between Units 3 and 2 (Figure 5). Radiocarbon dates on wood and bone from the base of Unit 3 range from 10,600 ± 250 RC yr B.P. (W-1358) to 12,210 ± 35 RC yr B.P. (UCIAMS-35591) (Table 1).

Besides the previously recovered Clovis artifacts from Big Bone Lick, the testing in 1981 recovered two additional Clovis artifacts in the same stratum as mastodon fossils. A heavily patinated
retouch flake was found in direct association with mastodon bone locality H, and a Clovis blade tool was found exposed in a nearby cut-bank locality M (Figure 6). More specifically, it is a spurred end scraper manufactured on the distal end of a retouched blade displaying a well-defined blade facet and proximal hinge break. The blade was struck from a prepared polyhedral core manufactured from Fort Payne chert, which outcrops almost 400 km southwest of Big Bone Lick.

Blade tools are an important and distinctive trait of the Clovis technological complex. They were first identified at the Clovis type site, Blackwater Draw, New Mexico. Since their initial discovery, blade tools have been found on Clovis sites across North America including the Aubrey, Kevin-Davis,
and Kincade Rockshelter sites in Texas, the Bostrom site in Illinois, the Busse cache and Sailor-Helton site in Kansas, the Domebo site in Oklahoma, the Cactus Hill and Williamson sites in Virginia, the Fenn cache in Wyoming, the Little River site complex in Kentucky, the Murray Springs site in Arizona, and the Wells Creek Crater and Carson-Conn Short sites in Tennessee (Tankersley 2004:55).

The modern floodplain (Figure 4:T–0) lies 143.5 to 144.0 m above sea level. The sediments underlying the floodplain are composed of four to eight meters of light brown to dark gray colored, poorly sorted, silty sand, clayey silt, sandy silt, and gravel (Unit 4). The gravels at the base of the floodplain contain the disarticulated remains of Bison bison (Modern Bison), Cervus canadensis (Elk), and Odocoileus virginianus (White-tailed Deer), and are especially abundant in the silty sand within the gravel. Radiocarbon dates from Unit 4 range from Modern to 530 ± 120 RC yr B.P. (UGa-4291; Table 1).

Geochronology

The radiocarbon technique has been used since 1965 to date the fauna and artifacts found at Big Bone Lick. Radiocarbon dating at Big Bone Lick was performed in three phases. The first series of dates were conventional, β-decay radiocarbon measurements made between 1965 and 1981 (Table 1). This work established that the stratigraphy extended from Modern to at least 17,200 ± 200 RC yr B.P. (W-1617), and that there was a physical association between mastodon remains and Clovis artifacts. It also suggested that there was significant physical mixing of recent and late Pleistocene fossils and sediments (Levin et al. 1965, 1967; Tankersley 1986, 1987, 1992a, 1992b).

Accelerator Mass Spectrometry (AMS) 14C dating enables smaller and chemically pure samples to be dated. During the second phase of testing in 1981, samples of bone, teeth, and ivory were submitted to the Oxford University Laboratory, in England for dating. These fossils could not be dated, however, because the specimens contained insufficient collagen for analysis. These fossils were from Unit 3 in excavation area H. At that time, it was concluded that digenesis destroyed the majority of the collagen, that the samples were probably significantly older than terminal Pleistocene, and that permeable sediments enabled collagen to be leached.

In 2007, the third phase of testing consisted of a second attempt to date the faunal remains and evaluate the potential Clovis-mastodon association. Three mastodon fossils collected in 1981 were selected for AMS dating because the specimens were in stratigraphic association with Clovis artifacts or Clovis-age sediments. The three specimens were excavated from a silty clay with gravel horizon of Unit 3 that was < 30 cm thick, within a one-by-one meter unit at locality H. Interestingly, a foot bone, possibly a pedal proximal phalanx, SR-7180, had a sharp curvilinear cut on the lateral ventral surface resembling a human-mediated cut mark. The cut is 3 mm in width and 1.6 cm in length and is not a vascular groove or other kind of natural feature. The width of the cut is comparable in size to a chert flake edge, and the curvature and location are consistent with a pattern of butchering.

Chemical preparation and AMS dating followed procedures described in Stafford et al. (1991) and Waters and Stafford (2007). Data for the chemical pretreatment and dating results are summarized in Table 1. These bones yielded ages of 11,020 ± 30
Table 1. Radiocarbon Measurements from Wood and Bone, Big Bone Lick, Kentucky.

<table>
<thead>
<tr>
<th>Sample &amp; Taxon</th>
<th>Unit</th>
<th>14C Age, Yr Bp, Cal Bp</th>
<th>Calibrated Age, 2σ (95.4%) (Oxcal 4.0)</th>
<th>Radiocarbon and Lab Numbers</th>
<th>14C Dating Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wood</td>
<td>1</td>
<td>&lt; 200</td>
<td>N/A</td>
<td>W-1357</td>
<td>°-Decay Counting</td>
</tr>
<tr>
<td>Unidentified</td>
<td>1</td>
<td>&lt; 250</td>
<td>N/A</td>
<td>W-908</td>
<td>°-Decay Counting</td>
</tr>
<tr>
<td>Bone Collagen Bison bison Wood</td>
<td>2</td>
<td>530 ± 105</td>
<td>680-314</td>
<td>UGa-4291</td>
<td>°-Decay Counting</td>
</tr>
<tr>
<td>Unidentified Bone Collagen Mammut americanum</td>
<td>2</td>
<td>10,600 ± 250</td>
<td>13,069-11,714</td>
<td>W-1358</td>
<td>°-Decay Counting</td>
</tr>
<tr>
<td>Bone Collagen Mammut americanum</td>
<td>2</td>
<td>11,020 ± 30</td>
<td>13,039-12,880</td>
<td>UCIAMS-35590 SR-7180</td>
<td>AMS</td>
</tr>
<tr>
<td>Bone Collagen Mammut americanum</td>
<td>2</td>
<td>12,210±35</td>
<td>14,179-13,961</td>
<td>UCIAMS-35591 SR-7181</td>
<td>AMS</td>
</tr>
<tr>
<td>Bone Collagen Mammut americanum</td>
<td>2</td>
<td>11,700 ± 35</td>
<td>13,676-13,428</td>
<td>UCIAMS-35592 SR-7182</td>
<td>AMS</td>
</tr>
<tr>
<td>Wood Picea sp.</td>
<td>3</td>
<td>17,200 ± 600</td>
<td>22,086-19,311</td>
<td>W-1617</td>
<td>°-Decay Counting</td>
</tr>
</tbody>
</table>

Abbreviations:
AMS = Accelerator Mass Spectrometry Direct 14C Counting
M = University of Michigan Radiocarbon Laboratory
SR = Stafford Research Laboratories
UCIAMS = University of California-Irvine Accelerator Mass Spectrometry Laboratory
UGa = University of Georgia Radiocarbon Laboratory
W = University of Wisconsin-Madison radiocarbon Laboratory

RC yr B.P. (UCIAMS-35590), 11,700 ± 35 RC yr B.P. (UCIAMS-35592) and 12,210 ± 35 RC yr B.P. (UCIAMS-35591) (Table 1). Despite their close vertical and horizontal proximity, these ages differ by 1190 14C years (1300 calendar years). Collagen content and preservation varies significantly and both decrease with increasing geologic age. The weight percentage of decalcified collagen varied from 13.7 to 1.2 percent, compared to values of 20 to 21 percent for modern bone, and the physical preservation (collagen pseudomorph) changed from 96 to 50 percent for the youngest and oldest mastodon bones. While the two best-preserved fossils had Carbon/Nitrogen (C/N) values in the range of modern decalcified collagen (2.9 to 3.6), the oldest specimen, SR-7181, had a C/N = 3.85, which is an indication that collagen degradation (deamination) has occurred. The low (1.2 percent) collagen yield and increased C/N values for SR-7181 are indications that collagen degradation is occurring for specimens older than 12,000 RC yr (Table 2).

Conclusions

Direct evidence that Clovis people hunted mastodons is demonstrated by the mastodon kill site at Kimmswick, Missouri (Graham et al. 1981; Graham and Kay 1988; Tankersley 1998). Here Clovis projectile points are unequivocally associated with mastodon remains. A less secure association between Clovis artifacts and mastodon, which may nevertheless represent mastodon hunting, occurs at the Hiscock site, New York. Here, Clovis-age mastodon bones have been directly dated to 10,790 ± 70 RC yr B.P. (CAMS-27143), 10,850 ± 140 RC yr B.P. (NZA-1106), 10,990 ± 100 RC yr B.P. (TO-3194), 11,070 ± 70 RC yr B.P. (UCAMS-30529), and 11,100 ± 80 RC yr B.P. (CAMS-30528) (Fisher 1988, Laub et al. 1988,
Table 2. Mastodon Bone Collagen Composition, Big Bone Lick, Kentucky.

<table>
<thead>
<tr>
<th>Radiocarbon Lab Numbers</th>
<th>Wt% Yield Decalcified Collagen</th>
<th>Collagen Pseudomorph</th>
<th>Gelatin Pseudomorph</th>
<th>δ13C%o (Vpdm)</th>
<th>δ15N%o (Air)</th>
<th>C/N</th>
</tr>
</thead>
<tbody>
<tr>
<td>UCIAMS-35591 SR-7181</td>
<td>1.2</td>
<td>50</td>
<td>80</td>
<td>-21.90</td>
<td>7.50</td>
<td>3.85</td>
</tr>
<tr>
<td>UCIAMS-35592 SR-7182</td>
<td>7.1</td>
<td>85</td>
<td>90</td>
<td>-21.13</td>
<td>6.36</td>
<td>3.25</td>
</tr>
</tbody>
</table>

Abbreviations:
UCIAMS = University of California-Irvine Accelerator Mass Spectrometry Laboratory
SR = Stafford Research Laboratories

Tankersley et al. 1998). Clovis artifacts have been found at the site and these dates overlap at one-sigma with the current, revised age range of Clovis (11,050 to 10,800 RC yr B.P.; Waters and Stafford 2007).

At Big Bone Lick, Clovis artifacts clearly lie in direct physical association with mastodon bones. However, these artifacts are rare and appear to lie in a secondary context among a palimpsest of mastodon bone. One AMS radiocarbon date, 11,020 ± 30 14C yr B.P. (UCIAMS-35590), obtained on purified collagen from a well-preserved mastodon phalanx that did not exhibit any abrasions but displayed a possible cut mark, clearly overlaps with the current, revised age range of Clovis (Waters and Stafford 2007). The information from Hiscock and Big Bone Lick shows that Clovis peoples and the American mastodons were contemporaneous during the late Allerød and before the start of the Younger Dryas. At present, however, there is no direct evidence that these animals were hunted, killed, or scavenged by Clovis peoples at Big Bone Lick. Consequently, Kimmswick still provides the only unequivocal evidence of a Clovis-Mastodon interaction.

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