



Supporting Online Material for

**Redefining the Age of Clovis:  
Implications for the Peopling of the Americas**

Michael R. Waters\* and Thomas W. Stafford Jr.

\*To whom correspondence should be addressed. E-mail: [mwaters@tamu.edu](mailto:mwaters@tamu.edu)

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Redefining the Age of Clovis: Implications for the Peopling of the Americas

Michael R. Waters<sup>\*</sup>, Thomas W. Stafford, Jr.

<sup>\*</sup>To whom correspondence should be addressed. E-mail: [mwaters@tamu.edu](mailto:mwaters@tamu.edu)

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## Materials and Methods

*Chemical protocols for dating bone, antler, and ivory.* AMS  $^{14}\text{C}$  chemistry followed Stafford (S1, S2) with the following modifications. Bone, ivory or tooth dentine were physically cleaned by removing the outer 1 to 3 mm of cortex, followed by washing in acetone and methanol and drying under vacuum. Bones were broken into approximately 5-10 mm fragments and decalcified in  $4^{\circ}\text{C}$ , 0.5N HCl over 3 to 5 days; after washing in DI water, the decalcified collagen was extracted with 0.1% KOH at  $4^{\circ}\text{C}$  for 24 hours, then washed to neutrality with DI water. The KOH-extracted, decalcified collagen's percent pseudomorph was recorded, and then freeze dried to determine percent yield of collagen relative to modern bone. Approximately 20-50 mg of decalcified, KOH-extracted collagen were heated at  $110^{\circ}\text{C}$  in 0.02N HCl to dissolve (gelatinize) the collagen. Heating continued only until the collagen dissolved, usually 5 to 30 minutes. After filtering the gelatin solution through  $0.45\ \mu\text{m}$  Millex Durapore filters, the solution was freeze-dried and a percent gelatinization and yield were determined. Approximately 20-25 mg of gelatin were hydrolyzed 22 hours at  $110^{\circ}\text{C}$  in 6N HCl. The hydrolyzate, which contained free amino acids, fulvic acids, and insoluble inorganic and organic detritus was passed through a 2 cm long X 5 mm diameter bed of XAD-2 resin in a solid phase extraction (SPE) column attached to a  $0.45\ \mu\text{m}$  Millex filter. The XAD column contained 100-200  $\mu\text{m}$  diameter research grade XAD-2, from Serva Biochemicals (Cat. No. 42825). The bulk resin was wetted by using acetone and washed voluminously with DI water and finally multiple washes with 1N HCl (distilled). Individual SPE columns were packed with the XAD-2 as slurry of resin and HCl. Each column was equilibrated with 50 ml of distilled 6N HCl and the washings discarded. The collagen hydrolyzate as approximately 1 to 5 ml of HCl was pipetted onto the SPE XAD column and eluted into a glass tube. Following the initial sample aliquot, the column was washed with 10 ml of 6N HCl that was added to the original eluate.

The XAD-purified collagen hydrolyzate was dried by passing UHP  $\text{N}_2$  gas over the glass tube heated to  $50^{\circ}\text{C}$ . The dried amino acids were a viscous syrup. The dry hydrolyzate was diluted with DI water and approximately 8-10 mg of amino acids were transferred to 4 mm ID X 20 mm long quartz tubes and dried under vacuum. Approximately 200-300 mg of purified CuO wire and 20 mg Ag were added to each quartz tube. Stock CuO wire (Fisher Scientific, Cat. No. C474-500) was first combusted in crucibles at  $900^{\circ}\text{C}$  and stored in Pyrex tubes that were subsequently combusted at  $570^{\circ}\text{C}$  immediately before each use. Aesar 99.9995%, 30-60 mesh silver powder was used without additional purification. All glass pipettes, beakers, and tubes were combusted at  $550^{\circ}\text{C}$  before use. After evacuation to  $< 20$  millitorr by vacuum pumping through a LN trap, the tubes were sealed with a  $\text{H}_2/\text{O}_2$  torch. The tubes were combusted at  $850^{\circ}\text{C}$  for 2 hours and cooled from  $850^{\circ}\text{C}$  to  $150^{\circ}\text{C}$  at  $30^{\circ}\text{C}$  per hour. Following purification of the combustion products to remove water and  $\text{N}_2$ , approximately 1 milligram of carbon as  $\text{CO}_2$  was converted into graphite by the Fe- $\text{H}_2$  method (Stafford, *et al.*, 1991). Contemporary  $^{14}\text{C}$  standards included Oxalic Acid-I and ANU sucrose. Respective chemistry and combustion backgrounds were determined by using  $> 70\text{ka}$  collagen isolated from the fossil *Eschritus* (Whale) bone (S2,S3) and Sigma Chemical Co alanine (Sigma A-7627). Graphite targets were analyzed at the Keck Carbon Cycle AMS Facility, Earth System Science Department, University of California-Irvine.

**Text**

The radiocarbon records for Clovis and Clovis-age sites are discussed below. The numbers associated with specific sites correspond to those on table S1.

1. Lange-Ferguson, South Dakota: Five radiocarbon ages were obtained from the Lange-Ferguson site in South Dakota. Two of these ages are disregarded because they were derived from unspecified organic material and unpurified mammoth bone collagen (*S4*), chemical fractions that are known to produce erroneous ages. Furthermore, the two dates have large standard deviations. Charcoal from the Clovis horizon (AA-905) (*S5*) and new ages on XAD-purified collagen (UCIAMS-11344 and 11345) are used to calculate an average date of  $11,080 \pm 40$   $^{14}\text{C}$  yr B.P. for this site.

2. Sloth Hole, Florida: One radiocarbon age on XAD-purified collagen from an ivory foreshaft was obtained from the Clovis layer at Sloth Hole, Florida (*S6*). This date, with the caveat that only one date was obtained for this horizon, appears to provide an accurate date for this site.

3. Anzick, Montana: The Anzick site in Montana is reported to be a Clovis burial and cache. At Anzick, 12 radiocarbon dates were obtained from the cranial elements of a purported Clovis infant skeleton and 2 dates on associated bone foreshafts. Collagen extracted from the foreshafts yielded an average age of  $11,040 \pm 35$   $^{14}\text{C}$  yr B.P. (*S7*). The human skeletal remains were dated during three separate research programs. The first batch of seven dates on bone comprise five chemical fractions that were considered reliable and averaged to  $10,680 \pm 50$   $^{14}\text{C}$  yr B.P. (*S2*). Later, a single purified collagen sample yielded a date of  $11,550 \pm 60$   $^{14}\text{C}$  yr B.P. (CAMS-35912). This measurement is rejected because subsequent dating of the same XAD fraction and preceding fractions from newly sampled bone did not replicate the  $11,550$   $^{14}\text{C}$  yr B.P. result. The source of the contaminating  $^{14}\text{C}$ -depleted carbon is unknown. A more recent series of dates from a single cranial fragment provided four new radiocarbon ages. These fractions confirm previous date estimates for the skeleton of  $10,705 \pm 35$   $^{14}\text{C}$  yr B.P. The  $^{14}\text{C}$  dates on the skeleton versus the dates on the bone foreshafts suggest that the skeletal remains and Clovis artifacts may not be related and that the foreshaft ages more accurately date the site. The 10,700 year old human remains could post-date the Clovis cache, but additional research is needed to resolve this issue. A more recent, late Paleoindian or early Archaic human skeleton was also found at the site (*S7*). The association of any of the human remains with the Clovis cache is problematic because the site had been excavated accidentally with heavy machinery before the human bones and artifacts were recognized and later recovered at some distance from the actual site. Thus, the directly dated Clovis artifacts—the foreshafts—appear to accurately date the site.

4. Dent, Colorado: Nine radiocarbon ages were obtained from the Dent site, Colorado. One date (I-622) is disregarded in the calculation of the age of this site because it was derived from unpurified mammoth bone collagen (known to produce questionable ages) and it has a large standard deviation (*S8*). Six dates, which average  $10,750 \pm 40$   $^{14}\text{C}$  yr B.P., were obtained on purified mammoth bone collagen (*S2*). Two additional dates (UCIAMS-11339 and -11340) were obtained on XAD-purified mammoth bone collagen to test the earlier results and improve the standard deviation of the previous ages. These new dates average  $10,990 \pm 25$  yr  $^{14}\text{C}$  yr B.P.

5. Paleo Crossing, Ohio: At the Paleo Crossing site, Ohio, ten radiocarbon dates were obtained from the horizon containing Clovis artifacts (*S9*). The initial dates for the site provided conflicting results. Careful analysis of the context of the dates revealed that the older ages were derived from the underlying deposits. Three dates that average  $10,980 \pm 75$  yr  $^{14}\text{C}$  yr B.P. from charcoal derived from post molds provided the most reliable date for the site.
6. Domebo, Oklahoma: Domebo, Oklahoma, is a mammoth kill site with associated Clovis projectile points within a well defined stratigraphic sequence. Numerous radiocarbon ages were obtained from the Domebo site, Oklahoma; however, most of the radiocarbon dates are on materials either above or below the Clovis horizon (*S3, S10, S11, S12*). Only four dated samples came directly from the Clovis artifact bearing unit. Three dates on purified mammoth bone collagen were obtained (*S2*) and averaged  $11,040 \pm 255$   $^{14}\text{C}$  yr B.P. This is considered a reliable date for the site, but the date has a very large standard deviation. Consequently, we redated additional Domebo bone and obtained a new date of  $10,960 \pm 30$   $^{14}\text{C}$  yr B.P. (UCIAMS-11341). This sample yielded a similar date mean, but a much reduced standard deviation that agrees well with dates generated from overlying tree stumps. The final  $^{14}\text{C}$  date is considered an accurate date for the Domebo site.
7. Lehner, Arizona: The age of the Clovis kill at Lehner, Arizona, has been placed at  $10,950 \pm 40$   $^{14}\text{C}$  yr B.P. based on the average of twelve radiocarbon dates on charcoal; they provide accurate dating of the Clovis component (*S5*).
8. Shawnee-Minisink, Pennsylvania: At Shawnee-Minisink, Pennsylvania, nine radiocarbon ages were obtained for the Clovis horizon. Four older ages are rejected (*S13*) in favor of five recently obtained dates. The rejected ages yielded widely scattered results with large standard deviations that are of limited utility in establishing the age of this site. Five samples of carbonized Hawthorn (*Crataegus*) seeds (*S14, S15*) were obtained from Clovis hearths and date the Clovis horizon to  $10,935 \pm 15$   $^{14}\text{C}$  yr B.P.
9. Murray Springs, Arizona: At Murray Springs, Arizona, eight radiocarbon dates on charcoal provide accurate dating of the Clovis component to  $10,885 \pm 50$  yr  $^{14}\text{C}$  yr B.P. (*S5*).
10. Colby, Wyoming: At Colby, Wyoming, five radiocarbon dates were obtained. Two dates on unpurified mammoth bone collagen (RL-392 and SMU-278) and on mammoth bone apatite (SMU-254) are disregarded (*S16*). These  $^{14}\text{C}$  dates have large standard deviations and are on chemical fractions known to produce unreliable ages. Two new dates (UCIAMS-11342 and 11343) were obtained from XAD-purified collagen obtained from mammoth bone associated with bone pile 2. These ages provide a credible average date of  $10,870 \pm 20$   $^{14}\text{C}$  yr B.P. for the Clovis activity.
11. Jake Bluff, Oklahoma: Three radiocarbon dates were obtained from the Clovis bison kill area at Jake Bluff, Oklahoma (*S17*). These are all on XAD-purified bison bone collagen. All have yielded consistent dates and are used to estimate the date of Clovis activity at this site as  $10,765 \pm 25$   $^{14}\text{C}$  yr B.P.

12. East Wenatchee, Washington: The East Wenatchee Clovis Cache, Washington, provides pertinent chronological information. At this site, traces of Glacier Peak Ash, Layer G occurred on the undersides of Clovis artifacts (S18). This ash has been dated to  $11,125 \pm 130$   $^{14}\text{C}$  yr B.P. (Beta-4951) (S19) and provides a maximum limiting date for Clovis at this site.

13. Indian Creek, Montana: At Indian Creek, Montana, a single radiocarbon date on charcoal of  $10,980 \pm 110$   $^{14}\text{C}$  yr B.P. was obtained from the earliest component with Clovis-like artifacts (S19). These artifacts overlie the Glacier Peak Ash (Layer G). Charcoal associated with the ash dated to  $11,125 \pm 130$   $^{14}\text{C}$  yr B.P. (Beta-4951) at the site. Folsom artifacts with younger  $^{14}\text{C}$  dates overlie the early horizon.

14. Lubbock Lake, Texas: At the Lubbock Lake site, Texas, two radiocarbon ages were reported from the possible Clovis horizon (S20). No diagnostic Clovis artifacts have been obtained *in situ* from this component of the site, but the excavators believe that cut marks and other modification of mammoth bone provide evidence for the presence of Clovis peoples. Two wood samples from the mammoth bone horizon (SMU-548 and -263) provide credible ages for this possible Clovis surface and average to  $11,100 \pm 60$   $^{14}\text{C}$  yr B.P.

15. Bonneville Estates, Nevada: A number of early hearths have been excavated in stratum 18b at Bonneville Estates Rockshelter, Nevada (S21). The oldest hearth has been dated to  $11,010 \pm 40$   $^{14}\text{C}$  yr B.P. (Beta-207009). Flaking debris, but no diagnostic artifacts, are associated with this hearth.

16. Kanorado, Kansas: Three radiocarbon dates on XAD-purified bone collagen were obtained from a reported Clovis horizon (no diagnostic artifacts were recovered) at the Kanorado site, Kansas (S22). One of these  $^{14}\text{C}$  dates is rejected as too young by the excavators (S22) and had a very large standard deviation. Averaging the remaining two dates provides a date of  $10,980 \pm 40$   $^{14}\text{C}$  yr B.P. for this component.

17. Arlington Springs, California: XAD-purified bone collagen from human remains from Arlington Springs, California, on Santa Rosa Island yielded a date of  $10,960 \pm 80$   $^{14}\text{C}$  yr B.P. (S23). This is considered to be an accurate age for the skeleton. A date of  $11,490 \pm 70$   $^{14}\text{C}$  yr B.P. (CAMS-17125) was obtained on XAD-purified collagen extracted from a bone of an extinct deer mouse (*Peromyscus nesodytes*) bone from the stratigraphic unit underlying the skeleton (S23).

18. Sheriden Cave, Ohio: At Sheriden Cave, Ohio, several bone points, a scraper, and a Clovis projectile point were recovered with the remains of late Pleistocene fauna. At this site, thirty radiocarbon dates were obtained on charcoal and bone collagen from the deposits (S24). Most of these dates are from underlying and overlying deposits and bracket the artifacts. The most reliable dates are those from an extensive charcoal lense that immediately underlies the artifacts within the shelter. Two dates from this unit average  $10,920 \pm 50$   $^{14}\text{C}$  yr B.P.

19. Blackwater Draw, New Mexico: At Blackwater Draw, New Mexico, five radiocarbon dates were reported from the Clovis horizon (S25, S26). Two ages on humates (AA-1360 and

SMU-1880) are minimum ages and do not provide an accurate age of the Clovis activity. The other three ages were obtained on carbonized plant remains and have large standard deviations. These three dates yielded an average of  $11,300 \pm 235$   $^{14}\text{C}$  yr B.P. This large standard deviation does not provide comparable chronological control.

20. Cactus Hill, Virginia: One radiocarbon age on charcoal was obtained from the Clovis layer at Cactus Hill, Virginia (S27). This date appears to provide a reliable date for this site; however this age provides limited chronological information because of its large standard deviation.

21. Wally's Beach, Canada: At Wally's Beach, Canada, four radiocarbon dates have been obtained on bone collagen from bison, horse, musk oxen, and caribou (S28, S29). These dates range from  $11,350 \pm 80$   $^{14}\text{C}$  yr B.P. (TO-8972) to  $10,980 \pm 80$   $^{14}\text{C}$  yr B.P. (TO-7691). While this site provides evidence for the butchering of horse it is unclear which, if any of the dates, related to the butchered remains. Finally, the association of Clovis artifacts with the butchered horse remains is unclear.

22. Union Pacific, Wyoming: At the Union Pacific site, Wyoming, mammoth remains are thought to be associated with Clovis artifacts; however, the mammoth-Clovis association has not been conclusively demonstrated (S30). Unpurified ivory collagen yielded a date of  $11,280 \pm 350$   $^{14}\text{C}$  yr B.P. (I-449) (S5). This date has limited use because of the questionable Clovis association with the mammoth, the likely contamination of this sample with humic acids, and its large standard deviation.

23. Aubrey, Texas: Two dates on charcoal, averaging  $11,570 \pm 70$   $^{14}\text{C}$  yr B.P., were obtained from the Clovis occupation surface at the Aubrey site, Texas (S31). The charcoal used to obtain these ages did not come from an archaeological feature or a discrete geological stratum. The dated charcoal was found dispersed on an eroded surface. Alluvial sediments underlying the Clovis surface have yielded radiocarbon ages on humates ranging from  $12,335 \pm 170$   $^{14}\text{C}$  yr B.P. (SMU-2478) to  $14,200 \pm 220$   $^{14}\text{C}$  yr B.P. (SMU-2236). The samples used to date the Clovis horizon may have originated from these older deposits. Further, the late Quaternary sediments at the site are derived from coal-bearing Cretaceous bedrock and large amounts of  $^{14}\text{C}$ -free carbon occur in these deposits. Large amounts of  $^{14}\text{C}$  depleted carbon occur in the late Pleistocene deposits in the form of recycled Cretaceous palynomorphs (S32). These represent a potential source of contamination of the disseminated solid organic matter collected from the Clovis horizon (S32). This geological environment could enable geologically ancient carbon to become commingled with and contaminate the samples. Finally, the precise provenience of the two dated samples from Camp B has not been reported. Interestingly, humates from Unit E1 overlying the Clovis surface in the west Pond Area yielded an age of  $10,940 \pm 80$   $^{14}\text{C}$  yr B.P. (SMU-2194) directly above the Clovis horizon. This age is well within the range of ages for Clovis reported here. This situation has raised concerns about the validity of the early ages from the site (S30).

24. Sheaman, Wyoming: At the Sheaman site, Wyoming, the Clovis occupation is thought to date to  $11,225 \pm 50$   $^{14}\text{C}$  yr B.P., based on the averaging of the three oldest dates from the Clovis

horizon (S33). However, these dates were obtained from charcoal and insoluble organic matter and not from a feature. Dispersed charcoal from the same horizon provided dates of around 10,200  $^{14}\text{C}$  yr B.P. (S33). A series of dates on XAD-purified collagen from the Clovis horizon foreshaft, yielded an averaged date of  $10,305 \pm 15$   $^{14}\text{C}$  yr B.P. The foreshaft was previously identified as ivory, but is actually cervid bone or antler. The results of this dating cast doubt on the Clovis assignment of the Sheaman site, which may instead be Goshen or represent a mixed site with Clovis and Goshen artifacts.



**Table S1. Radiocarbon Dates from Clovis and Clovis-Age Sites.**

Site	Date <sup>14</sup> C yr B.P.	Laboratory Number	Material Dated	Reference	Remarks
<b>Clovis sites (credible ages and Clovis diagnostics)</b>					
1. Lange-Ferguson, SD	10,670 ± 300	I-11,710	Organic material	S4	Clovis – rejected
	10,730 ± 530	I-13,104	Mammoth bone (collagen)	S4	Clovis – rejected (10,800 ± 530 <sup>14</sup> C yr B.P. with δ <sup>13</sup> C correction)
	11,140 ± 140	AA-905	Charcoal	S5	Clovis
	10,710 ± 130	UCIAMS-11344	Mammoth bone (XAD gelatin KOH collagen)	This report	Clovis
	11,110 ± 40	UCIAMS-11345	Mammoth bone (XAD gelatin KOH collagen)	This report	Clovis
	AVERAGE	11,080 ± 40			
2. Sloth Hole, FL	11,050 ± 50	SL-2850	Proboscidean Ivory (XAD collagen)	S6	Clovis – ivory haft element
3. Anzick, MT	8,690 ± 310	AA-313A	Human bone (HCl insoluble collagen)	S2	Clovis – rejected
	10,500 ± 400	AA-313B	Human bone collagen (untreated gelatin)	S2	Clovis – rejected
	10,240 ± 120	AA-2978	Human bone collagen (aspartic acid from hydrolysed gelatin)	S2	Clovis ?
	10,820 ± 100	AA-2979	Human bone collagen (glutamic acid from hydrolysed gelatin)	S2	Clovis ?
	10,710 ± 100	AA-2980	Human bone collagen (hydroxyproline from hydrolysed gelatin)	S2	Clovis ?
	10,940 ± 90	AA-2981	Human bone collagen (glycine from hydrolysed gelatin)	S2	Clovis ?
	10,370 ± 130	AA-2982	Human bone collagen (alanine from hydrolysed gelatin)	S2	Clovis ? (Average of AA-2978, 2979, 2980, 2981, and 2982: 10,680 ± 50 <sup>14</sup> C yr B.P.)

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**Table S1. Radiocarbon Dates from Clovis and Clovis-Age Sites**

Site	Date <sup>14</sup> C yr B.P.	Laboratory Number	Material Dated	Reference	Remarks
	11,550 ± 60	CAMS-35912	Human bone collagen (XAD gelatin)	This report	Clovis ? fraction from archived vial of gelatin – rejected
	10,580 ± 35	CAMS-80535	Human bone (HCl decalcified untreated collagen)	This report	Clovis ? – rejected
	10,525 ± 35	CAMS-80536	Human bone (KOH extracted collagen)	This report	Clovis ? – rejected
	10,610 ± 30	CAMS-80537	Human bone collagen (gelatin)	This report	Clovis ? – rejected
	10,705 ± 35	CAMS-80538	Human bone collagen (XAD-KOH-gelatin)	This report	Clovis ? – most reliable age
	11,040 ± 60	Beta-163832	Bone (alkali collagen)	S7	Clovis foreshaft
	11,040 ± 40	Beta-168967	Bone (alkali collagen)	S7	Clovis foreshaft
AVERAGE	11,040 ± 35				Average of two foreshaft ages (Beta-163832 and 168967)
4. Dent, CO	11,200 ± 500	I-622	Mammoth bone (collagen)	S8	Clovis – rejected
	10,980 ± 90	AA-2941	Mammoth bone collagen (XAD hydrolysate)	S2	Clovis
	10,660 ± 170	AA-2942	Mammoth bone collagen (aspartic acid)	S2	Clovis
	10,800 ± 110	AA-2943	Mammoth bone collagen (glutamic acid)	S2	Clovis
	10,600 ± 90	AA-2945	Mammoth bone collagen (hydroxyproline)	S2	Clovis
	10,710 ± 90	AA-2946	Mammoth bone collagen (glycine)	S2	Clovis (Average of A-2941, 2942, 2943, 2945, 2946, and 2947: 10,750 ± 40 <sup>14</sup> C yr B.P.)
	10,670 ± 120	AA-2947	Mammoth bone collagen (alanine)	S2	Clovis
	11,065 ± 35	UCIAMS-11339	Mammoth bone (XAD gelatin KOH collagen)	This report	Clovis
	10,940 ± 30	UCIAMS-11340	Mammoth bone (XAD gelatin KOH collagen)	This report	Clovis
AVERAGE	10,990 ± 25				Average of two ages (UCIAMS 11339 and 11340)

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**Table S1. Radiocarbon Dates from Clovis and Clovis-Age Sites**

Site	Date <sup>14</sup> C yr B.P.	Laboratory Number	Material Dated	Reference	Remarks
5. Paleo Crossing, OH	12,250 ± 100	AA-8250	Charcoal	S9	From post mold – rejected
	10,800 ± 185	AA-8250-D	Charcoal	S9	From post mold
	10,980 ± 110	AA-8250-E	Charcoal	S9	From post mold
	11,060 ± 120	AA-8250-C	Charcoal	S9	From post mold
	12,000 ± 110	AA-8250-B	Charcoal	S9	From post mold – rejected
	12,175 ± 115	AA-8250-F	Charcoal	S9	From post mold – rejected
	13,100 ± 100	AA-8251	Organic fragments	S9	Cylindrical pit containing Clovis point base – side wall – rejected
	9230 ± 80	AA-8252	Charcoal	S9	Above cylindrical pit
	12,900 ± 110	AA-19131A	Charcoal	S9	Matrix into which post holes were dug – natural sediments
	11,675 ± 90	AA-10131B	Humates	S9	Matrix into which post holes were dug – natural sediments
AVERAGE	10,980 ± 75				Average of three ages (AA- 8250-D, 8250-E, and 8250-C)
6. Domebo, OK	4952 ± 304	TBN-311	Untreated mammoth tusk	S10	Rejected
	11,045 ± 647	SMU-695	Elm ( <i>Ulnus</i> ) wood	S10	Stump above Clovis – rejected
	11,220 ± 500	SI-172	Mammoth bone (collagen)	S10	Rejected
	11,200 ± 600	SI-175	Mammoth bone (collagen)	S10	Rejected
	9400 ± 300	OX-56	Humic acids	S10	Sediment sample – rejected
	10,123 ± 280	SM-610	Lignitic wood	S10	Above Clovis – rejected
	10,980 ± 70	Beta-24212	Elm ( <i>Ulnus</i> ) wood	S11	Above Clovis
	11,490 ± 450	AA-823	Elm ( <i>Ulnus</i> ) wood	S3	Above Clovis
	11,480 ± 450	AA-825	Mammoth bone (XAD purified collagen)	S3	Clovis
	10,860 ± 450	AA-811	Mammoth bone (proline and hydroxyproline)	S3	Clovis
	10,810 ± 420	AA-805	Mammoth bone (XAD hydrolysate)	S3	Clovis (Average of three bone ages: 11,040 ± 255 <sup>14</sup> C yr B.P.)
	10,815 ± 85	AA-12536	Elm ( <i>Ulnus</i> ) wood	S12	Above Clovis (rooted tree stump)
	11,090 ± 110	AA-12534	Bulk organic sand	S12	Above Clovis
	11,010 ± 85	AA-12533	Elm ( <i>Ulnus</i> ) wood	S12	Above Clovis
	10,845 ± 90	AA-13028	Humates	S12	Above Clovis (humates from wood AA-12533)
12,350 ± 100	AA-13026	Bulk organics and sediment	S12	Below Clovis	

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**Table S1. Radiocarbon Dates from Clovis and Clovis-Age Sites**

Site	Date <sup>14</sup> C yr B.P.	Laboratory Number	Material Dated	Reference	Remarks
	10,960 ± 30	UCIAMS-11341	Mammoth bone (XAD gelatin KOH collagen)	This report	Clovis
7. Lehner, AZ	10,770 ± 140	SMU-168	Charcoal	S5	Clovis
	10,940 ± 100	A-378	Charcoal	S5	Clovis
	11,080 ± 200	SMU-181	Charcoal	S5	Clovis
	10,950 ± 110	SMU-194	Charcoal	S5	Clovis
	10,860 ± 280	SMU-164	Charcoal	S5	Clovis
	10,950 ± 90	SMU-290	Charcoal	S5	Clovis
	11,080 ± 230	SMU-196	Charcoal	S5	Clovis
	10,620 ± 300	SMU-347	Charcoal	S5	Clovis
	10,700 ± 150	SMU-297	Charcoal	S5	Clovis
	10,710 ± 90	SMU-340	Charcoal	S5	Clovis
	11,170 ± 200	SMU-264	Charcoal	S5	Clovis
	11,470 ± 110	SMU-308	Charcoal	S5	Clovis
AVERAGE	10,950 ± 40				Average of all 12 ages
8. Shawnee- Minisink, PA	10,590 ± 300	W-2994	Charcoal and charred seeds	S13	Clovis – rejected
	10,750 ± 600	W-3134	Charcoal	S13	Clovis hearth – rejected
	9,310 ± 1000	W-3388	Charcoal-stained soil matrix	S13	Clovis fluted point – rejected
	11,050 ± 1000	W-3391	Charcoal-stained soil matrix	S13	Clovis fluted point – rejected
	10,940 ± 90	Beta-101935	Carbonized Hawthorn seed ( <i>Crataegus</i> )	S14	Clovis hearth
	10,900 ± 40	Beta-127162	Carbonized Hawthorn seed ( <i>Crataegus</i> )	S14	Clovis hearth
	10,820 ± 50	Beta-203865	Carbonized Hawthorn seed ( <i>Crataegus</i> )	S15	Clovis hearth
	10,915 ± 25	UCIAMS-24865	Carbonized Hawthorn seed ( <i>Crataegus</i> )	This report	Clovis hearth
	11,020 ± 30	UCIAMS-24866	Carbonized Hawthorn seed ( <i>Crataegus</i> )	This report	Clovis hearth
AVERAGE	10,935 ± 15				Average of five ages (Beta- 101935, 127162, and 203865, UCIAMS-24865 and 24866)

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**Table S1. Radiocarbon Dates from Clovis and Clovis-Age Sites**

Site	Date <sup>14</sup> C yr B.P.	Laboratory Number	Material Dated	Reference	Remarks
9. Murray Springs, AZ	11,190 ± 180	SMU-18	Charcoal	S5	Clovis
	11,150 ± 450	A-805	Charcoal	S5	Clovis
	11,080 ± 180	TX-1413	Charcoal	S5	Clovis
	10,930 ± 170	TX-1462	Charcoal	S5	Clovis
	10,890 ± 180	SMU-27	Charcoal	S5	Clovis
	10,840 ± 70	SMU-41	Charcoal	S5	Clovis
	10,840 ± 140	SMU-42	Charcoal	S5	Clovis
	10,710 ± 160	TX-1459	Charcoal	S5	Clovis
AVERAGE	10,885 ± 50				Average of all eight ages
10. Colby, WY	11,200 ± 220	RL-392	Mammoth bone (collagen)	S16	Clovis – Bone Pile 2 – rejected
	10,864 ± 141	SMU-254	Mammoth bone (bone apatite carbonate)	S16	Clovis – Bone Pile 2 – rejected
	8719 ± 392	SMU-278	Mammoth bone (collagen)	S16	Clovis – rejected
	10,790 ± 30	UCIAMS-11342	Mammoth bone (XAD gelatin KOH collagen)	This report	Clovis – Bone Pile 2
	10,950 ± 30	UCIAMS-11343	Mammoth bone (XAD gelatin KOH collagen)	This report	Clovis – Bone Pile 2
	AVERAGE	10,870 ± 20			
11. Jake Bluff, OK	10,750 ± 40	CAMS-79940	Bison bone (XAD- purified collagen)	S17	Clovis
	10,840 ± 45	CAMS-90968	Bison bone (XAD- purified collagen)	S17	Clovis
	10,700 ± 45	CAMS-90969	Bison bone (XAD- purified collagen)	S17	Clovis
	AVERAGE	10,765 ± 25			
<b>Clovis sites (indirectly dated and Clovis diagnostics)</b>					
12. East Wenatchee, WA	<11,125 ± 130	Beta-4951	Charcoal	S18, S19	Date for Glacier Peak Ash G from Indian Creek, Montana. Clovis artifacts post-date Glacier Peak Ash G

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**Table S1. Radiocarbon Dates from Clovis and Clovis-Age Sites**

Site	Date <sup>14</sup> C yr B.P.	Laboratory Number	Material Dated	Reference	Remarks	
<b>Clovis-age sites (credible ages, but no Clovis diagnostics)</b>						
13.	Indian Creek, MT	10,980 ± 110	Beta-4619	Charcoal	S19	Artifacts overlie Glacier Peak Ash Layer G dated to 11,125 ± 130 <sup>14</sup> C yr B.P. (Beta-4951)
14.	Lubbock Lake, TX	11,100 ± 100	SMU-548	Wood	S20	Stratum 1C – Clovis?
		11,100 ± 80	SMU-263	Wood	S20	Stratum 1C – Clovis?
	AVERAGE	11,100 ± 60				Average of two ages (SMU-548 and 263)
15.	Bonneville Estates, NV	11,010 ± 40	Beta-207009	Hearth charcoal	S21	Stratum 18b – hearth with artifacts
16.	Kanorado, KS	10,150 ± 500	CAMS-112740	Bone (XAD collagen)	S22	Clovis? – 14SN101 – rejected
		10,950 ± 60	CAMS-112741	Bone (XAD collagen)	S22	Clovis? – 14SN105
		11,005 ± 50	CAMS-112742	Bone (XAD collagen)	S22	Clovis? – 14SN106
	AVERAGE	10,980 ± 40				Average of two ages (CAMS-112741 and 112742)
17.	Arlington Springs, CA	10,960 ± 80	CAMS-16810	Bone (XAD collagen)	S23	Human skeleton
<b>Problematic Clovis and Clovis-age sites</b>						
18.	Sheriden Cave, OH	10,550 ± 70	Beta-117604	Charcoal	S24	Above artifacts
		10,570 ± 70	Beta-117605	Charcoal	S24	Above artifacts
		10,600 ± 60	Beta-117603	Charcoal	S24	Above artifacts
		10,620 ± 70	Beta-117606	Charcoal	S24	Above artifacts
		10,680 ± 80	AA-21710	Charcoal	S24	Above artifacts
		10,840 ± 80	Beta-127909	Charcoal	S24	Below artifacts
		10,960 ± 60	Beta-127910	Charcoal	S24	Below artifacts
	AVERAGE (above artifacts)	10,600 ± 30				Average of five ages (Beta-117604, 117605, 117603, 117606 and AA-21710)
	AVERAGE (below artifacts)	10,920 ± 50				Average of two ages (Beta-127909 and 127910)

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**Table S1. Radiocarbon Dates from Clovis and Clovis-Age Sites**

Site	Date <sup>14</sup> C yr B.P.	Laboratory Number	Material Dated	Reference	Remarks
19. Blackwater Draw, NM	11,170 ± 360	A-481	Carbonized plants “organic laminae”	S25	Clovis (C0)
	11,040 ± 500	A-490	Carbonized plants “organic laminae”	S25	Clovis (C1)
	11,630 ± 400	A-491	Carbonized plants “organic laminae”	S25	Clovis (C1) (Average of A- 481, A-490, and A-491: 11,230 ± 235 <sup>14</sup> C yr B.P.)
	10,580 ± 100	AA-1360	Humates	S25	Clovis (C) – rejected
	10,780 ± 180	SMU-1880	Humates	S26	Clovis (humates from sediment around mammoth bones in plaster jacket) – rejected
AVERAGE	11,300 ± 235				Average of three ages (A-481, 490, and 491)
20. Cactus Hill, VA	10,920 ± 250	Beta-81589	Charcoal (southern hard pine)	S27	Clovis hearth (lower half)
	9790 ± 200	Beta-80181	Charcoal (hard pine, oak, hickory)	S27	Clovis hearth (upper half) – rejected
	9155 ± 80	AA-15023	Charcoal (pine, oak, hickory)	S27	Clovis – single layer of charcoal – rejected
	6905 ± 55	AA-15026	Charcoal (pine, oak, hickory)	S27	Clovis – single layer of charcoal – rejected
	6580 ± 55	AA-15025	Charcoal (pine, oak, hickory)	S27	Clovis – single layer of charcoal – rejected
	5285 ± 50	AA-15024	Charcoal (pine, oak, hickory)	S27	Clovis – single layer of charcoal – rejected
21. Wally’s Beach, Canada	11,130 ± 90	TO-7693	Bison bone (collagen)	S28	Clovis association?
	11,330 ± 70	TO-7696	Horse bone (collagen)	S28	Clovis association?
	10,980 ± 80	TO-7691	Musk oxen bone (collagen)	S28	Clovis association?
	11,350 ± 80	TO-8972	Caribou bone (collagen)	S28	Clovis association?
22. Union Pacific, WY	11,280 ± 350	I-449	Proboscidean tusk organics (approximately collagen)	S5	Date likely associated with Clovis

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**Table S1. Radiocarbon Dates from Clovis and Clovis-Age Sites**

Site	Date <sup>14</sup> C yr B.P.	Laboratory Number	Material Dated	Reference	Remarks
23. Aubrey, TX	11,540 ± 110	AA-5271	Charcoal	S31	Clovis occupation surface Camp B
	11,590 ± 90	AA-5274	Charcoal	S31	Clovis occupation surface Camp B
	AVERAGE	11,570 ± 70			Average of both ages
24. Sheaman, WY	9086 ± 70	AA-42532	Dispersed charcoal	S33	Above cultural horizon
	10,251 ± 72	AA-42533	Dispersed charcoal	S33	Cultural horizon
	10,026 ± 86	AA-42534	Humic acids from AA-42533	S33	Cultural horizon
	1820 ± 170	AA-42535	Charcoal	S33	Below cultural horizon
	10,153 ± 90	AA-42979	Charcoal	S33	Below cultural horizon
	11,379 ± 70	AA-40991	Charcoal and insoluble organic matter	S33	Cultural horizon
	11,810 ± 300	AA-40988	Charcoal and insoluble organic matter	S33	Cultural horizon
	11,040 ± 70	AA-40989	Charcoal and insoluble organic matter	S33	Cultural horizon
	10,328 ± 65	AA-40990	Humic acids	S33	Cultural horizon (AA-40991, AA-40988, AA-40989, and AA-40990 from same sample)
	10,370 ± 30	UCIAMS-11675	Bone (XAD gelatin KOH collagen)	This report	Cultural horizon – antler/bone foreshaft
	10,275 ± 25	UCIAMS-21992	Bone (KOH collagen)	This report	Cultural horizon – antler/bone foreshaft
	10,295 ± 20	UCIAMS-21993	Bone (XAD gelatin KOH collagen)	This report	Cultural horizon – antler/bone foreshaft
	AVERAGE	10,305 ± 15			Average of three ages (UCIAMS-11675, 21992 and 21993)
<b>Ages from other early sites</b>					
25. Mill Iron, MT	11,010 ± 140	Beta-16178	Charcoal	S5	Goshen
	10,760 ± 130	Beta-20110	Charcoal	S5	Goshen
	10,770 ± 85	AA-3669	Charcoal	S5	Goshen
	10,990 ± 170	NZA-623	Charcoal	S5	Goshen
	AVERAGE	10,840 ± 60			Average of all four ages

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**Table S1. Radiocarbon Dates from Clovis and Clovis-Age Sites**

Site	Date <sup>14</sup> C yr B.P.	Laboratory Number	Material Dated	Reference	Remarks
26. Hell Gap, WY	10,955 ± 135	AA-14434	Charcoal	S34	Goshen
27. Cerro Tres Tetas, Argentina	10,850 ± 150	LP-781	Charcoal	S35	Hearth – Lower Unit 5
	10,853 ± 70	AA-39366	Charcoal	S35	Hearth – Lower Unit 5
	10,915 ± 65	OXA-9244	Charcoal	S35	Hearth – Lower Unit 5
	11,015 ± 66	AA-39368	Charcoal	S35	Hearth – Lower Unit 5
	11,100 ± 150	AA-22233	Charcoal	S35	Hearth – Lower Unit 5 (same as LP-781)
	11,560 ± 140	LP-525	Charcoal	S35	Rejected
AVERAGE	10,935 ± 35				Average of five ages (LP-781, AA-39366, OXA-9244, AA- 39368, 22233 and AA-11340)
28. Cueva Casa del Minero, Argentina	10,967 ± 55	AA-37208	Charcoal	S36	Hearth – Unit 4
	10,999 ± 55	AA-37207	Charcoal	S36	Hearth – Unit 4
	AVERAGE	10,985 ± 40			Average of both ages
29. Piedra Museo, Argentina	10,925 ± 65	OXA-8528	Bone collagen	S37	Unit 6 – bottom
	11,000 ± 65	AA-27950	Charcoal	S37	Unit 6 – bottom
	12,890 ± 90	AA-20125	Charcoal	S37	Unit 6 – bottom – rejected
	AVERAGE	10,960 ± 45			Average of two ages (OXA- 8528 and AA-27950)
30. Fell's Cave, Chile	10,080 ± 160	I-5146	Charcoal	S38	Hearth – Level 18 – Fishtail
	10,720 ± 300	W-915	Charcoal	S38	Hearth – Level 19 – Fishtail
	11,000 ± 170	I-3988	Charcoal	S38	Hearth – Level 20 – Fishtail

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