Mammoth Ivory Rods in Eastern Beringia: Earliest in North America

Brian T. Wygal, Kathryn E. Krasinski, Charles E. Holmes, Barbara A. Crass, and Kathlyn M. Smith

The Holzman archaeological site, located along Shaw Creek in interior Alaska, contained two mammoth ivory rods, of which one is bi-beveled, within a stratigraphically sealed cultural context. Dated 13,600–13,300 cal BP, these are the earliest known examples of osseous rod technology in the Americas. Beveled ivory, antler, and bone rods and points share technological similarities between Upper Paleolithic Europe, Asia, eastern Beringia, and the Clovis tradition of North America and are important tool types in understanding the late Pleistocene dispersal of modern humans. The Holzman finds are comparable to well-known Clovis tradition artifacts from Anzick (Montana), Blackwater Draw (New Mexico), East Wenatchee (Washington), and Sherman Cave (Ohio). We describe these tools in the broader context of late Pleistocene osseous technology with implications for acquisition and use of mammoth ivory in eastern Beringia and beyond.

Keywords: late Pleistocene, osseous rods, peopling of the Americas

El sitio arqueológico de Holzman, ubicado a lo largo de Shaw Creek en el interior de Alaska, contenía dos varillas de marfil de mamut, de las cuales una es bi-biselada, dentro de un contexto cultural estratigráficamente sellado. Fechado en 13.600-13.300 cal aP, estos son los primeros ejemplos conocidos de tecnología de varillas óseas en las Américas. Las varillas y puntas biseladas de marfil, cornamenta y hueso comparten similitudes tecnológicas entre el Paleolítico Superior de Europa, Asia, Beringia oriental, y la tradición Clovis de América del Norte, y son tipos de herramientas importantes en la comprensión de la dispersión del Pleistoceno tardío de los seres humanos modernos. Los hallazgos de Holzman son comparables a los conocidos artefactos de la tradición Clovis de Anzick (Montana), Blackwater Draw (Nuevo México), East Wenatchee (Washington), y Sherman Cave (Ohio). Describimos estas herramientas en el contexto más amplio de la tecnología ósea del Pleistoceno tardío con implicaciones para la adquisición y el uso de marfil de mamut en el este de Beringia y más allá.

Palabras clave: Pleistoceno tardío, varillas oseas, colonización de las Américas

Bone and mammoth ivory rods and points have been recognized as a late Pleistocene tool type since first discovered with Pleistocene fauna at Blackwater Draw in New Mexico (Cotter 1937; Figgins 1927; Howard 1935), Lindenmeier in Colorado (Holen and Holen 2009; Roberts 1935; Wilmsen and Roberts 1978), Goldstream near Fairbanks (Rainey 1939), and submerged in the Itchtucknee River in northern Florida (Jenks and Simpson 1941). Today, hundreds of beveled osseous tools have been identified in late Pleistocene contexts across North America, but relatively few are made of mammoth ivory (Figure 1). Many of

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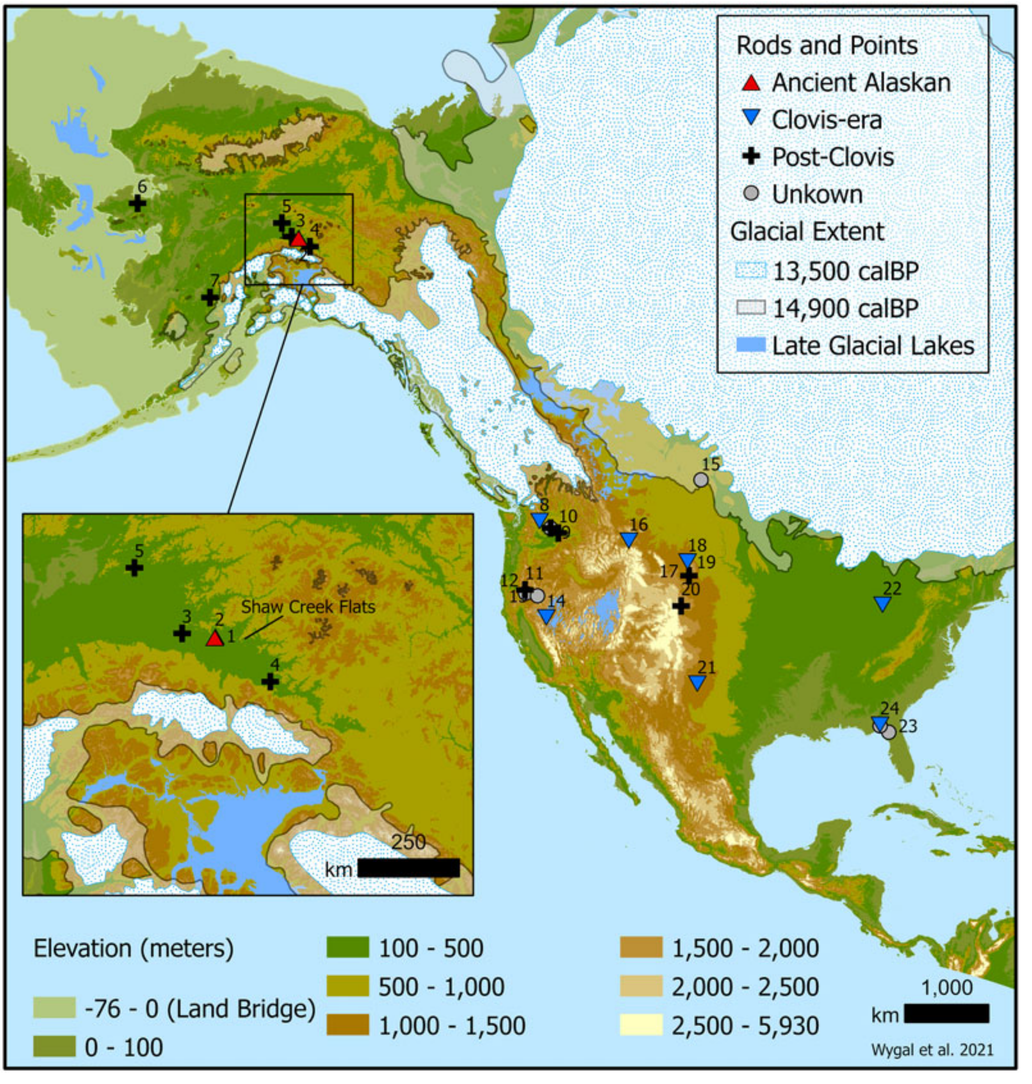

Figure 1. Osseous rods and extent of late Pleistocene glaciation in North America. Ice extent after Dalton and colleagues (2020). Ancient Lake Lahontan and Bonneville after Duke and King (2014). Ancient Lake Atna after Wiedmer and colleagues (2010). Ancient lakes in Beringia after Bond (2019). Information for sites containing osseous rods referenced in Table 1. Location key: (1) Holzman, (2) Broken Mammoth, (3) Upward Sun River, (4) Gerstle River Quarry, (5) Goldstream, (6) Trail Creek Caves, (7) Lime Hills Cave, (8) East Wenatchee, (9) Lind Coulee, (10) Marmes Rockshelter, (11) Klamath Lake, (12) Lower Klamath Lake, (13) Goose Lake, (14) Pyramid Lake, (15) Grenfell, (16) Anzick, (17) Agate Basin, (18) Crook County, (19) Sheaman, (20) Lindenmeier, (21) Blackwater Draw, (22) Sheridan Cave, (23) Itchtucknee River, and (24) Sloth Hole.

these points are associated with well-dated Clovis caches and kill sites (Bradley 1995; Haynes 2002; Morrow and Fiedel 2006; Tankersley 1997, 2004) and are reminiscent of artifacts from Upper Paleolithic Eurasia (Saunders and Daeschler 1994; Saunders et al. 1990). Here, we report on the oldest documented osseous rods from securely dated contexts in North America. Although "osseous" refers specifically to bone, throughout this article, we use this term to describe bone, antler, and ivory materials to distinguish these from the broader range of materials that the term "organic" would imply.

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In North America, the northernmost examples of beveled rods outside of Alaska occur in Saskatchewan (Wilmeth 1968) and the Pacific Northwest (Gramly 1993). Florida has yielded the largest number of osseous points and rods, although most are in private collections where they remain undated. Osseous tools from Clovis contexts date to 13,000–12,900 cal BP[1]—at the earliest (Lyman et al. 1998; Pearson 1999; Sutton 2018). In Beringia, the oldest known occupations with bone and mammoth ivory rods date to 13,600–13,300 cal BP at sites along Shaw Creek (Heppner 2017; Lanoë and Holmes 2016), but dates on tusk acquisition and ivory working are oldest—14,100 cal BP—at Swan Point. Specific mammoth tusk reduction techniques at Swan Point CZ4b (Lanoë and Holmes 2016) are reminiscent of similar behaviors that took place at Blackwater Draw as well as in Upper Paleolithic sites in Europe (Saunders et al. 1990).

The Shaw Creek Flats region, located along the middle Tanana Valley north of Big Delta in interior Alaska, is renowned for well-preserved and deeply stratified late Pleistocene sites. Zooarchaeological remains reveal broad-spectrum hunting and gathering of migratory waterfowl (*Cygnus columbianus*, *Anas* sp.), occasional fish (*Salmonid*), and extinct Pleistocene megafauna including bison (*Bison priscus*), mammoth (*Mammuthus primigenius*), and at least one instance of horse (*Equus* sp.) hunting between 14,100 and 13,500 cal BP (Holmes 2011; Potter 2008; Potter et al. 2013). Wapiti (*Cervus* sp.) and moose (*Alces alces*) appear during the terminal Pleistocene about the same time as humans (Krasinski and Haynes 2010).

During the late glacial period, the Shaw Creek region provided a periglacial refuge for Pleistocene megafauna, including some of the last remaining populations of woolly mammoth in continental North America (Krasinski and Haynes 2010). The area offered a rich source of fresh and subfossil ivory on the mostly treeless mammoth steppe (Holmes 2001; Lanoë and Holmes 2016; Lanoë et al. 2017; Potter et al. 2013). Foragers spent considerable time working ivory around hearths while overlooking the Shaw Creek Flats near the northern gateway of the Ice-Free Corridor. The recently discovered Holzman tools were found in stratigraphic and spatial association alongside fragmented large mammal and avian remains scattered around hearth features dated to 13,600–13,300 cal BP (Wygal et al. 2018). A minimum number of three individual mammoths were used at Holzman. The importance of mammoth ivory tool manufacture to Ancient Alaskans is evident at several late Pleistocene Shaw Creek sites centuries before the development of Clovis further south.

Mammoth bone and ivory have been found archaeologically throughout the Paleolithic period (Haynes et al. 2021), and unequivocal mammoth ivory "retoucher" tools appear first in eastern European Middle Paleolithic assemblages (Anikovich et al. 2007; Hoffecker and Hoffecker 2017; Hutson et al. 2018). The earliest ivory rods date to the early Upper Paleolithic transition in Aurignacian and Gravettian occupations at Spy in Belgium (Khlopachev 2013), on the Russian Plain at Kostenki (Hoffecker et al. 2015), and in Siberia at Afontova Gora (Pitulko et al. 2015:335). From the rather extravagant bone, antler, and ivory traditions of Eurasia, the beveled ivory rod and eyed needles appear to be the few osseous tool types shared between late Pleistocene sites in Siberia and North America. Although osseous tools occur among late Pleistocene traditions in North America, items of artistic expression are more or less absent (Haynes 2002; Haynes and Klimowicz 2015). Here, we describe the form and function of these tools in North America, and then we provide a brief overview of key finds in Siberia, Alaska, and midcontinent North America. Then, we provide the wider context for the archaeology of Shaw Creek in interior Alaska to situate the provenience and dating of the mammoth ivory rods from the Holzman site. We also discuss mammoth ivory acquisition pertaining to the broader implications of the Holzman finds.

Background on Bone and Ivory Rods

Form and Function

Sutton (2018:183–184) categorized late Pleistocene osseous rods from North America into four variants: straight uni-beveled (Type 1), straight bi-beveled (Type 2), curved uni-beveled (Type 3), and bi-pointed (Type 4). In cross section, points

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and rods tend to be circular, plano-convex (split), or rectangular (Sutton 2018:184). Osseous rod manufacture "involved splitting, grinding, and shaping" with "a remarkable amount" of technological continuity (Pitulko et al. 2015:124). The bi-beveled style tends to be round, oval, or cylindrical in cross section, with etched bevels on either end ranging in length from 50 to 280 mm.

Despite 90 years of analyses, the function of these tools is still debated. Form and distribution of osseous rods have been thoroughly documented, and many archaeologists consider them foreshaft components of composite hunting armatures (Bradley 1995; Cotter 1937; Lyman and O'Brien 1999; Lyman et al. 1998; O'Brien et al. 2016; Pearson 1999; Rainey 1939; Saunders et al. 1990; Wilmeth 1968). Others propose they functioned as wedges or levers (Lanoë and Holmes 2016; Lyman et al. 1998; Saunders and Daeschler 1994), fishing spear components (Sutton 2018), pressure flakers (Wilke et al. 1991), and sled runners (Gramly 1993). However, limited experimental research has been conducted to test these hypotheses (Boldurian 2007a).

Discrepancies in reporting have broadened disagreements over function and cultural affiliation for many of the osseous rod specimens south of the ice sheets. For example, Lyman and O'Brien (1999) discounted Pearson's (1999) analysis of osseous rod function because he included many points not likely associated with Clovis occupations (Lyman and O'Brien 1999:350). These included tools from Lind Coulee, Washington (Daugherty 1956), Goose Lake, California (Riddell 1973), Klamath Lake, Oregon (Cressman 1956), and Grenfell, Saskatchewan (Wilmeth 1968). Despite this, O'Brien and colleagues (2016) and Sutton (2018) continued including many of these undated artifacts in subsequent studies of late Pleistocene osseous points. Therefore, so do we. Table 1 compiles information including primary references for previously reported osseous rods in North America.

Siberia and Alaska

A rich osseous industry flourished during the middle Upper Paleolithic in Siberia (Derev'anko et al. 1998), including at Mal'ta and Buret', where retouchers, awls, needles, ivory beads, pendants, plaques, 3D and 2D zoomorphic figurines, and Venus figurines have been reported (Graf and Buvit 2017:S589). Unslotted osseous rods and points have also been dated to the middle Upper Paleolithic in Siberia at the Yana RHS, Mal'ta, Buret', and Igeteiskii Log sites (Graf and Buvit 2017; Pitulko et al. 2015). The northernmost of these is Yana RHS, where several osseous tools have been recorded, including some made of mammoth ivory dated around 30,000 cal BP. Ivory technology is widespread across arctic Siberia, especially in the Yana-Indighirka lowlands, where the *chaîne opératoire* of ivory tool manufacture is preserved (Pitulko et al. 2015). This wealth of bone, antler, and ivory artifacts included points and rods at Kurtak 3, Shlenka, Afontova Gora, and Mal'ta. Late Upper Paleolithic specimens in Siberia appear in a wider variety of forms and dimensions, but many are unilaterally or bilaterally slotted for microblade insets (Graf and Buvit 2017: S591).

Osseous rods in Alaska and Siberia are sometimes "slotted" or incised with a long groove down one or two lateral edges for the insertion of microblades, which are small and thin standardized flakes systematically produced for the purpose of creating composite tools. Microblades link Paleolithic traditions in Alaska with ancestral forms in Siberia (Coutouly 2012; Hirasawa and Holmes 2017). The trend in Siberia for unslotted osseous points to occur earlier in the record than those with lateral grooves for microblade inserts is replicated in Alaska. Other rods may be incised with crosshatchings but are not slotted—an indication that microblades were not used in all situations.

The earliest late Pleistocene forms of osseous rods in Alaska are made on ivory and occasionally bone. These are unslotted and associated with assemblages lacking microblade technology at Broken Mammoth and Holzman (Heppner 2017; Wygal et al. 2018). Early Holocene slotted osseous rods tend to be made of antler, at Trail Creek Caves and Lime Hills, and are associated with the Denali complex (Ackerman 1996; Lee and Goebel 2016). The antler rods from Upward Sun River are much longer than other specimens found in Alaska and were associated with bifacial projectile points. Although they were

Table 1. Organic Rods and Points from North America.

Specimen	Description	Condition	Length (mm)	Width (mm)	Thickness (mm)	Cal BP	Culture	Primary References
Agate Basin, WY	bone, point	complete, nearly	254.0	9.7	8.5	12,187	Folsom	Frison and Zeimens 1980
Agate Basin, WY	bone, point	proximal segment	66.0	8.0	—	12,187	Folsom	Frison and Zeimens 1980
Agate Basin, WY	bone, point	distal segment	109.0	8.0	—	12,187	Folsom	Frison and Zeimens 1980
Anzick, MT 118/119	antler, bi-beveled	complete	280.0	17.4	14.6	13,010	Clovis	Lahren and Bonnichsen 1974
Anzick, MT-117	antler	medial	92.0	15.0	10.0	13,000	Clovis	Lahren and Bonnichsen 1974
Anzick, MT-37	antler, uni-beveled point	incomplete	132.0	18.0	12.3	13,000	Clovis	Lahren and Bonnichsen 1974
Anzick, MT-38/122	antler	medial	97.5	20.0	13.6	13,010–12,900	Clovis	Lahren and Bonnichsen 1974
Anzick, MT-39	antler, uni-beveled point	incomplete	54.0	17.4	12.3	13,000	Clovis	Lahren and Bonnichsen 1974
Anzick, MT-67	antler, uni-beveled point	complete	227.0	15.5	13.8	13,000	Clovis	Lahren and Bonnichsen 1974
Anzick, MT-94	antler, uni-beveled point	incomplete	133.0	19.8	12.6	13,000	Clovis	Lahren and Bonnichsen 1974
Anzick, MT-95/123	antler	incomplete	128.0	19.9	13.4	13,000	Clovis	Lahren and Bonnichsen 1974
Anzick, MT-120	antler	medial	92.0	19.0	11.0	13,000	Clovis	Lahren and Bonnichsen 1974
Blackwater Draw, NM (36-19-6)	bone, uni-beveled point	complete	234.0	17.0	13.1	13,000	Clovis	Cotter 1937
Blackwater Draw, NM (36-19-5)	bone, bi-beveled	complete	252.0	15.0	13.0	13,000	Clovis	Cotter 1937
Blackwater Draw, NM EL-79/937-61	bone, point, rounded end	complete	249.0	20.0	12.0	13,000	Clovis	Cotter 1937
Broken Mammoth, AK OA-2	ivory, uni-beveled point	complete	243.0	19.0	20.0	13,400	Ancient Alaska	Heppner 2017; Holmes 1996
Broken Mammoth, AK OA-3	ivory, blunted point	complete	193.0	21.0	18.0	13,400	Ancient Alaska	Heppner 2017; Holmes 1996
Broken Mammoth, AK OA-4	ivory, handle?, bifacial beveled	incomplete	153.0	20.0	18.0	13,400	Ancient Alaska	Heppner 2017; Holmes 1996
Broken Mammoth, AK OA-5	antler, rounded base, pointed tip	complete	166.0	10.0	10.0	13,400	Ancient Alaska	Heppner 2017; Holmes 1996
Broken Mammoth, AK OA-6	ivory, bi-beveled	complete	318.0	12.0	8.0	13,400	Ancient Alaska	Heppner 2017; Holmes 1996
Broken Mammoth, AK OA-7	bone, beveled	incomplete	308.0	10.0	10.0	13,400	Ancient Alaska	Heppner 2017; Holmes 1996
Crook Clovis Cache, WY ($n = 2$)	bone	—	—	—	—	—	Clovis?	Byrd 1997; Tankersley 1998
East Wenatchee, WA-A	bone, bi-beveled	complete	263.0	25.0	18.0	13,000	Clovis	Gramly 1993
East Wenatchee, WA-B	bone, bi-beveled	complete? damaged	209.0	24.0	17.0	13,000	Clovis	Gramly 1993
East Wenatchee, WA-C	bone, bi-beveled	complete	252.0	24.0	18.0	13,000	Clovis	Gramly 1993
East Wenatchee, WA-D	bone, uni-beveled point	medial, gnawed	242.0	29.0	19.0	13,000	Clovis	Gramly 1993
East Wenatchee, WA-E	bone, uni-beveled point	medial, gnawed	231.0	28.0	20.0	13,000	Clovis	Gramly 1993
East Wenatchee, WA-F	bone, bi-beveled	—	190.0	26.0	18.0	13,000	Clovis	Gramly 1993
East Wenatchee, WA-G	bone	medial	232.0	30.0	22.0	13,000	Clovis	Gramly 1993
East Wenatchee, WA-H	bone	incomplete, gnawed	177.0	26.0	18.0	13,000	Clovis	Gramly 1993
East Wenatchee, WA-I	bone, uni-beveled point	complete?	215.0	30.0	21.0	13,000	Clovis	Gramly 1993

(Continued)

Table 1. Continued.

Specimen	Description	Condition	Length (mm)	Width (mm)	Thickness (mm)	Cal BP	Culture	Primary References
East Wenatchee, WA-J	bone	incomplete	171.0	27.0	19.0	13,000	Clovis	Gramly 1993
East Wenatchee, WA-K	bone, uni-beveled point	complete? damaged	193.0	28.0	20.0	13,000	Clovis	Gramly, 1993
East Wenatchee, WA-L	bone	incomplete, gnawed	115.0	13.0	12.0	13,000	Clovis	Gramly, 1993
Gerstle River Quarry, AK	ivory, uni-beveled point	complete	238.0	9.0	7.0	8285–7791	Paleoarctic	Potter 2005:530
Goldstream Creek, AK-34700	bone, bi-pointed	complete	283.0	15.0	8.0	9500	Paleoarctic	Dixon 1999; Rainey 1939
Goldstream Creek, AK-34701	bone, bi-pointed	complete	172.0	15.0	8.0	9600	Paleoarctic	Dixon 1999; Rainey 1939
Goose Lake, CA-1d	bone, uni-beveled point?	distal	133.0	10.0	—	—	—	Riddell 1973
Goose Lake, CA-1e	bone, uni-beveled point?	distal	168.0	11.0	—	—	—	Riddell 1973
Goose Lake, CA-1f	bone, uni-beveled point	complete	197.0	13.0	—	—	—	Riddell 1973
Goose Lake, CA-2a	bone, uni-beveled point	complete	112.0	8.0	—	—	—	Riddell 1973
Goose Lake, CA-2b	bone, bi-beveled	complete	198.0	12.0	—	—	—	Riddell 1973
Goose Lake, CA-2c	bone, bi-beveled	complete	180.0	9.0	—	—	—	Riddell 1973
Grenfell, Saskatchewan, AB	bone, bi-pointed	distal	207.0	15.0	12.5	9500	—	Wilmeth 1968
Holzman, AK 16-601.1	ivory, rounded base	complete (nearly)	125.4	12.0	6.8	13,400	Ancient Alaska	Wygal et al., this article
Holzman, AK 16-601.2	ivory, bi-beveled	complete	102.5	13.4	10.1	13,400	Ancient Alaska	Wygal et al., this article
Itchtucknee River, FL-A	bone, uni-beveled point	complete	182.0	12.3	12.0	—	—	Jenks and Simpson 1941
Itchtucknee River, FL-B	ivory, uni-beveled point	incomplete	91.0	8.5	—	—	—	Jenks and Simpson 1941
Itchtucknee River, FL-C	ivory, uni-beveled point	incomplete	150.5	10.1	—	—	—	Jenks and Simpson 1941
Klamath Lake, OR (1-14300)	bone, uni-beveled point	complete	190.0	15.0	12.0	Holocene	—	Cressman 1956
Lime Hills Cave 1, AK	antler	medial	5.0	8.6	6.3	12,280	Paleoarctic	Ackerman 1996
Lime Hills Cave 1, AK	antler	incomplete	10.7	7.2	5.8	9712	Paleoarctic	Ackerman 1996
Lind Coulee, WA-140	bone	medial	251.0	16.4	10.4	—	—	Daugherty 1956
Lind Coulee, WA-178	bone, uni-beveled point	complete?	177.0	13.4	—	12,000–11,200	Western Stemmed	Daugherty 1956
Lind Coulee, WA-2	bone, bi-beveled	medial	172.0	11.0	—	12,000–11,200	Western Stemmed	Daugherty 1956
Lindenmeier, CO	bone, uni-beveled point	complete?	175.0	13.6	—	10,950	Cody	Wilmsen and Roberts 1978
Lower Klamath L., CA ($n = 10$)	bone, uni-beveled point	—	<280.0	—	—	—	—	Cressman 1942
Marmes Rockshelter, WA	bone, uni-beveled?	incomplete	110.0	—	—	12,500	Western Stemmed	Fryxell et al. 1968
Pyramid Lake, NV-1	ivory, uni-beveled point	complete	130.0	8.0	—	12,340	Clovis	Dansie and Jerrems 2004
Pyramid Lake, NV-2	bone, uni-beveled, barbed	complete?	267.0	17.0	—	12,300	Clovis	Dansie and Jerrems 2004
Sheaman, WY	bone, uni-beveled point	complete (nearly)	203.4	13.6	12.0	12,175	Goshen	Frison 1982
Sheridan Cave, OH-1	bone, uni-beveled point	complete	134.2	14.8	10.6	13,000	Clovis	Redmond and Tankersley 2005
Sheridan Cave, OH-2	bone, uni-beveled point	complete	119.4	14.2	11.6	13,000	Clovis	Redmond and Tankersley 2005
Sloth Hole, Aucilla River, FL	bone, uni-beveled point	complete	255.0	15.0	14.0	12,900	Clovis-era	Hemmings 2004:188–189
Sloth Hole, FL ($n = 116$)	one/ivory, uni-beveled point	—	—	—	—	—	—	Hemmings 2004:188–189

(Continued)

Table 1. Continued.

Specimen	Description	Condition	Length (mm)	Width (mm)	Thickness (mm)	Cal BP	Culture	Primary References
Sloth Hole, FL (UF#206412)	ivory, uni-beveled point	complete?	400.0	—	—	—	—	Hemmings 2004:188–189
Trail Creek Caves 2, AK 6816	antler	incomplete	93.0	8.0	7.0	11,350	Paleoarctic	Lee and Goebel 2016
Trail Creek Caves 2, AK 6823	antler	incomplete	73.0	9.0	7.0	11,257	Paleoarctic	Lee and Goebel 2016
Trail Creek Caves 2, AK 6825	antler, uni-beveled point	incomplete	74.0	9.0	6.0	11,305	Paleoarctic	Lee and Goebel 2016
Trail Creek Caves 2, AK 6826	antler	incomplete	61.0	8.0	5.0	—	Paleoarctic	Lee and Goebel 2016
Trail Creek Caves 2, AK 6827	antler	incomplete	93.0	7.0	7.0	—	Paleoarctic	Lee and Goebel 2016
Trail Creek Caves 2, AK 6835	antler	incomplete	24.0	10.0	5.0	—	Paleoarctic	Lee and Goebel 2016
Trail Creek Caves 2, AK 6845	antler, uni-beveled point	incomplete	102.0	9.0	7.0	10,335	Paleoarctic	Lee and Goebel 2016
Upward Sun River, AK 58-82	antler, bi-beveled	complete	279.0	15.2	11.3	11,700–11,200	Paleoarctic	Potter et al. 2014
Upward Sun River, AK 58-83	antler, bi-beveled	complete	492.0	18.4	12.0	11,700–11,200	Paleoarctic	Potter et al. 2014
Upward Sun River, AK 58-84	antler, bi-beveled	complete	446.0	17.0	11.5	11,700–11,200	Paleoarctic	Potter et al. 2014
Upward Sun River, AK 58-85	antler, bi-beveled	complete	525.0	16.4	11.4	11,700–11,200	Paleoarctic	Potter et al. 2014

Note: In addition to primary references, the following were consulted in the collection of these data: Bradley 1995; Ives et al. 2014; Lyman and O'Brien 1999; Lyman et al. 1998; Morrow and Fiedel 2006; O'Brien et al. 2016; Pearson 1999; Sutton 2018.

incised with crosshatching, these do not appear to be slotted. The artifacts were placed alongside two child burials covered with red ochre in the Middle Tanana Valley, across the river and slightly downstream from Shaw Creek. The dates from Upward Sun River (Potter et al. 2011, 2014) are 2,000 years younger than the osseous tools found at Holzman and Broken Mammoth.

North America Midcontinent

Clovis is the earliest confirmed techno-complex in midcontinent North America dated broadly between 13,250 and 12,800 cal BP and more narrowly between 13,125 and 12,925 cal BP (Haynes 2015; Prasciunas and Surovell 2015). The oldest known osseous rods from Clovis assemblages at Anzick (Montana), Blackwater Draw (New Mexico), East Wenatchee (Washington), and Sheridan Cave (Ohio) (Figure 2) do not exceed 13,000 cal BP (Boldurian 2007a, 2007b; Bradley 1995; Gramly 1993; Lyman et al. 1998; Morrow and Fiedel 2006; O'Brien et al. 2016; Redmond and Tankersley 2005). Most of these tools are constructed of mammoth or bison bone when associated with Clovis assemblages. More than 140 bone and ivory tools have been recorded in Florida, with many finds from the Aucilla and Itchtucknee Rivers (Hemmings 1998, 2004; Jenks and Simpson 1941), but most are of unknown cultural affiliation, age, and uncertain context (Lyman and O'Brien 1999:350). Although the osseous points from Florida represent a wide diversity in tool form, at least one example from Sloth Hole along the Aucilla River yielded an "ivory point haft" dated to [11,050 ± 50 BP] 12,900 cal BP (Hemmings 2004:5). Later Paleoindian groups continued the use of osseous rods and points; however, the bi-beveled style has not been found among the Folsom or later Paleoindian traditions (Sutton 2018:84).

Archaeology of Shaw Creek

Along Shaw Creek, mammoth tusks recovered from the earliest components of the Holzman and Swan Point sites indicate that complete tusks were collected, cached, and processed. A tusk fragment recovered from Broken

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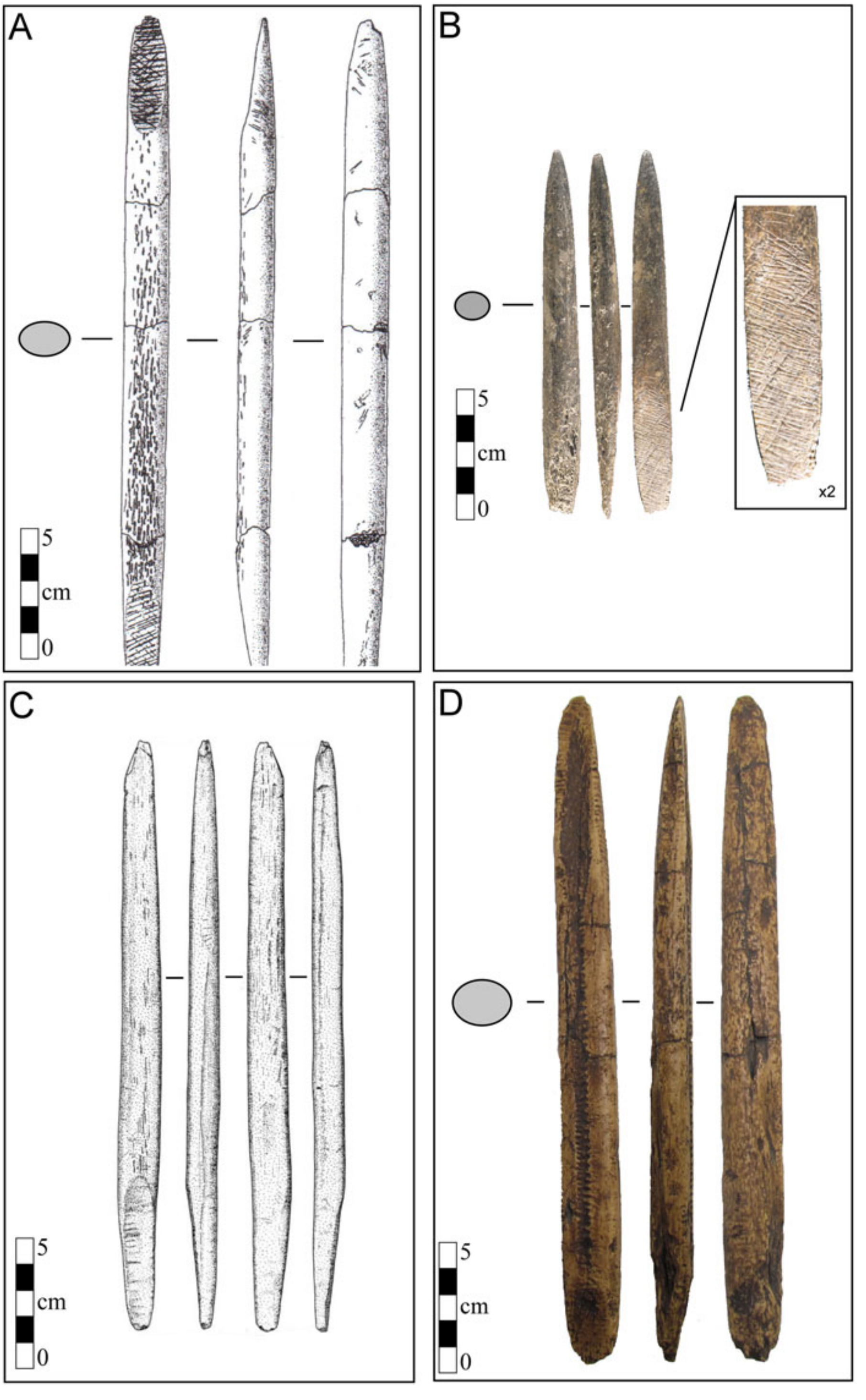

Figure 2. Comparative Clovis bone and ivory rods: (a) Anzick Ivory Bi-Beveled Rod #118/119 (redrawn after Morrow and Fiedel 2006:Figure 7.4); (b) Sheridan Cave Uni-Beveled Point (photo by Lithic Casting Lab, Peter A. Bostrom); (c) Blackwater Draw Bone Uni-Beveled Point #36-19-6 (redrawn after Boldurian 2007a:Figure 1; Boldurian and Cotter 1999); (d) East Wenatchee Engraved Bi-Beveled Rod #1990.15 (photo by Brian Wygal of an artifact caste by Peter A. Bostrom [2018], Lithic Castings Lab Inc.).

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Mammoth CZ4 is dated 13,750–13,120 cal BP (AA-17601; Dilley 1998:85). The earliest component at Swan Point (CZ4b) preserved evidence of tusk acquisition with initial ivory reduction at 14,100 cal BP alongside the only known examples of Alaskan Diuktai-style microblade technology derived from Paleolithic Siberia (Coutouly 2012; Hirasawa and Holmes 2017; Lanoë and Holmes 2016). The late Pleistocene components at Broken Mammoth, Mead (Potter et al. 2013), and Holzman (Wygal et al. 2018) contained limited lithic industries dominated by core and flake technology made on local quartz immediately available along nearby outcrops. A few formal lithic tools including small triangular bifaces, some with concave bases, from Mead and Broken Mammoth date between 13,500 and 13,000 cal BP but notably lack microblade technology (Potter et al. 2013).

Descriptions of the osseous tools from Broken Mammoth CZ4 (Figure 3) are limited to brief reports (Heppner 2017; Holmes 1996; Yesner 1994). These include an incomplete bone rod with one beveled end and a uni-beveled antler point. Ivory artifacts include a bi-beveled rod, uni-beveled point, blunted point, and a "handle" described as bifacially beveled on one end and broken on the other (Heppner 2017:45–46). Holmes (1996:315) reported on the oldest occupations at Broken Mammoth (CZ4b), which included an "east hearth" dated 13,450–13,160 cal BP (CAMS-5358), a swan bone dated 13,580–13,180 cal BP (CAMS-8261), and a "central hearth" dated 13,600–13,160 cal BP (WSU-4262). A bone eyed needle was found in CZ3 "in association" with a hearth feature dated 12,470–11,810 cal BP (CAMS-5357; Holmes 1996:317).

Holzman Provenience and Dating

The Holzman archaeological site was discovered in 2015 on a gradual slope along the west bank overlooking Shaw Creek, 1 km north of its confluence with the Middle Tanana River. With seven stratified cultural components dated between 14,100 cal BP and the historic period (Wygal et al. 2018), the site contains a similar cultural chronology as other sites in the area (Holmes 2001; Potter et al. 2013). Table 2 presents radiocarbon information from Holzman components 5a and 5b, which are the focus of this article.

Aeolian silts and sands from the glacially fed Tanana River form a deep soil sequence (>3 m) blanketing the Yukon-Tanana Uplands (Péwé 1965), including Shaw Creek. Gneiss and schist with quartz veins form the bedrock. Calcareous soils preserve a remarkable archaeological record, including late Pleistocene faunal assemblages and well-preserved hearth features (Dilley 1998). At Holzman, six distinct units of sediments have no cryoturbation (Figure 4). The lower components (C3–C5) are separated from the late (C1) and middle Holocene (C2) occupations by 80–100 cm of sterile loess. From 1.0 to 1.6 m below surface, silt and very fine sandy loam (Stratum V) preserve a series of organic-rich lenses (Wygal et al. 2018). These darker soils are distinctive, with black, brown, purple, and reddened hues. In much of the literature, these features are referred to as "stringers" or "paleosols" (Dilley 1998; Holmes 1996) enhanced from human activities (Gilbert 2011; Kielhofer et al. 2020). The Pleistocene light-gray sands (Stratum VI) include bedded laminations from ~1.6 m to bedrock at approximately 3.0–3.5 m. Some limited and easily identifiable small to medium rodent krotovinas occur in some areas of the upper sands.

The cultural chronology of the site has been established through radiocarbon dates on hearth charcoal (*Salix* and *Populus* sp.), bone, and mammoth ivory. Lithic assemblages occur among fragmented mammalian remains—primarily bison, wapiti, and caribou—scattered among hearth and organic features sealed as distinct layers or components. Deeply buried late Pleistocene components 5a and 5b at Holzman occur within a stratified series of organic-rich anthropogenically enhanced stringers (Figure 5). Component 5a (C5a) contained fragmented long bones and an expedient lithic assemblage alongside tusk fragments associated with hearths. Hearth charcoal along with burned mammal and avian long bone fragments indicate a few repeat visits contributed to the formation of C5a at Holzman. Much of the C5a assemblage was oriented toward the working of mammoth ivory. Although formal lithic analyses are pending, we recovered a large anvil and numerous

Figure 3. Ivory rods and tools from Broken Mammoth CZ4, Alaska. Photos by Charles E. Holmes. Artifact numbers and descriptions after Heppner (2017).

quartz flakes, scrapers, and a heavy bifacial quartz chopper associated with an extensive ivory workstation. In one example, a steep backed quartz scraper was found in situ resting on top of a section of mammoth tusk—a clear indication of ivory working at 13,500 cal BP.

C5a contained two ivory rods associated with dated material, including a burned twig from a hearth feature dated 13,590–13,440 cal BP (BETA-531773), a mammal bone fragment dated 13,590–13,240 cal BP (D-AMS 019818), and another mammal bone fragment from a second hearth dated 13,480–13,320 cal BP (BETA-479328). A third bone fragment associated with an activity area dated to 13,080–12,830 cal BP (BETA-465551), in addition to other dates on bones that generally fall within this range (Table 2).

Component 5b (C5b) is separated from C5a by at least 10 cm of sterile bedded sand deposits and between approximately 160 and 175 cm below surface. C5b (two dates excluding ivory ranging from 14,150 to 13,520 cal BP) yielded artifacts dispersed among the Pleistocene sand deposits, including a nearly complete mammoth tusk and two small clusters of lithic artifacts, disbursed ochre, and some faunal remains. The first area, located nearest the mammoth tusk, included basalt flakes and ochre associated with a bison rib bone dated 13,770–13,520 cal BP (BETA-531771). The other artifact cluster found in the southern end of the excavation block consisted of high-quality chert flakes associated with small fragments of bone and some dispersed charcoal (*Populus-Salix* group). One of these flakes had affixed to its surface charcoal dated between 14,150 and 13,810 cal BP (BETA-531772). Therefore, the earliest evidence for mammoth ivory collection at Holzman is comparable in age to the earliest component at Swan Point CZ4b.

Holzman Ivory Rods

We recovered two ivory rods from C5a at the Holzman site (Figure 6). The first tool (AU-16-601.1) is fractured in five conjoining

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Table 2. Radiocarbon Data from Component 5a and 5b at the Holzman Site.

Lab #	^{14}C BP	1σ	Cal BP 2σ	$\delta^{13}C$‰	Component	Context/Association	Material Dated
BETA 465551	11,030	40	13,080–12,830	−19.9	5a	greasy residue and some bone	bone collagen, large mammal
D-AMS 014248	11,417	37	13,340–13,170	—	5a	anvil activity area, ivory reduction	bone collagen, large mammal
BETA 548588	11,500	40	13,470–13,300	−21.3	5a	lithic reduction area	bone collagen, bird
D-AMS 019818	11,538	81	13,590–13,240	—	5a	ivory reduction area	bone collagen, large mammal
BETA 479328	11,540	30	13,480–13,320	21.4	5a	hearth, ivory reduction area	bone collagen, large mammal
BETA 465549	11,600	30	13,580–13,350	21.8	5a	fractured mammal remains	collagen, mammoth ivory rod (tool)
BETA 531773	11,640	30	13,590–13,440	25.5	5a	hearth feature	burnt twig, Betulaceae
D-AMS 016636	11,827	34	13,790–13,590	—	5a	ivory reduction area	collagen, mammoth ivory
BETA 531771	11,800	30	13,770–13,520	−20.7	5b	sand deposits, lithic flakes, ochre	collagen, bison rib
D-AMS 018572	12,137	47	14,150–13,810	—	5b	sand deposits	collagen, mammoth tusk
BETA 531772	12,140	40	14,150–13,810	−25.9	5b	sand deposits, attached to a flake	charcoal, *Populus-Salix* group
BETA 465550	12,200	40	14,310–14,020	−22.0	5b	sand deposits	collagen, mammoth tusk

Notes: Radiocarbon dates calibrated at 2σ using OxCal v4.4.2 (Bronk Ramsey 2020). Atmospheric data from IntCal20 (Reimer et al. 2020).

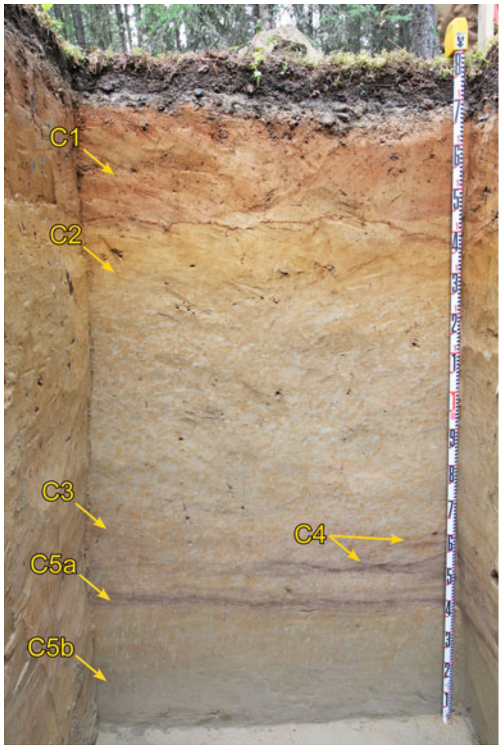

Figure 4. Stratigraphic profile of the Holzman site showing organic rich stringers and general location of cultural components. Photo of 2015 test unit by Teresa Wriston (Desert Research Institute).

fragments, including a rounded proximal base with a slightly beveled distal tip. It weighs 7.17 g and measures 125.36 L × 12.02 W × 6.82 T mm, respectively. The artifact was originally rectangular with rounded corners forming a slightly flat cross section, but it was fractured along the longitudinal plane either intentionally or from heavy postdepositional weathering. A fragment of this tool was directly dated to 13,580–13,350 cal BP (BETA-465549), representing one of the youngest dates on mammoth ivory on the Alaska mainland and overlapping with associated dates on hearth charcoal, thereby confirming concurrent occupation of mammoth and people at Shaw Creek.

The second rod (AU-16-601.2) is complete but fractured in two conjoining fragments. It is beveled on both ends with visible striations, or "hatching," on one end, and the other bevel is less discernable due to weathering. The bevel

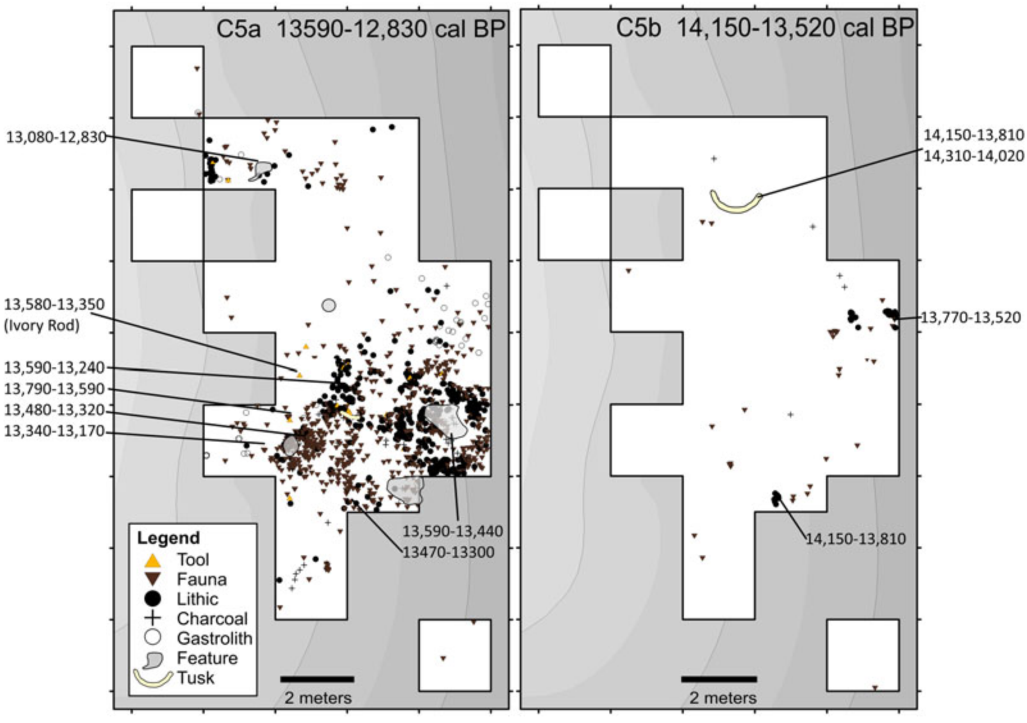

Figure 5. Map of Component 5a and 5b from the Holzman site with calibrated radiocarbon dates from Table 2. All tools recovered at Holzman to date are lithic, with the exception of the two ivory rods found in situ lying parallel to each other. A fragment from one of the rods was dated 13,580–13,350 cal BP. The dates and locations of the ivory rods are highlighted in the left margin.

lengths are 17.56 and 11.10 mm, respectively. It is round to oval in cross section, weighs 10.6 g, and measures 102.45 L × 13.4 W × 10.1 T mm.

Comparing North American Osseous Rods

The majority of late Pleistocene rods from North America are made of bone, with only a few examples of ivory tools from the Clovis era. This includes artifacts from northern Florida and one from Pyramid Lake in Nevada. Most rods made of ivory occur in Alaska (Table 1). A length and width comparison of complete and near-complete osseous rods and points from across North America indicates the two Holzman ivory rods plot nearest the two Clovis-era bone rods from Sheridan Cave, Ohio (Figure 7). A Kolmogorov-Smirnov test of rod lengths and widths indicated a significant deviation from normality. Therefore, we used a Kruskal-Wallis nonparametric test of means to test the null hypothesis that the distribution of rod lengths and widths were the same across cultural periods. Results indicate no significant difference between the cultural periods and rod lengths ($p = 0.261$), but there is a significant difference between rod widths ($p = 0.005$). A post-hoc Dunn test indicates a significant difference in rod widths between Clovis and rods from unknown late Pleistocene periods ($p = 0.004$). The post-hoc Dunn test also indicates a significant difference in the ratio of rod widths and lengths between Clovis era and post-Clovis rods ($p = 0.034$). The greatest variability among rod lengths and widths from the four periods analyzed occurred during the Clovis era.

Ivory Acquisition

There are currently 12 dates on mammoth ivory from archaeological deposits at Shaw Creek (Dilley 1998; Heppner 2017; Holmes 1996, 2001; Krasinski and Yesner 2008; Lanoë and Holmes 2016; Potter et al. 2013; Wygal et al. 2018).

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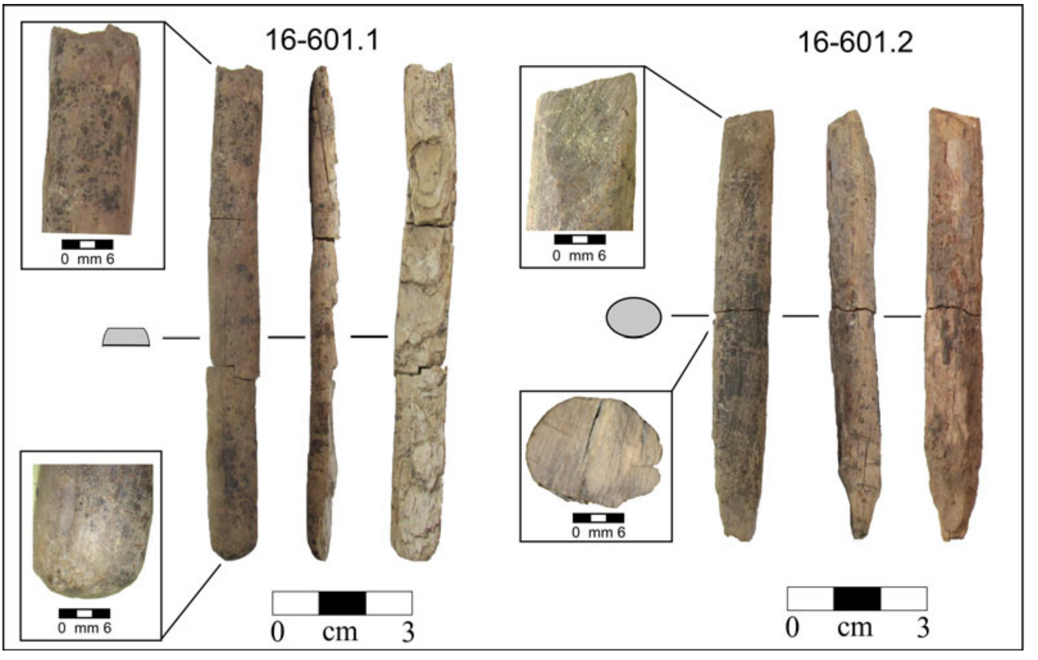

Figure 6. Ivory rods from the Holzman Component 5a. Photos by Brian Wygal.

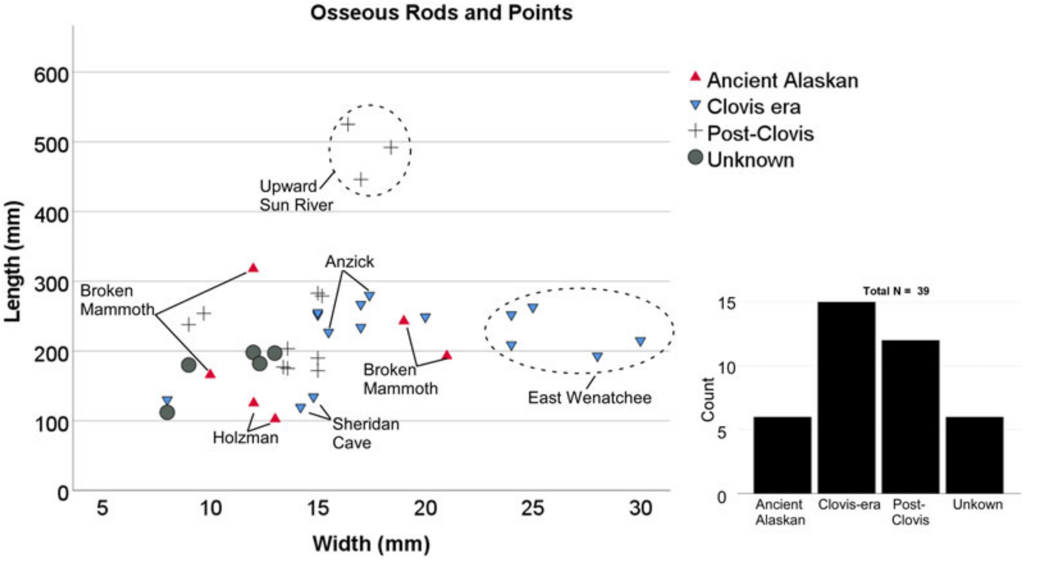

Figure 7. Comparative scatter plot of late Pleistocene complete and near-complete osseous rods and points from North America. See Table 1 for original sources.

Dates on mammoth ivory from Broken Mammoth and Mead are millennia older than the cultural components in which they were recovered, indicating that old ivory was scavenged for tool production (Heppner 2017; Lanoë et al. 2017; Potter et al. 2013; Yesner 1994, 2001). There is also evidence at Swan Point CZ4b that a juvenile mammoth was hunted as early as 14,000 cal BP (Lanoë and Holmes 2016; Lanoë et al. 2017), but such definitive evidence for hunting is rare in Alaska.

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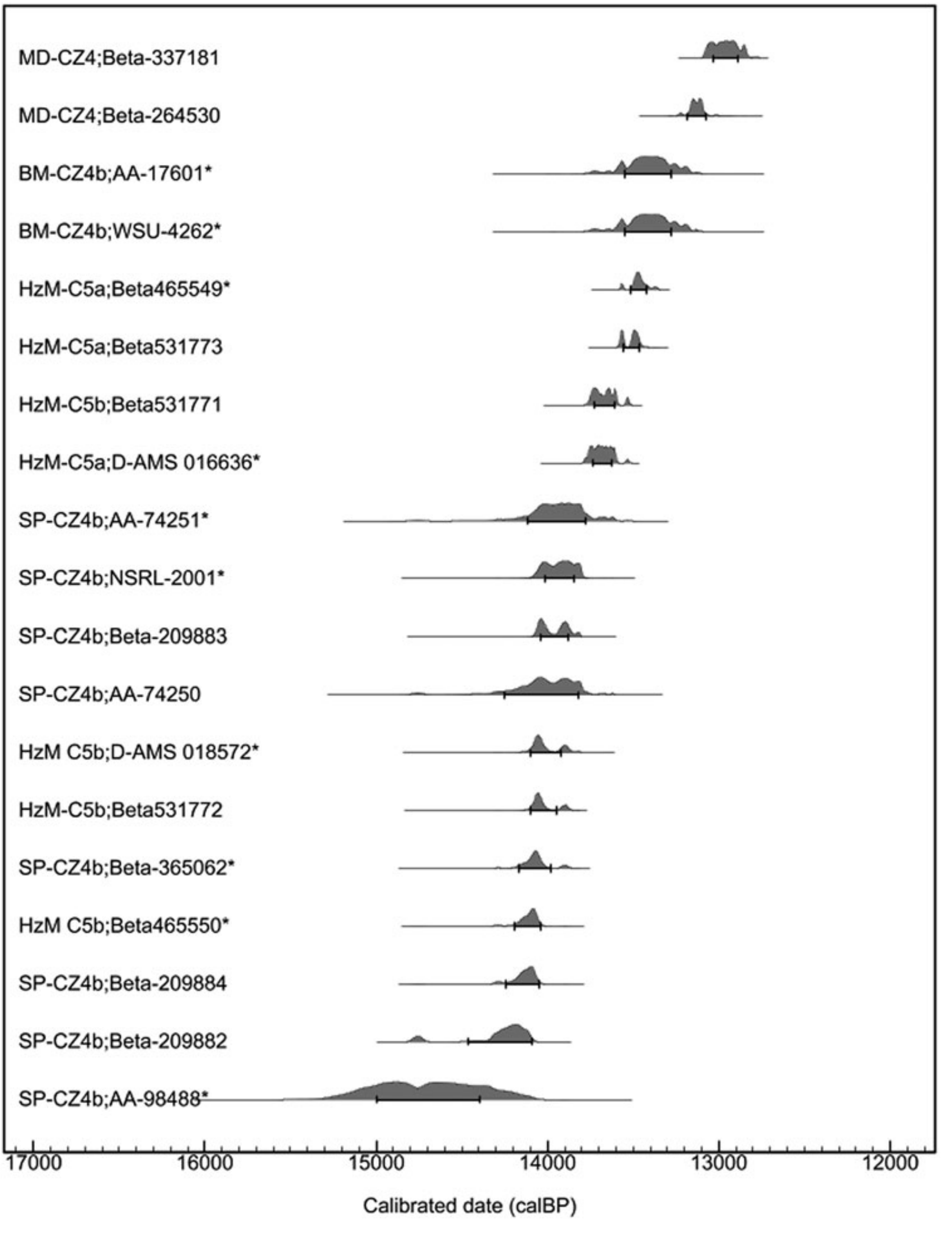

Figure 8. Earliest dates from cultural features and associated mammoth ivory at Shaw Creek sites. Data labels indicate key sites, including Mead CZ 4 (MD-CZ4), Broken Mammoth CZ4b (BM-CZ4b), Swan Point CZ4b (SP-CZ4b), and Holzman C5a and C5b (HzM-C5a/C5b), followed by the original laboratory number. Dates on ivory are indicated by *. Radiocarbon dates are calibrated at 2σ using OxCal v4.4.2 (Bronk Ramsey 2020) and atmospheric data from IntCal20 (Reimer et al. 2020).

Subfossilized ivory is easier to work than fresh ivory (Lanoë et al. 2018) and tusk caching with the intention of drying or curing ivory for later dates back to 30,000 cal BP in northern Siberia (Pitulko et al. 2015). Therefore, to determine if humans and mammoths were contemporaneous at Shaw Creek, it is important to date ivory directly and compare it to dates from

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charcoal or burned bone associated with hearth features (Figure 8). Based on four nonoverlapping radiocarbon dates on ivory artifacts from Holzman, a minimum number of three mammoths ranging in age from 14,310 to 13,350 cal BP are currently represented among the C5a and C5b assemblages (Table 2).

At Holzman, bone, ivory, and some poorly preserved antlers have been recovered from Components 4–5. In the laboratory, we distinguish ivory from bone and antler by identifying Schreger lines, unique to ivory (Fisher et al. 1998). Detailed analyses of complete tusks can provide important metrics of individual mammoths at Shaw Creek. A nearly complete and unmodified *Mammuthus primigenius* tusk (AU-16-635), thought to have been collected from nearby and cached at the Holzman site for later use, was recovered from C5b (Figure 9). The tusk has yielded two radiocarbon dates. The first from the tusk exterior dated 14,150–13,810 (D-AMS 018572), and the second from the tusk core dated 14,310–14,020 cal BP (BETA-465550). The tusk fractured during recovery, but it is preserved in two major portions: a shorter distal portion is missing the very tip, and the longer proximal portion lacks some of the pulp cavity. Pieced together, the total length of the tusk is 177 cm along its curve and 134 cm measuring straight from tip to proximal end. Exterior tusk enamel is in the process of exfoliation, but the overall shape of the tusk is preserved, showing a relatively round transverse profile and a slight curvature to the left (suggestive of a right tusk). The maximum tusk diameter, located near the proximal end of the tusk, is 81.4 mm. Comparison of tusk length and diameter to previously existing data (Averaniov 1996; Grigoriev et al. 2017; Haynes 1991; Maschenko et al. 2006; Vereshchagin and Tikhonov 1986) suggests that the Holzman tusk belongs to an adult female that was at least 30 and possibly as many as 60 years old, although a specific age at death has yet to be determined.

A thin section made from an approximately 150 × 65 mm block of dentin shows a "V" Schreger pattern, indicating that the tusk belongs to *Mammuthus* sp. (Trapani and Fisher 2003). The angle between Schreger bands (measured in ImageJ at seven different locations) ranged from 35.1° to 64.1° (mean = 45.5°), within the range of reported Schreger angles also associated with *Mammuthus* dentin (Espinoza and Mann 1993; Fisher et al. 1998). Preliminary analysis of tusk growth indicates 70 second-order increments represented, in which each increment represents approximately one week of growth (Koch et al. 1989). The average growth rate for this section of tusk is 0.09 mm per week.

Figure 9. Mammoth tusk (#16-635) from Component 5b at the Holzman site. Photo by Brian Wygal.

At Holzman, the caching of a mammoth tusk in C5b is interesting considering the limited ivory artifacts represented in this layer, and there is no evidence (so far) in either C5b or C5a of postcranial mammoth remains. The relatively sparse distribution of artifacts in C5b is also curious when compared to the density of the overlying C5a.

Discussion

Sutton (2018:194) proposed North American osseous rod technology originated with the Clovis tradition after 13,000 cal BP "perhaps with some ancestry in Beringia." Sutton (2018:184) further suggested bi-beveled and bi-pointed rods ended with Clovis, whereas uni-beveled styles continued into later Paleoindian traditions, concluding that "bi-beveled rods are Clovis markers while the other types are not." Ivory rods from Broken Mammoth and Holzman at Shaw Creek predate the earliest Clovis forms by at least 400 years. If bi-beveled rods are diagnostic of the Clovis tradition, this suggests a connection

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between the earlier Alaska forms and Clovis in the midcontinent—perhaps a direct ancestral relationship. That the Holzman ivory rods are not associated with microblade technology further supports a Paleoindian connection.

Bison clades in southern Alberta arrived from the south by 13,400 cal BP, suggesting a passable southern opening of the Ice-Free Corridor by at least that time. By 12,400 cal BP, this population arrived at the Liard River in northern British Columbia, demonstrating a northward dispersal into the heart of the Ice-Free Corridor (Heintzman et al. 2016). Studies of ice retreat suggest an earlier availability through western Alberta by 15,000 cal BP (Munyikwa et al. 2017:163). Potter and colleagues (2018:4) point to taiga vole at 14,870 cal BP (Hebda et al. 2008) and poplar from Boone Lake in northwestern Alberta, indicating the presence of woody plants by 13,500 cal BP (White et al. 1985). Potter and colleagues (2018) further argue vegetated conditions existed in some parts of the Ice-Free Corridor "well before minimum age estimates of ecological viability derived from the presence of bison and horse at 13,100 cal BP" (Potter et al. 2018:4). Based on these data, archaeologists should consider other possibilities such as migratory waterfowl as an indication of Ice-Free Corridor viability. Dalton and colleagues (2020) provide the most updated analysis on North American deglaciation, with ice retreat well underway across the Canadian Prairies of Northern Alberta after 15,000 cal BP (see Figure 1).

It should also be noted that Clovis fluted point technology is widely reported to have developed in midcontinent North America, and its iconic fluting style spread north through the Ice-Free Corridor during the early Holocene (Goebel et al. 2013; Roper and Wygal 2003; Smith and Goebel 2018; Smith et al. 2020; Wormington 1970). The Northern Fluted Point tradition, found mostly in the Brooks Range of Alaska, postdates Clovis by millennia and has not been found in association with osseous tools.

Ancient DNA provides the timing of population splits among the roots of ancestral Native Americans during the Upper Paleolithic (Pinotti et al. 2019; Raghavan et al. 2014). The genomes from the 11,500 cal BP Upward Sun River infants suggest the First Americans split from east Asians at 26,000–24,000 cal BP (Tackney et al. 2015) and subsequent divergences occurred at 22,000–18,000 and 17,500–14,500 cal BP (Moreno-Mayar et al. 2018). A genetic bottleneck is proposed during this period, although the location of this remains unknown (Graf and Buvit 2017; Huang et al. 2020; Scott et al. 2018; Sun et al. 2021). A major genetic expansion between 16,000 and 13,000 cal BP is associated with a migration south into the midcontinent of North America (Llamas et al. 2016; Skoglund and Reich 2016). Potter and colleagues (2018:2) "observe a clear pattern of human expansion from Siberia to Beringia around 16,000 to 14,000 years (Potter et al. 2017) and the first unequivocal widespread occupations south of glacial ice in the Americas after 13,500 years ago, associated with Clovis."

The late Pleistocene sites along Shaw Creek are located near the northern gateway to the Ice-Free Corridor through Canada, and they represent the earliest evidence for technological continuity between Asia and eastern Beringia. The Shaw Creek sites offer the strongest incontrovertible evidence for people in interior Alaska before the development of the Clovis tradition. In the absence of comparable lithic assemblages bearing diagnostic traits linking Clovis with Beringia or Siberia (Haynes 2015), the beveled rods from Holzman provide intriguing similarities that suggest a proximal population located at the right place and time. Moreover, the earliest Alaskans are found in the interior, from where some time was taken before coastal regions were initially exlpored. Consequently, the timing of continental deglaciation, viability of the Ice-Free Corridor, and recent aDNA analyses (Huang et al. 2020; Moreno-Mayar et al. 2018; Sun et al. 2021) are important factors to consider when working out the timing and route of the First Americans.

Conclusion

Beveled points and rods were a stable component of late Pleistocene technology and therefore offer the opportunity to discuss continuity of osseous technology relative to the continental dispersals of modern humans. The preference for ivory use over bone and antler is apparent in Eurasia and Alaska—perhaps a result of its abundance on the landscape relative to the lack of wood on the mammoth steppe—but in midcontinent North America, rods and points are more commonly made on bison or mammoth long bone. Mammoth tusk acquisition and ivory tool production is a common theme among the earliest components (14,100–13,300 cal BP) at Broken Mammoth, Mead, Swan Point, and the recently discovered Holzman site along Shaw Creek in interior Alaska.

We describe two late Pleistocene ivory rods from the Holzman site. The tools are similar in style and age to tools recovered at Broken Mammoth. The beveled ivory rods from Shaw Creek, Alaska, predate the Clovis tradition from south of the ice sheets making them the oldest known examples of rod technology in the Americas. The finds are significant when compared to the timing of late Pleistocene deglaciation of the Canadian ice sheets and within the broader contexts of recent aDNA studies into the source migrations of Native Americas.

Acknowledgments. We recognize that our research occurs at Debedee Na' (sheep horn creek) on ancestral Dene land. This research was made possible by Shaw Creek Archaeological Research LLC and funded by Adelphi University in New York. We also thank David McMahan for contributing charcoal identifications and Yan Axel Gómez Coutouly for reviewing our Spanish abstract translation. We express particular gratitude to the many field school students and field supervisors who spent considerable effort excavating the deep deposits at Holzman.

Data Availability Statement. The data and artifacts for this article are stored at the Adelphi University Archaeology Laboratory in Garden City, New York.

Note

1. All previously reported dates from other sources were calibrated here from original radiocarbon dates at 2σ using OxCal v4.4.2 (Bronk Ramsey 2020) and the Intcal20 climate curve (Reimer et al. 2020).

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