

## DRY CREEK REVISITED: NEW EXCAVATIONS, RADIOCARBON DATES, AND SITE FORMATION INFORM ON THE PEOPLING OF EASTERN BERINGIA

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*The multicomponent Dry Creek site, located in the Nenana Valley, central Alaska, is arguably one of the most important archaeological sites in Beringia. Original work in the 1970s identified two separate cultural layers, called Components 1 and 2, thought to date to the terminal Pleistocene and suggesting that the site was visited by Upper Paleolithic hunter-gatherers between about 13,000 and 12,000 calendar years before present (cal B.P.). The oldest of these became the type-assembly for the Nenana complex. Recently, some have questioned the geoarchaeological integrity of the site's early deposits, suggesting that the separated cultural layers resulted from natural postdepositional disturbances. In 2011, we revisited Dry Creek to independently assess the site's age and formation. Here we present our findings and reaffirm original interpretations of clear separation of two terminal Pleistocene cultural occupations. For the first time, we report direct radiocarbon dates on cultural features associated with both occupation zones, one dating to 13,485–13,305 and the other to 11,060–10,590 cal B.P.*

*El sitio de múltiples componentes de Dry Creek ubicado en el valle de Nenana, Alaska central, es sin duda uno de los sitios arqueológicos más importantes de Beringia. En el trabajo original se identificaron dos capas culturales independientes, los componentes 1 y 2, que datan del Pleistoceno Terminal y se estableció que el sitio fue visitado por cazadores-recolectores del Paleolítico superior hace aproximadamente 13.000 y 12.000 años calendáricos antes del presente (cal a.P.). Desde entonces varios investigadores han puesto en duda la integridad geoarqueológica de los depósitos tempranos del sitio, y sugirieron que la separación de las capas culturales es el resultado de procesos postdeposicionales. En 2011 volvimos a visitar Dry Creek para llevar a cabo un estudio integral de las fechas y de los procesos de formación del sitio. En este trabajo presentamos nuestras conclusiones y reafirmamos las interpretaciones originales acerca de la existencia de una clara separación de dos ocupaciones culturales del Pleistoceno terminal. Por primera vez, se presentan fechas directas de radiocarbono sobre los rasgos culturales asociados con cada uno de estos dos eventos de ocupación, uno datado en 13,485–13,305 y el otro de 11,060–10,590 cal a.P.*

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**T**raditionally archaeologists have looked to Beringia for origins of the first Americans, explaining the peopling of the Americas as the result of migration from Asia to North America via Beringia, the northern expanse that connected the two continents during the late Pleistocene. Beringia and Siberia, however, have yet

to provide an obvious archaeological progenitor predating and resembling Clovis (Stanford and Bradley 2012), the earliest unequivocal archaeological complex of sites in the Americas dating to about 13,000 calendar years before present (cal B.P.) (Waters and Stafford 2007). Despite the lack of perceived technological continuity between late

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Pleistocene Siberia and the Americas, human genomic data from both modern and ancient Native Americans and Asians (Fu et al. 2013; Raghavan et al. 2014; Rasmussen 2014; Tamm et al. 2007) clearly document that all Native Americans originated in Northeast Asia. Therefore, we are compelled to continue searching Beringia for clues to unravel the story of dispersal to the New World. Recent developments in the terminal Pleistocene archaeological record in central Alaska fueled our desire to revisit one of the best known Beringian sites, Dry Creek. Concerns regarding the site's stratigraphic and archaeological integrity have emerged, calling into question its importance as an early site. Our research provides answers to these questions and places Dry Creek squarely at the heart of Beringian research.

### Background

Alaska's and northeast Asia's varied landscapes are remote and difficult to access, so that few sites unequivocally dating before the Younger Dryas have been found. Moreover, known late Pleistocene sites present a complicated array of lithic assemblages, the significance of which we still do not fully understand (Bever 2006; Goebel and Buvit 2011). A perfect case is the central Alaskan record from the Nenana and Tanana valleys, and more specifically the National Historic Landmark site of Dry Creek. Despite never being fully reported, since its discovery over 40 years ago, Dry Creek has remained perhaps the best known early Alaskan archaeological site (Feder 2013; Klein 2009). In 1974 and 1976–1977, W. R. Powers directed excavations of the site, excavating 347 m<sup>2</sup> and finding three cultural components with distinct lithic assemblages. The lower two, dating to the late Pleistocene, are the focus of this paper. The upper of these, Component 2, was considered to date to 12,200 cal B.P. and contained wedge-shaped microblade cores, microblades, burins, and lanceolate bifaces typical of the “Denali complex” (as defined by F. H. West [1967]). The lower Component 1 was different, reportedly dating to about 13,000 cal B.P. and containing small triangular-shaped bifacial points and unifacial tools but no evidence of microblade technology. Based on the stratigraphic separation and technological distinctiveness of

the lower component, as well as subsequent findings at other Nenana Valley sites such as Walker Road, Moose Creek, and Owl Ridge, Powers and Hoffecker (1989) defined the “Nenana complex.” They proposed that the Nenana complex could represent the initial human dispersal from Northeast Asia to Beringia as well as the Americas, a possible antecedent of Clovis in temperate North America, while the Denali complex represented a subsequent migration from Northeast Asia (Goebel et al. 1991; Hoffecker et al. 1993; see also Bever 2001; Haynes 1987; Haynes 2002). Soon after reports on Broken Mammoth, a Tanana Valley site with Nenana-complex-like artifacts, were published with radiocarbon dates ranging from 14,000–13,000 cal B.P., pushing the age of the Nenana complex back into the Allerød, before Clovis (Yesner 1996, 2001; Yesner et al. 1992).

This interpretation of the eastern Beringian archaeological record was soon challenged. First, complications surfaced with discovery of Swan Point, located a few kilometers from Broken Mammoth. A microblade-based industry, more similar to the Siberian Diuktai complex than Alaska's Denali complex (Gómez-Coutouly 2011), was found in the site's lowest layer, predating the Nenana complex by several centuries (Holmes 2001, 2011; Holmes et al. 1996). Suddenly Nenana sites could no longer represent the initial wave of migration to Beringia. Obvious questions emerged. Why did some late-glacial Beringian sites contain microblade industries while others did not? Was there really temporal and technological separation between cultural occupations with assemblages that had microblades and those that did not? Did terminal Pleistocene lithic variability represent different human groups or different activities performed by the same population (Dumond 1980, 2001; Goebel and Buvit 2011; Hoffecker and Elias 2007; Holmes 2001; Potter 2008; Potter et al. 2014; West 1996a)?

Another challenge came from emerging concerns regarding the geological integrity of the Dry Creek site itself. The problem centered on whether we could rely on the stratigraphic, temporal, and technological separation of Dry Creek's Components 1 and 2 (Colinvaux and West 1984; Dumond 1980, 2001; Odess and Shirar 2007; Potter 2008; Schweger et al. 1982; Thorson 2006), with concerns falling into two categories: (1) sampling

bias and (2) postdepositional movement and mixing of cultural materials.

Schweger et al. (1982) argued that the sample size of Component 1 was too small to reject the possibility that it represented a Denali complex occupation in which microblades either had not been found or simply were not made and used. "The differences between the two Dry Creek assemblages would probably appear less significant if a larger inventory" was available from Component 1 (Schweger et al. 1982:440). Dumond (1980) and Colinvaux and West (1984) expressed similar concerns. Conceivably, this argument was plausible in the early 1980s; however, it is no longer tenable because at 347 m<sup>2</sup> the Dry Creek excavation surpasses all other horizontal areas excavated at early-period sites in Alaska (except perhaps Broken Mammoth [see Potter et al. 2014]). Moreover, the Component 1 assemblage of 4,524 artifacts numbers at or near other assemblages predating 13,000 cal B.P. (e.g., Moose Creek Component 1, 2,259 [Pearson 1999]; Walker Road Component 1, 4,980 [Goebel et al. 1991; Goebel et al. 1996]; Owl Ridge Component 1, 1,038 [Gore and Graf 2015]; Broken Mammoth Cultural Zone 4, 1,319 [Krasinski and Yesner 2008]). Further, most Denali complex assemblages contain far fewer artifacts than the 4,524 from Dry Creek Component 1 (e.g., Donnelly Ridge, 1,513 [West 1996]; Chugwater, 1,223 [Lively 1996]; Phipps, 1,628 [West, Robinson, and Curran 1996]; Sparks Point, 586 [West, Robinson, and Dixon 1996]; Hidden Falls, 612 [Davis 1996]; Panguingue Creek, 72 [Goebel and Bigelow 1996]; Owl Ridge Component 2, 1,386 [Gore and Graf 2015]; Broken Mammoth Cultural Zone 3, 4,065 [Krasinski and Yesner 2008]). Given the central Alaskan record that has emerged during the past 30 years, it is very difficult to argue that Dry Creek Component 1 is too small to make determinations about its technological character. Even if it was, the existence of similar Nenana complex assemblages at other sites, especially Walker Road, Moose Creek, and Owl Ridge, make this argument moot.

The more enduring issue raised about Dry Creek Component 1 focuses on postdepositional displacement of Component 2 artifacts. Dumond (2001) pointed out that Component 1 artifact clusters underlie Component 2 clusters, which could

have resulted from postdepositional movement of Component 2 artifacts downward to form either an artificial Component 1 made solely of Component 2 artifacts or a mixed layer containing both secondarily deposited Component 2 and Component 1 artifacts. Thorson (2006) echoed this by making three additional points regarding possible movement and mixing. First, Sand 1, which separated the two components, was thin and discontinuous across the site, so in some places Loess 3 (containing Component 2) was found directly overlying Loess 2 (Component 1). Second, when original radiocarbon dates reported for Loess 2 and 3 were calibrated, they overlapped at  $2\sigma$ , making their ages statistically contemporaneous. Third, because Component 1 clusters were found only near the terrace edge, a place where site deposits annually freeze and thaw and during summer months become desiccated, they were highly susceptible to postdepositional processes such as crack formation, faunal burrowing, and solifluction.

While examining Powers's original assemblage in the University of Alaska Museum of the North, Odess and Shirar (2007:130) found a single artifact in Component 1 that they interpreted to be a microblade-core tablet, which original site investigators and subsequent lithic analysts misidentified as "non-diagnostic debitage." To them, the presence of this artifact meant one of two things: either it originated from overlying Component 2 and moved down through the profile, or Component 1 was really a Denali complex occupation. The lead author (Graf) examined this artifact in 2010 and found it to be a bipolar spall, not a core tablet (Supplemental Text 1). Nonetheless, these critiques, coupled with the findings at Swan Point, have contributed to a downplaying of the lithic technological variability potentially evident at Dry Creek, and the emergence of the notion of a comprehensive "Beringian Tradition" inclusive of all late Pleistocene/early Holocene Alaskan assemblages (Holmes 2001; Potter 2008), which by its large scope obviously subsumes multiple industries and masks potentially significant assemblage differences (Goebel and Buvit 2011).

For years, Dry Creek was heralded as one of the oldest and most important sites in first Alaskans and Americans research. Given the concerns raised above, the site deserved to be reinvestigated using modern techniques to assess ge-

ological and cultural stratigraphic integrity. Therefore, in 2011, we revisited Dry Creek to carefully document site formation to test the hypothesis that Dry Creek Component 1 resulted from post-depositional movement and mixing from overlying Component 2. Below we present our findings, focusing on Components 1 and 2, but first we briefly review past work at the site and methods we employed in collecting new data.

### Dry Creek

The Dry Creek site (HEA-005) was initially discovered in May 1973 by C. Holmes. He found artifacts eroding from the loess-mantled Healy-aged glacial-outwash terrace overlooking Dry Creek about 3 km west of its confluence with the Nenana River (Figure 1). Geological studies were initially undertaken by T. Hamilton and R. Thorson and subsequently by N. Bigelow, faunal analyses were conducted by R. D. Guthrie, and lithic technological analyses were performed by Powers and subsequently by T. Goebel (Bigelow and Powers 1994; Goebel 1990; Goebel et al. 1991; Guthrie 1983; Powers and Hamilton 1978; Powers and Hoffecker 1989; Powers et al. 1983; Thorson and Hamilton 1977). Cultural components were found in loess units interbedded with eolian sands, with Component 1 in Loess 2, and Component 2 in Loess 3 and associated with Paleosol 1.

Early investigations reported 18 radiocarbon dates and a single thermoluminescence assay for the site's unconsolidated sediment package (Table 1) (Bigelow and Powers 1994; Hoffecker 1988; Hoffecker et al. 1996; Powers and Hamilton 1978; Powers et al. 1983; Thorson and Hamilton 1977). Due to contamination from locally derived lignite dust and attempts to date problematic materials like soil organics, many of the radiocarbon assays obtained by Powers's team in the 1970s were found to be incongruent and dismissed. Only two dates,  $11,120 \pm 85$  radiocarbon years before present (B.P.) (SI-2880) from Loess 2 and  $10,690 \pm 250$  B.P. (SI-1561) from Loess 3 (Paleosol 1), were used to date the late-glacial cultural components. To better date site sediments using AMS radiocarbon methods, Bigelow and Powers (1994) cleaned profiles along the western margin of the excavation block, obtaining an additional six ages on natural wood charcoal from Paleosol 1. Sig-

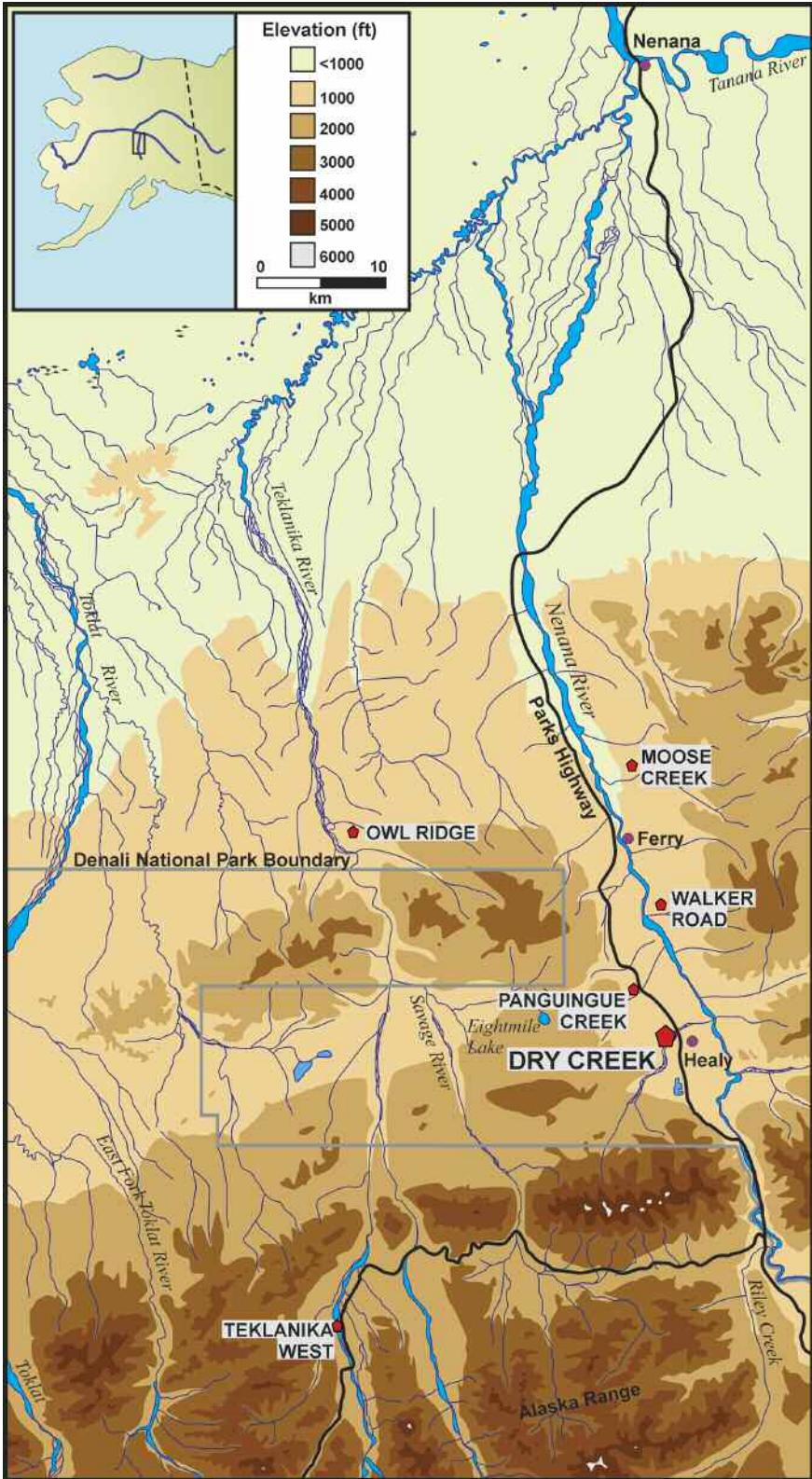
nificantly, none of the previously reported radiocarbon dates were obtained directly from identified and mapped cultural features, and dispersed samples from the paleosols likely reflect a boreal-forest wildland-fire regime (Lloyd et al. 2006). All came from dispersed charcoal and macrobotanical remains providing age ranges of 13,130–12,780 cal B.P. for Loess 2 and 13,100–11,200 cal B.P. for Loess 3 (Paleosol 1).

Original excavations produced 35,777 lithic artifacts and at least 74 faunal remains (Powers et al. 1983). In Component 1, three artifact clusters, labeled X, Y, and Z, were mapped near the bluff edge (Figure 2). About 50 percent of the cultural materials excavated from Component 1 came from these concentrations. Lithics from Component 1 numbered 4,524, including 4,461 debitage pieces, seven cores, and 56 tools (Goebel 1990; Graf and Goebel 2009). Goebel's (1990) technological study found that primary reduction centered on reduction of blade and flake cores, and secondary reduction focused on production and maintenance of small triangular-shaped bifacial points, end scrapers, side scrapers, graters, notches, retouched flakes and blades, and cobble tools. Microblade technology was absent. Twenty-seven extremely weathered faunal remains were found (Hoffecker 1983); among them were several poorly preserved fragments of teeth identified as Dall sheep and wapiti (Guthrie 1983). Spatial distributions of artifacts indicated that weapon production and maintenance, as well as animal butchering, took place in the three artifact clusters (Hoffecker 1983; Smith 1985).

Fourteen clusters (ca. 70 percent of the assemblage) were mapped in Component 2. Powers et al. (1983) reported 28,881 artifacts. Goebel's (1990) analysis sampled 14,434 debitage pieces, but included all cores (116) and tools (330). Primary reduction focused on production of microblades, blades, and flakes, while secondary reduction focused on production of lanceolate bifacial points and unifacial tools, including retouched flakes and blades, side scrapers, graters, notches, denticulates, burins, and cobble tools. Faunal remains numbered 47 (Hoffecker 1983), with identifiable pieces being Dall sheep and bison (Guthrie 1983). Cluster ac-

**Figure 1 (opposite).** Locations of the Dry Creek site and others in greater Nenana Valley.





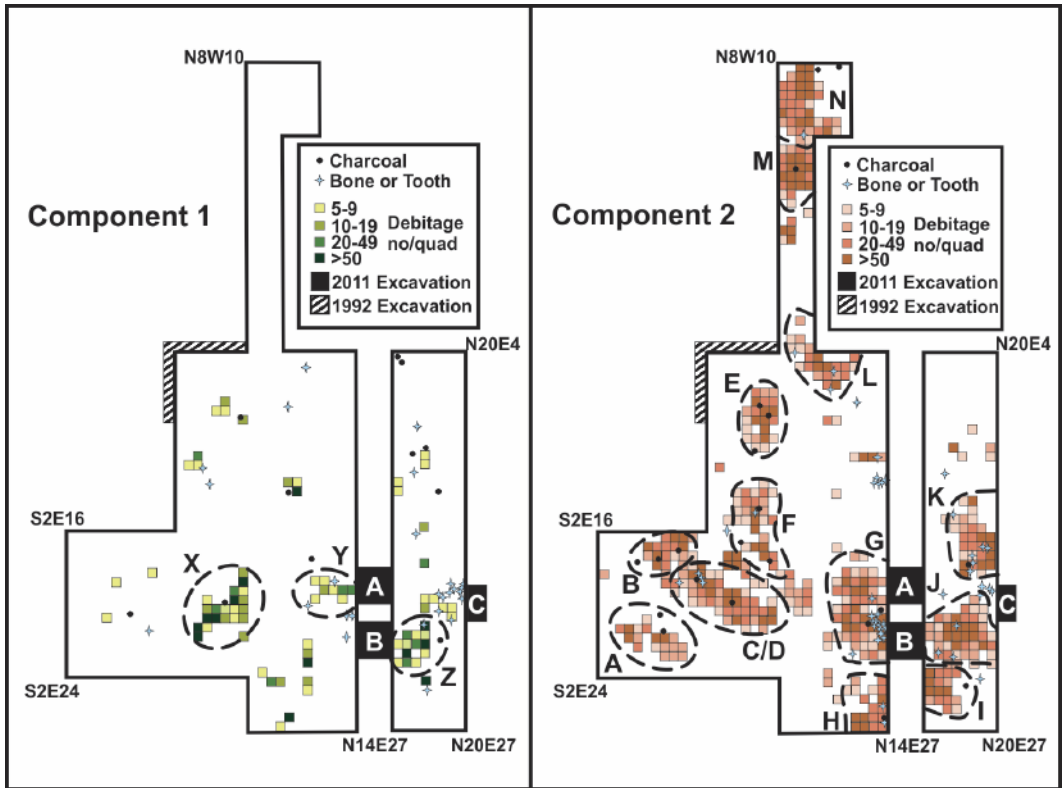


Figure 2. Excavation maps of Components 1 and 2 from original excavations at Dry Creek (adapted from Powers et al. 1983). Note relative locations of 2011 excavation blocks A, B, and C.

tivities focused on weapon production and maintenance, butchering-tool maintenance, and animal-carcass butchering (Hoffecker 1983).

#### Site Excavation Methods and Analytical Procedures

The 2011 excavations at Dry Creek covered an area of 10 m<sup>2</sup>. Two 2-x-2-m blocks (A and B) and one 1-x-2-m block (C) were placed adjacent to previous excavations where Component 1 artifact clusters (Y and Z) were directly overlain by Component 2 artifact clusters (G and J) (Figure 2). During our excavations of blocks A and B, we encountered a mixture of backfill and very recent cliffhead sands directly overlying the contact of Loess 5/Paleosol 3 with Loess 4 (Figure 3). (Much to the chagrin of Powers, and while backfilling in 1977, the bulldozer operator inadvertently scraped away the top 50–80 cm of intact deposits in this area of the site.) Although we were unable to ex-

perience the late Holocene profile in this area of the site, we were able to quickly access the lower portion of the profile, our immediate objective. Block C remained unscathed by the 1970s bulldozer and provided a view of the entire stratigraphic profile.

The 2011 excavations followed standard procedures. Site sediments were removed by hand troweling. All excavated sediment was dry-screened through 1/8-inch mesh. Artifacts, bones, and charcoal samples recovered in situ were recorded with three-point provenience using a Sokkia EDM total station. Materials recovered from the screen were assigned to 50-cm<sup>2</sup> horizontal quadrants and 5-cm vertical levels excavated within recognizable stratigraphic units. The top of each new stratigraphic unit was exposed, mapped, and photographed across the entire block before its excavation commenced. Trend and plunge (i.e., dip direction and angle) of artifacts were measured using Silva Ranger clinometer

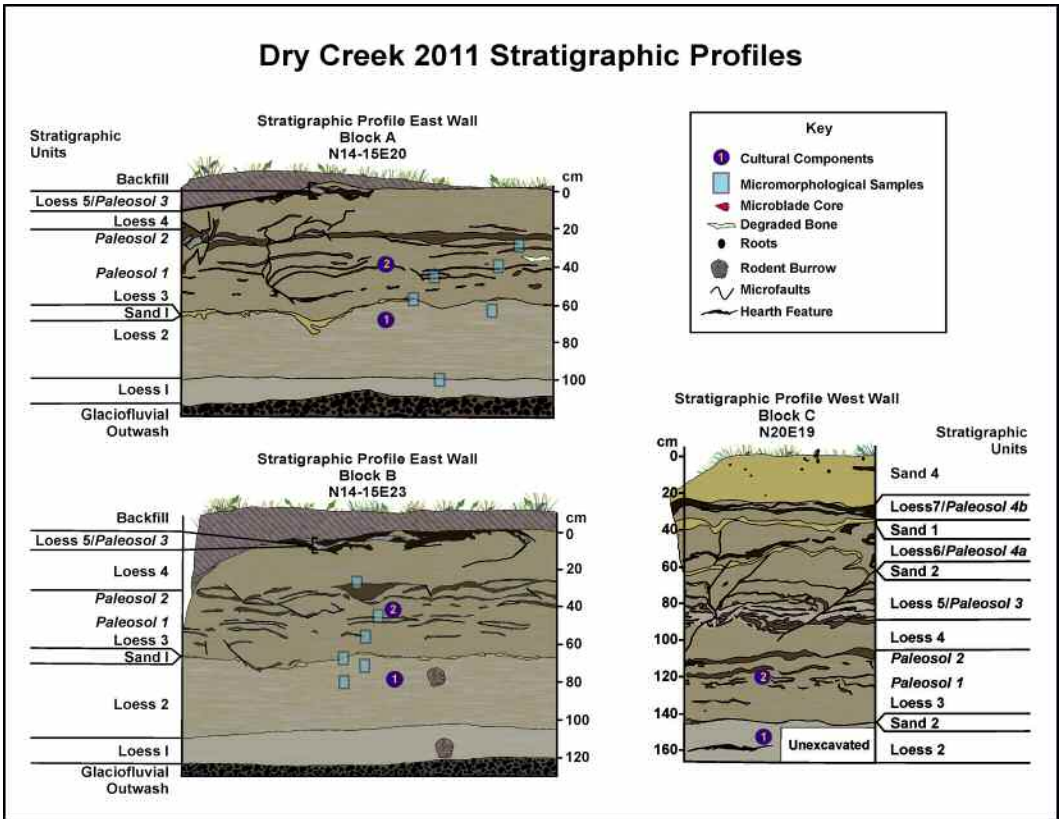


Figure 3. Stratigraphic profiles from the 2011 excavations. Profiles of blocks A and B represent their eastern walls, while the profile of block C represents the western wall.

compasses when the artifact’s original aspect could be confidently assessed. All postdepositional disturbances were documented in plan views for each stratigraphic boundary and reflected in site profiles. Sediment and stratigraphic descriptions and profiles were completed in the field.

Micromorphological samples were collected by driving plastic conduit boxes into exposed excavation faces and profile walls. Samples encased in the boxes were removed with provenience and orientation information recorded in the field. In the lab, samples were air dried, impregnated with Hillquist epoxy, and prepared into 2-x-3-in thin sections. Analyses of the micromorphological samples were accomplished using an Olympus BX-51 research microscope with both polarized light and UV fluorescence at Baylor University. Thin sections were photographed using a Leica DFC 450 camera attachment.

Charcoal samples were identified taxonomically using plant reference collections and libraries

at the Desert Research Institute (Reno) and Department of Anthropology at Texas A&M University. Radiocarbon analyses were based entirely on samples collected directly from hearth features during our excavations. Two samples were prepared, pretreated, and analyzed by Beta Analytic, Inc. Four additional samples were prepared and pretreated at the Human Paleocology and Isotope Geochemistry Lab, Pennsylvania State University, with assays obtained from the W. M. Keck Carbon Cycle Accelerator Mass Spectrometry facility at the University of California, Irvine (UCIAMS). Physical preparation and chemical pretreatment of samples followed regular procedures (Supplemental Text 1). All <sup>14</sup>C ages were δ<sup>13</sup>C-corrected for mass dependent fractionation with measured δ<sup>13</sup>C values, following Stuiver and Polach (1977). Paired dates from hearth features were combined using the method of Ward and Wilson (1978) after testing for contemporaneity (χ<sup>2</sup> test) and calibrated and modeled with OxCal 4.2.3 (Bronk Ramsey

Table 1. Dry Creek Radiocarbon Dates.

				Previously Reported Radiocarbon Dates.			
Stratum	Component	Square	Feature	Lab Material	Age Number <sup>a</sup>	Age Estimate <sup>b</sup>	Calibrated <sup>c</sup>
PSc 4b	--	--	--	charcoal	SI-1933A	modern	--
PS 4b	--	--	--	charcoal	SI-1933B	375 ± 40	507–315
PS 4b	--	--	--	charcoal	SI-2333	1145 ± 60	1229–934
PS 4a	4	--	--	charcoal	SI-2332	3430 ± 75	3876–3483
PS 4a	4	--	--	charcoal	SI-1934	3655 ± 60	4150–3835
PS 4a	4	--	--	charcoal	SI-1937	4670 ± 95	5597–5054
PS 3	--	--	--	charcoal	SI-2331	6270 ± 110	7424–6930
PS 3	--	--	--	charcoal	SI-1935C	6900 ± 95	7932–7588
PS 3	--	--	--	charcoal	SI-1935B	8355 ± 190	9860–8762
PS 3	--	--	--	charcoal	SI-2115	8600 ± 460	11,070–8537
PS 3	--	--	--	charcoal	SI-1935A	10,600 ± 580d	13,715–10,756
PS 3	--	--	--	charcoal	SI-1544	19,050 ± 1500 <sup>d</sup>	27,164–19,952
PS 2	--	test pit	--	charcoal	SI-2328	7985 ± 105 <sup>d</sup>	9129–8560
PS 2	--	--	--	charcoal	SI-2329	9340 ± 195 <sup>e</sup>	11,182–10,188
PS 2	--	--	--	charcoal/plant	AA-11733	9340 ± 95	11,057–10,249
PS 2	--	--	--	charcoal/plant	AA-11732	9690 ± 75	11,237–10,780
PS 2	--	--	--	charcoal/plant	AA-11731	10,540 ± 70 <sup>d</sup>	12,690–12,167
PS 2	--	--	--	charcoal	SI-1936	12,080 ± 1025 <sup>d</sup>	17,666–11,978
PS 2	--	--	--	charcoal	SI-1938	23,980 ± 9300 <sup>d</sup>	45,061–7259
PS 1	--	--	--	charcoal/plant	AA-11730	8915 ± 70 <sup>d</sup>	10,222–9776
PS 1	2	--	--	charcoal/plant	AA-11727	10,060 ± 75	11,963–11,286
PS 1	2	--	--	charcoal/plant	AA-11728	10,615 ± 100	12,733–12,187
PS 1	2	--	--	charcoal	SI-1561	10,690 ± 250	13,094–11,825
Loess 2	1	--	--	charcoal	SI-2880	11,120 ± 85	13,131–12,774

New Radiocarbon Dates from the Current Study.

Stratum	Component	Square	Feature	Material	Lab Number	Age Estimate <sup>a,f</sup>	Age Calibrated <sup>c</sup>
Loess 3	2	N14E19	11.01	hearth charcoal, <i>Salix</i> sp.	UCIAMS-135115	9480 ± 35	11,070–10,580
Loess 3	2	N14E19	11.01	hearth charcoal, <i>Salix</i> sp.	BETA-315410	9460 ± 40	11,070–10,560
Loess 2	1	N14/15 E21/22	11.02	hearth charcoal, <i>Salix</i> sp.	UCIAMS-135114	11,510 ± 40	13,450–13,270
Loess 2	1	N14-15 E21-22	11.02	hearth charcoal, <i>Salix</i> sp.	BETA-315411	11,530 ± 50	13,460–13,280
Loess 2	1	N20E19	11.03	hearth charcoal, <i>Salix</i> sp.	UCIAMS-135113	11,580 ± 40	13,490–13,300
Loess 2	1	N20E19	11.03	hearth charcoal, <i>Salix</i> sp.	UCIAMS-135112	11,635 ± 40	13,570–13,380

<sup>a</sup>SI dates from Thorson and Hamilton (1977); AA dates from Bigelow and Powers (1994).

<sup>b</sup>Age in radiocarbon years before present (B.P.); reported with 1σ (standard deviation).

<sup>c</sup>Calibrated using OxCal v4.2.3 Bronk Ramsey 2013; r:5 IntCal13 atmospheric curve (Reimer et al. 2013); 2σ range.

<sup>d</sup>Dates dismissed by Thorson and Hamilton (1977), Powers et al. (1983), and Bigelow and Powers (1994).

<sup>e</sup>Date erroneously associated with component 2 in Table 4 of Thorson and Hamilton (1977; see in-text discussion).

<sup>f</sup>Dates corrected for isotopic fractionation following Stuiver and Polach (1977).

2009, 2013) using the IntCal13 northern hemisphere atmospheric curve (Reimer et al. 2013).

Faunal remains were not well-preserved, with analyses being limited to taxonomically identifying better-preserved bone and tooth fragments using comparative specimens in the Alaska Consor-

tium of Zooarchaeology in Anchorage and Department of Mammalogy, University of Alaska Museum of the North, and scoring standard descriptive zooarchaeological and taphonomic variables developed by Krasinski (2010). Basic lithic artifact analyses followed an analytical protocol



for early-period archaeological assemblages from Alaska and Siberia (following Graf 2010; Graf and Goebel 2009).

## Results

Here we present Component 1 and Component 2 data collected from the 2011 fieldwork to assess the integrity of the terminal Pleistocene cultural deposits. Data are derived from site stratigraphy, micromorphology, and chronology and associated features, lithics, and faunal remains.

### *Stratigraphic Context and Site Formation*

The Dry Creek site rests within a package of eolian silts and sands with maximum thickness of 200 cm, with a slope aspect of 120 degrees east of true north and a slope gradient of 10.5 percent or 6 degrees. This package is positioned unconformably above early Upper Pleistocene glacial outwash, a remnant of the local Healy terrace (Dortch et al. 2010; Ritter 1982; Thorson 1986; Wahrhaftig 1958). We recognized the same 11 eolian sedimentological units identified by Thorson and Hamilton (1977) (Figure 3), but here we present only the lower sediment package containing and bracketing Components 1 and 2: Loess 1, Loess 2, Sand 1, and Loess 3.

Loess 1 forms the base of the late Pleistocene-Holocene deposits, measures 10–20 cm in thickness, and is composed of a compact grayish brown (2.5Y 5/2) silty loam with unsorted angular clasts and tight cohesiveness. Generally, the unit forms an abrupt boundary with the underlying glacial outwash, but occasionally isolated lenses of pebble-sized clasts, likely frost heaved up from below, are seen near its lower boundary. The upper boundary of Loess 1 is texturally gradual, becoming coarser in its upper 5 cm. There is an abrupt color change at the boundary with Loess 2, helping to delineate the contact. Loess 2 measures 25–40 cm thick and is composed of a cohesive, yellowish brown (10YR 5/8) to light gray (10YR 7/1) mottled sandy loam with unsorted angular clasts. *Mottles* are redoximorphic masses and filaments that resulted from periods of alternating reduction and oxidation of iron compounds in the sediment. A few ancient krotovinas were observed. The upper boundary of Loess 2 with Sand 1 is clear. Cultural Component 1 is isolated within a 5–10 cm thick

layer about 5 cm below the upper contact of Loess 2 with overlying Sand 1.

Sand 1 measures 5 cm in thickness. Contrary to Thorson (2006) but in agreement with Thorson and Hamilton (1977), we were able to document Sand 1 as a continuous unit across our excavations. Though quite thin (< 1 cm) in some places, through careful excavation we were able to observe concentrations of medium-sized sand grains when Sand 1 was thinning and capture its upper boundary in situ. Sand 1 consists of well-sorted rounded to subrounded clasts, is yellowish brown (10YR 5/4) in color, and occasionally expresses some minor down-slope creep or solifluction folds of 1–2 cm vertical distance over 5–20 cm horizontal distance. Its upper boundary is clear. Loess 3 measures 25–35 cm in thickness, is composed of a cohesive strong brown (7.5YR 5/8) to light gray (10YR 7/1) mottled sandy loam with unsorted, angular clasts, and contains two paleosols. Loess 3 expresses weak microfaulting and forms a clear upper boundary with Loess 4. Paleosol 1 was described as a complex of three to four AB horizons within Loess 3 (Thorson and Hamilton 1977). We observed this pattern in the field, but we attribute it not to individual horizons but to the same AB horizon that is minimally affected by solifluction with folds of 2–3 cm vertical distance over 25–50 cm horizontal distance. In cross section, this condition appears to resemble multiple closely associated paleosol horizons, but upon further inspection we isolated several minor yet recognizable involutions of a singular paleosol. Paleosol 1 is 7.5YR 4/3 brown to 5YR 5/4 reddish brown in color. Cultural Component 2 is reportedly associated with Paleosol 1 (Thorson and Hamilton 1977); however, we isolated artifacts with three-point provenience both in the paleosol and mottled loess around it. Paleosol 2, also in Loess 3, consists of at least two sets of weakly developed A/Eg/B soil horizons measuring about 8–10 cm in thickness and found continuously distributed across the excavation blocks. No artifacts were found associated with this set of soil horizons in upper Loess 3. The upper sediment package (70–110 cm in thickness) consists of alternating loesses and eolian sands and contains Component 4.

Field observations of the geological context of the site suggest the stratigraphic integrity of Dry Creek. Boundaries at stratigraphic contacts are

well-defined. Cryoturbation is present at the macroscopic level in Sand 1 and Loess 3. Frost cracking and solifluction folds are minimal and restricted to within-stratum disturbances only in Loess 3, where Component 2 is found, and absent from Loess 2, where Component 1 is found. Microfault displacement is minor in the lower section of the profile, where Components 1 and 2 are found. Bioturbation is uncommon throughout the profile and easy to identify and isolate both in plan view and vertically during excavation. Despite the presence of postdepositional disturbances, we found all stratigraphic units intact and recognizable across the excavation. We repeatedly witnessed archaeological integrity with cultural components well-circumscribed within their associated sedimentological units (Supplemental Videos 1 and 2).

Examination of microstratigraphic features through micromorphological analyses also helped to assess the geological integrity of the site's lower stratigraphy. According to Thorson (1990), repeated freeze-thaw cycles and the accumulation of ice lenses in soil voids lead to volumetric changes, causing shifting of both individual grains within a soil profile and soil material as a whole. Even more troublesome for northern sites is the increased susceptibility of ice-lens formation in silty to sandy loam soils (Van Vliet-Lanoe 2010). Despite the Dry Creek sediment package falling into this highly susceptible grain-size category, cryogenic activity in the lower portion of the profile appears to have been minimal (Figure 4). Microscale features typical of frost-affected and soliflucted soils are virtually absent from Loess 2 and Loess 3 (Figure 4a, 4b). A small number of elongated grains with non-horizontal orientations and incipient silt capping were observed on a few coarser grains restricted mostly to Sand 1 (Figure 4c). Patterns of cryoturbation are minor and do not constitute the degree of disturbance typifying translocation of materials from one stratum to another.

According to Thorson (2006), if bioturbation was a primary mechanism for artifact displacement at Dry Creek, subsurface voids created by burrowing fauna would have collapsed in on themselves, translocating sediment, soil material, and artifacts down through the profile (Johnson and Watson-Stegner 1990). Relict voids .1–.2 mm in

diameter and created by mesofauna are observed in most Loess 3 (Figure 4d) and all Loess 2 (Figure 4e) thin sections. These voids, however, are not collapsed or infilled. Similarly, small accumulations of iron oxides with fecal morphology are present in both Paleosols 1 and 2 (but do not line void spaces), and preserved insect parts were observed in Paleosol 2 (Figure 4f). None of these features were associated with microdebitage, and no burrows with meniscate backfilling were observed. Mesofaunal bioturbation did not contribute to downward movement of lithic debitage.

#### *Dating of Cultural Features and Site Formation*

Three hearth features were observed and excavated during our excavations (Figure 5). In block A, we encountered feature F11.01, stratigraphically isolated in Loess 3 and associated with Paleosol 1 and Component 2. The feature's contents followed the same solifluction-fold pattern of the paleosol in this block and consisted of black-colored (10YR 2/1), charred, greasy sandy-loam sediment, charred and calcined bone fragments, and flakes with evidence of heat alteration (i.e., discoloration, crazing). It measured 80 x 65 cm in plan view and 1–2 cm in thickness. Despite being disfigured from solifluction, the discrete nature of the feature in a well-circumscribed area containing wood charcoal, charred bone, and a few artifacts and surrounded by many lithic artifacts and faunal remains suggests that it resulted from intentional burning by humans and represents a Component 2 hearth feature. Two AMS dates obtained on separate pieces of *Salix* sp. charcoal from the hearth feature provided radiocarbon dates of  $9480 \pm 35$  (PSU-5835/UCIAMS-135115) and  $9460 \pm 50$  B.P. (Beta-315410) (Table 1), together producing a weighted mean of  $9473 \pm 29$  B.P. ( $\chi^2 = .107$ ;  $df = 1$ ;  $T_{crit} = 3.841$ ). This provides chronological control for Component 2 in our excavation of artifact cluster G.

In block B, we encountered a hearth feature isolated in Loess 2 and associated with Component 1 artifacts and bones. This hearth, F11.02, measured 50 x 35 cm in plan view, formed a 6-cm-thick basin after being excavated, and had a hemispheric shape. Its western and southern margins were distinctly circular but its northern and eastern margins were truncated by an ancient kro-

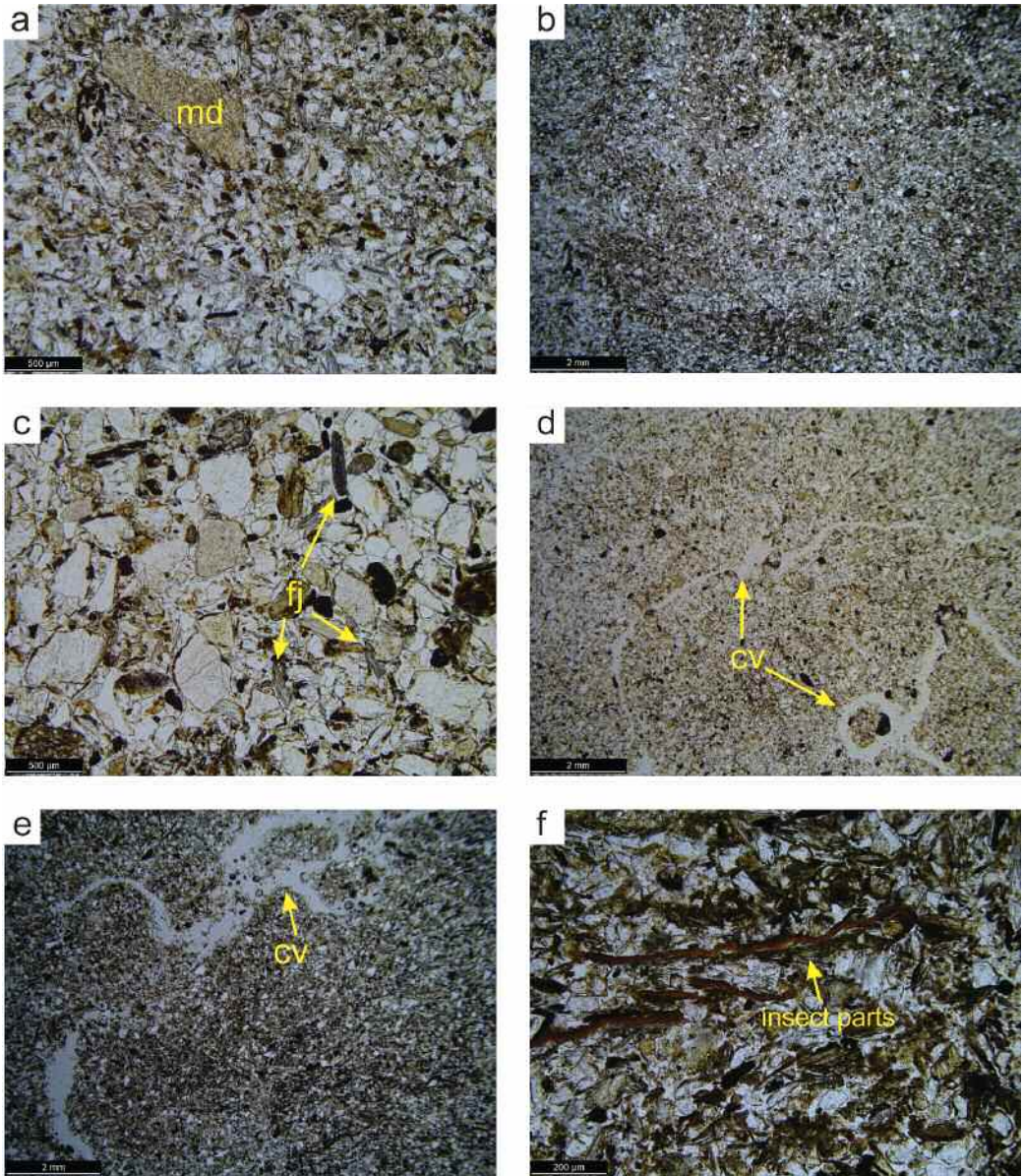


Figure 4. Photomicrographs of Loess 2, Sand 1, and Loess 3, taken in plane polarized light (PPL): (a) non-vertical lithic microdebitage (md) surrounded by silty matrix which has not been cryogenically disturbed; (b) Loess 3 silt showing lack of cryogenic fabrics; (c) frost-jacked (fj) sand grains in Sand 1; (d) channel voids caused by soil mesofauna in loess 3; (e) channel voids caused by soil mesofauna in loess 2; and (f) preserved insect parts in Paleosol 2 (Loess 3).

toovina. We are confident that the burrow is ancient because it was infilled with sediment that became weathered and thus mottled like the surrounding loess. The hearth feature was well-bounded, with fill consisting of ashy, charcoal-rich silt ranging from very dark brown (10YR 2/2) to dark reddish brown (5YR 3/2) and reddish brown (5YR 4/4) and several large (1 cm diameter) pieces of wood

charcoal. It also contained degraded bone “powder” and a biface-thinning flake. Two pieces of *Salix* sp. charcoal collected within the hearth provided dates of  $11,510 \pm 40$  (PSU-5834/UCIAMS-135114) and  $11,530 \pm 50$  B.P. (Beta-315411), together producing a weighted mean of  $11,520 \pm 28$  B.P. ( $\chi^2 = .125$ ;  $df = 1$ ;  $T_{crit} = 3.841$ ). This provides an age estimate for Component 1 in this



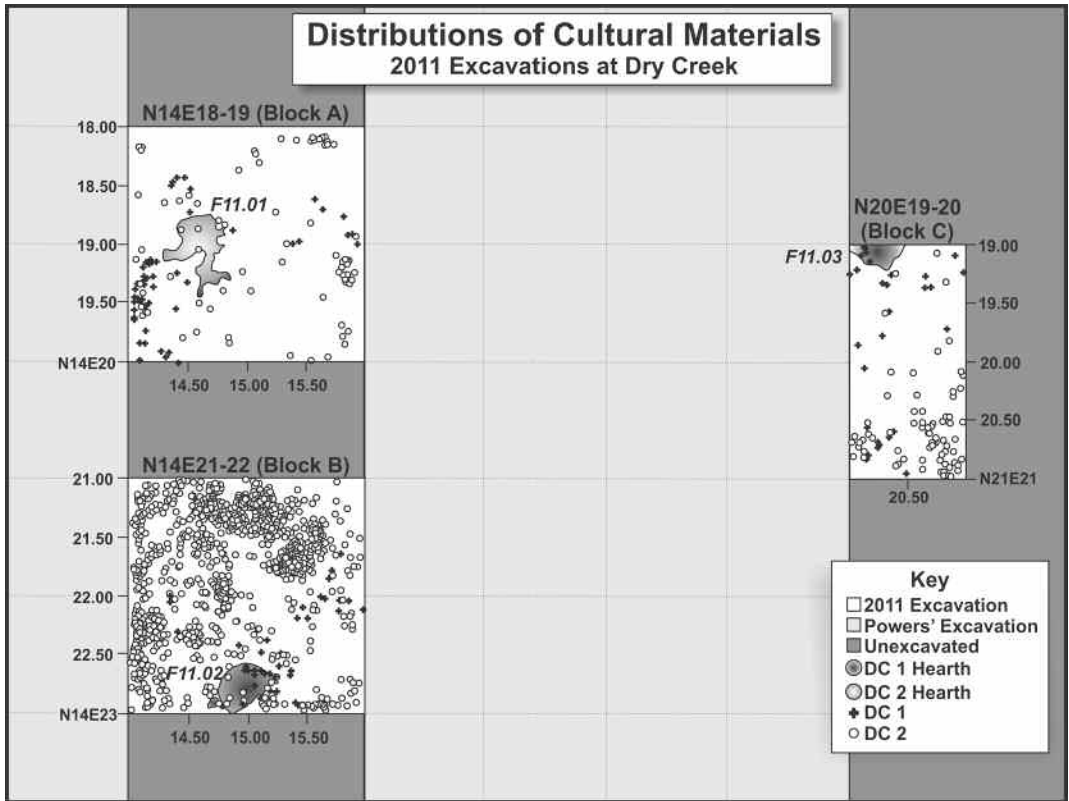


Figure 5. Map of 2011 excavation with locations of blocks relative to Powers's excavation and horizontal distributions of three-point plotted cultural materials.

area of the excavation associated with the southeastern portion of artifact cluster Z.

In block C, we found another hearth feature, F11.03, also within Loess 2 and associated with Component 1 materials. This circular feature is still partially preserved in Dry Creek's deposits and visible in the western profile of square N20E19. The excavated portion of the hearth measured 50 x 25 cm. It consisted of a concentration of ashy, charcoal-smearred silt ranging in color from black (5YR 2.5/1) to dark reddish brown (5YR 3/4) and reddish brown (5YR 5/4). Charcoal pieces, 44 pieces of burnt and calcined bone and ungulate (*Ovis dalli*) teeth, and a few lithics were found in the feature, while 21 pieces of unburnt bone, teeth, and lithics were found surrounding the feature. Two wood charcoal pieces from the feature, identified as *Salix* sp., provided dates of  $11,580 \pm 40$  (PSU-5833/UCIAMS-135113) and  $11,635 \pm 40$  B.P. (PSU-5832/UCIAMS-135112) for F11.03, together producing a weighted mean

of  $11,608 \pm 28$  B.P. ( $\chi^2 = .945$ ;  $df = 1$ ;  $T_{crit} = 3.841$ ). This provides an age estimate for Component 1 in this area of the excavation associated with the northwestern portion of artifact cluster Z.

Dates from the three hearth features were placed in a stratigraphic model in OxCal for calibration to better estimate age differences between Components 1 and 2 (Figure 6a). Results of unmodeled and modeled (prior and posterior) calibrated ranges are reported in Table 2. For each hearth, the paired dates were averaged using the *combine* command. Component 1 was modeled as a *phase*, with Features 11.02 and 11.03 constrained by *boundaries* approximating the beginning and end of activities during Component 1. Feature 11.01 in Component 2 was modeled outside of the sequence as a stand-alone combined date. Modeled  $2\sigma$  calibrated ages for Features 11.03 and 11.02 are 13,485–13,365 cal B.P. and 13,441–13,307 cal B.P., respectively. The boundary for the *end* of Component 1 activity is poorly



OxCal v4.2.4 Bronk Ramsey (2013), r:5 IntCal13 atmospheric curve (Reimer et al 2013)

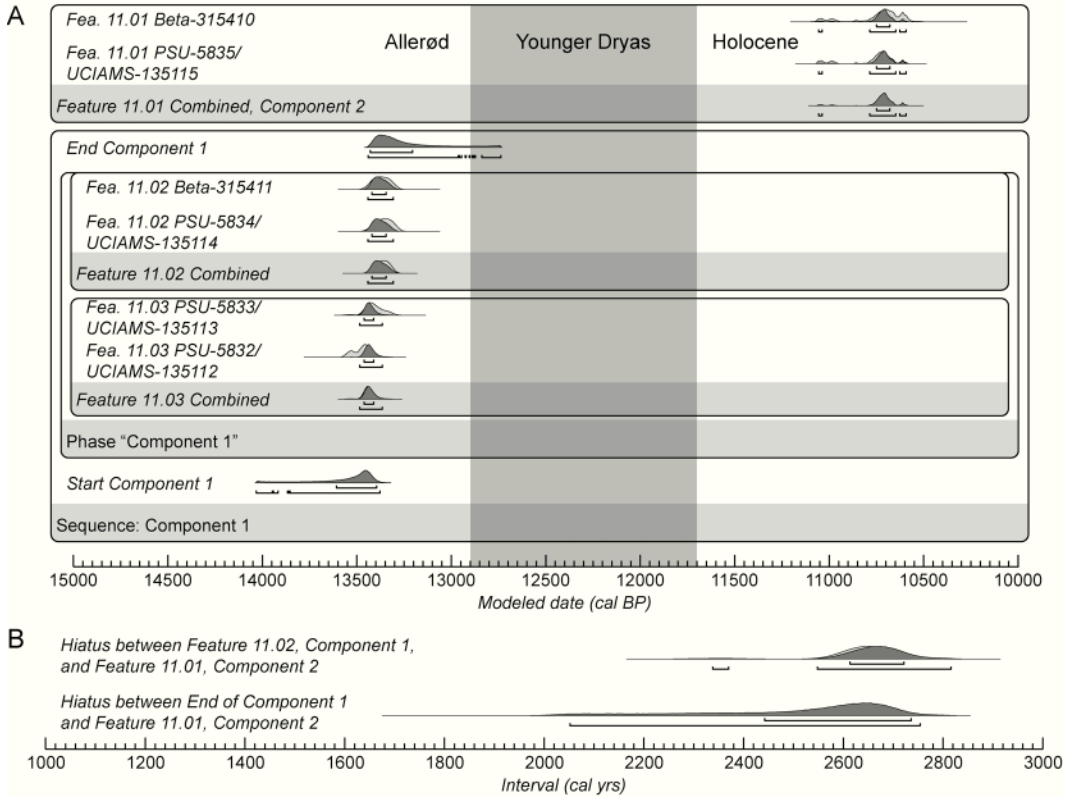


Figure 6. Analyses of new radiocarbon dates from Dry Creek. (a) Modeled calibrations of new radiocarbon dates from Dry Creek components 1 and 2 in OxCal v.4.2.3 (Bronk Ramsey 2009, 2013) using the IntCal13 curve (Reimer et al. 2013). Paired dates are combined as weighted averages within a sequence for Component 1, as a stand-alone weighted average for Component 2. Shaded bar indicates the span of the Younger Dryas. (b) Estimated length of the hiatus between components 1 and 2 is calculated using the *difference* command to compare the ages of Features 11.02 and 11.01, and the estimated end of component 1 and Feature 11.01.

constrained, ranging from 13,440–12,735 cal B.P.; this represents the whole range of a discontinuous distribution wherein 87.9 percent of the probability density covers 13,440–12,930 cal B.P. Feature 11.01 in Component 2 has a modeled 2σ calibrated range of 11,060–10,590 cal B.P., also a discontinuous distribution, with 88.1 percent probability density from 10,785–10,645 cal B.P. Agreement indices for individual and combined dates and the overall model are all above 100 percent, indicating good agreement between the model and the dates themselves.

Components 1 and 2 are clearly separate cultural occupations, and two methods were used to estimate the length of the hiatus between the occupations. Using the *difference* command in OxCal, we estimated the length of time elapsed between Feature 11.02 in Component 1 and Feature

11.01 in Component 2 as 2335–2820 calendar years at 2σ, with a weighted mean of 2655 ± 85 calendar years. A more conservative estimate of the gap takes the difference of the boundary estimate for the end of Component 1 and Feature 11.01, which is 2050–2755 calendar years at 2σ, with a weighted mean of 2510 ± 195 calendar years (Figure 6b). Thus, in the area we excavated, the hiatus between Components 1 and 2 is at least 2000 calendar years, and possibly as much as 2800 calendar years.

*Lithic Artifacts and Site Formation*

Another means to test the integrity of both Components 1 and 2 is close examination of the lithic artifact assemblage collected during our field investigations. If Component 1 represents down-drifted Component 2 artifacts, we expected to find

Table 2. Modeling Calibrations of New Radiocarbon Dates from Dry Creek Components 1 and 2.

Lab Number	Square	Feature	14C Age B.P.a	Unmodeled 2σ cal B.P.	%	Modeled 2σ cal B.P.	%
Loess 3, Component 2							
PSU-5835/UCIAMS-135115	N14E19	11.01	9480 ± 35	11,070–10,960	13.5	10,860–10,850	.4
				10,800–10,580	81.5		
Beta-315410	N14E19	11.01	9460 ± 40	11,070–10,950	12.1	10,870–10,840	.9
				10,810–10,560	82.4		
				Feature 11.01 Combined		11,060–11,030	1.6
						10,990–10,980	.2
						10,790–10,640	88.1
						10,630–10,590	5.5
Loess 2, Component 1							
				End of Component 1		13,440–12,930	87.9
						12,880–12,730	7.5
PSU-5834/ UCIAMS-135114	N14/15 E21/22	11.02	11,510 ± 40	13,450–13,270	95.4		
Beta-315411	N14/15 E21/22	11.02	11,530 ± 50	13,460–13,280	95.4		
				Feature 11.02 Combined		13,450–13,300	95.4
PSU-5833/ UCIAMS-135113	N20E19	11.03	11,580 ± 40	13,490–13,300	95.4		
PSU-5832/ UCIAMS-135112	N20E19	11.03	11,635 ± 40	13,570–13,380	95.4		
				Feature 11.03 Combined		13,490–13,360	95.4
				Beginning of Component 1		14,030–13,910	6.9
						13,900–13,880	.5
						13,860–13,370	88.0
Hiatus Estimates							
				Between Features 11.02 and 11.01		2330–2370 cal year	1.2
						2540–2820 cal year	94.2
				Between End of Component 1 and Feature 11.01		2050–2760 cal year	95.4

no significant differences between components in behavioral site-formation variables (i.e., types of technological activities and raw material selection) but significant differences between components in natural site-formation variables (i.e., artifact-size sorting and artifact plunge).

*Lithic Technological Organization and Behavioral Site Formation.* During our excavations we found a total of 3,880 artifacts and evidence for both cultural occupations (Components 1 and 2) identified in the original 1970s excavations (Powers et al. 1983). Three-point provenience was recorded for 1,984 artifacts or 51 percent of the assemblage (Figure 5), compared with 26 percent during original excavations. Component 1 artifacts number 251 and Component 2 artifacts number 3,629 (Table 3).

Core and tool numbers are quite low. The only core found in Component 1 is a bipolar core man-

ufactured on a flake. Component 2 cores include three flake, three bipolar, and eight microblade cores. Microblade cores were found only in Component 2. Component 1 tools include one retouched blade, one retouched flake, and two end scrapers. Component 2 tools include one side scraper, one burin, one biface fragment, three hammerstones, and nine marginally retouched unifacial tools. In Component 1, primary-reduction debitage (i.e., cortical spalls, flakes, blade-like flakes, and bipolar flakes) comprises nearly half (46.3 percent) of the debitage assemblage and likely resulted from reduction of simple flake cores. Secondary reduction activities focused on core trimming and tool resharpening with just over half (53.7 percent) of the debitage being resharpening chips or biface-thinning flakes. No microblades are present in the Component 1 assemblage. In contrast, Component 2 is dominated

Table 3. Artifact Types by Component from the 2011 Excavations of Dry Creek.

Artifact Typology	n	%	Components	
			1	2
<i>Cores</i>				
Flake cores	3	< .1	--	3 (< .1%)
Bipolar cores	4	.1	1 (.4%)	3 (< .1%)
Microblade cores	8	.2	--	8 (.2%)
Subtotal	15	.4	1 (.4%)	15 (.4%)
<i>Debitage</i>				
Angular shatter	87	2.2	7 (2.8%)	80 (2.2%)
Cortical spalls	70	1.8	36 (14.3%)	34 (.9%)
Flakes	795	20.5	66 (26.3%)	729 (20.1%)
Blade-like flakes	10	.3	2 (.8%)	8 (.3%)
Bipolar flakes	15	.4	2 (.8%)	13 (.4%)
Resharpener chips	2,166	55.8	118 (47.0%)	2,048 (56.4%)
Biface thinning flakes	157	4.0	14 (5.6%)	143 (3.9%)
Burin spalls	30	.8	--	30 (.9%)
Microblades	491	12.7	--	491 (13.5%)
Microblade technical spalls	24	.6	--	24 (.7%)
Blade technical spalls	1	<.1	1 (.4%)	--
Subtotal	3,846	99.1	246 (98.0%)	3,600 (99.2%)
<i>Tools</i>				
Side scrapers	1	< .1	--	1 (< .1%)
End scrapers	2	< .1	2 (.8%)	--
Angle burins	1	< .1	--	1 (< .1%)
Retouched blades	1	< .1	1 (.4%)	--
Retouched microblades	3	< .1	--	3 (< .1%)
Retouched flakes	7	.2	1 (.4%)	6 (.2%)
Bifaces	1	< .1	--	1 (< .1%)
Hammerstones	3	< .1	--	3 (< .1%)
Subtotal	19	.5	4 (1.6%)	15 (.4%)
Component totals			251 (100.0%)	3,629 (100.0%)
Assemblage totals	3,880	100.0%	251 (6.5%)	3,629 (93.4%)

by secondary-reduction debitage (61.7 percent), including resharpener chips, biface thinning flakes, and burin spalls, with only 38.7 percent of debitage representing primary reduction activities. Chi-square analysis, comparing primary and secondary reduction activities, indicates significant differences in technological activities between the components ( $\chi^2 = 6.333, df = 1, p < .02$ ). Additionally, we examined presence and absence of cortex between component assemblages and found significantly more than expected Component 1 artifacts with cortex on their surfaces and more than expected pieces in Component 2 without cortex ( $\chi^2 = 187.891, df = 1, p < .001$ ). Results support a focus on primary-reduction activities in Component 1 and secondary-reduction activities in Component 2.

Seven different classes of lithic raw materials were identified in the 2011 assemblage. Of these,

23 individual raw-material types were observed and scored (Table 4), including four types of rhyolite, 12 fine-grained cherts and chalcedonies collectively called cryptocrystalline silicates (CCS), two varieties of quartzite, one basalt, and three “other” raw materials (quartz, granite, and hematite) numbering so few they were combined together. Several raw-material types make up the Component 1 assemblage and include a mixture of quartzites (29 percent), rhyolites (30 percent), CCS (20 percent), and basalt (21 percent). In contrast, Component 2 artifacts are almost entirely manufactured on CCS (nearly 82 percent). Significantly, more quartzites, rhyolites, and basalts than expected occur in Component 1, but more CCS than expected occurs in Component 2 ( $\chi^2 = 596.948, df = 4, p < .01$ ). Nearly 70 percent of Component 2 was manufactured on a single CCS type, caramel chalcedony, while, in sharp contrast,

Table 4. Raw Material Types by Component from the 2011 Excavations of Dry Creek.

Raw Materials	n	%	Component	
			1	2
<i>Rhyolite</i>				
Light gray with black specks	114	2.9	17 (6.8%)	97 (2.7%)
Medium gray	133	3.4	32 (12.7%)	101 (2.8%)
Tan/gray banded	66	1.7	25 (10.0%)	41 (1.2%)
Grayish green	1	< .1	--	1 (< .1%)
Subtotal	314	8.0	74 (29.5%)	240 (6.7%)
<i>CCS</i>				
Medium gray	59	1.5	1 (.4%)	58 (1.6%)
Dark gray	32	.8	3 (1.2%)	29 (.8%)
Black	8	.2	--	8 (.2%)
Gray/black banded	19	.5	--	19 (.5%)
Grayish purple	1	< .1	--	1 (< .1%)
Gray/tan/brown banded	4	.1	--	4 (.1%)
Light grayish green	1	< .1	--	1 (< .1%)
Olive gray	1	< .1	--	1 (< .1%)
Caramel/clear chalcedony <sup>a</sup>	2,517	64.9	--	2,517 (69.3%)
Gray chalcedony <sup>a</sup>	255	6.6	46 (18.3%)	209 (5.8%)
Brown/black chalcedony <sup>a</sup>	109	2.8	1 (.4%)	108 (3.0%)
Black/clear chalcedony <sup>a</sup>	21	.5	--	21 (.6%)
Subtotal	3,027	77.9	51 (20.3%)	2,976 (81.9%)
<i>Quartzite</i>				
Medium gray	344	8.9	38 (15.1%)	306 (8.4%)
Tan/gray banded	46	1.2	35 (13.9%)	11 (.3%)
Subtotal	390	10.1	73 (29.0%)	317 (8.7%)
<i>Basalt</i>				
Dark gray	133	3.5	52 (20.7%)	81 (2.3%)
<i>Other</i>				
Gray quartz	2	< .1	--	2 (< .1%)
White quartz	8	.2	1 (.4%)	7 (.2%)
Granite	5	.1	--	5 (.1%)
Hematite	1	< .1	--	1 (< .1%)
Subtotal	16	.4	1 (.4%)	15 (.4%)
Component totals			251 (100.0%)	3,629 (100.0%)
Assemblage totals	3,880	100.0%	251 (6.5%)	3,629 (93.4%)

<sup>a</sup>Banded chalcedonies; colors listed reflect solid or opaque portions of the raw material that typically grade to milky-colored translucent stone (or "clear" or transparent as noted).

no caramel chalcedony was found in Component 1. If Component 2 artifacts moved down through the profile to form Component 1 or mix with it, altering its character, then we would have found this raw material in Component 1; yet this was not the case. Clear differences between the components in technological activities and raw-material selection support the integrity of two independent cultural components reflecting separate occupation events.

*Lithics and Natural Site Formation.* If cryoturbation significantly affected the site, we should expect to see smaller clasts lower in the profile and larger clasts thrust up and therefore higher in

the profile (Bowers et al. 1983; Johnson et al. 1977; Thorson 1990). If bioturbation significantly affected the profile, we should expect to find larger clasts near the bottom of the artifact-rich zone, as animals brought smaller clasts up and out of burrows and left larger clasts behind in lower positions (Hansen and Morris 1968; Johnson 1989). To test for these patterns, each artifact was assigned a ranked size value, with 1 being assigned to artifacts measuring < 1 cm in overall dimension, 2 to artifacts measuring 1–3 cm, and 3 to artifacts measuring > 3 cm in overall dimension. Both component assemblages contained mostly small-sized artifacts falling into size values 1 and 2.



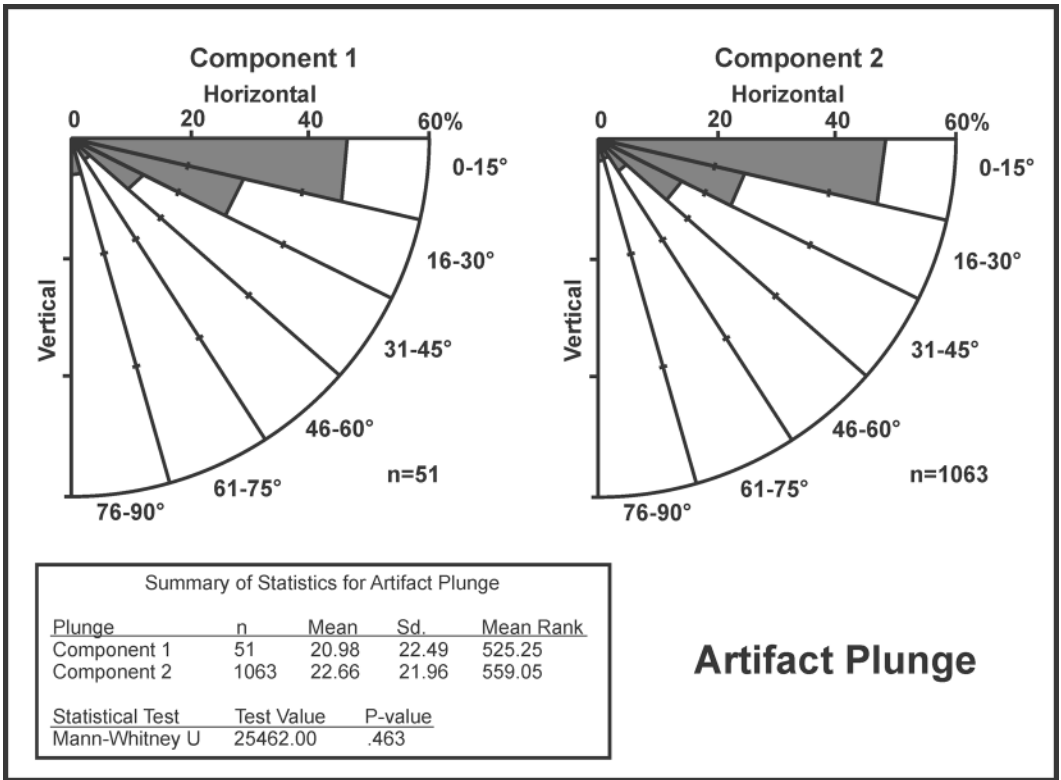


Figure 7. Frequencies of artifact plunge by component with statistical results from analysis of this variable.

Less than 4 percent of artifacts from each component were larger than size value 2. No significant relationship (Mann-Whitney  $U = 444020.0$ ,  $P = .403$ ) between components in size distributions indicates that there was no size sorting between or within the components.

Artifact plunge was scored on 1,114 in situ artifacts to better understand their vertical orientations. Because artifacts with plunges  $> 45$  degrees are more likely to have moved in the profile (Goebel et al. 2000; Johnson and Hansen 1974; Schweger 1985; Wood and Johnson 1978), we reasoned that if the majority of artifact plunges were  $> 45$  degrees, then significant cryoturbation and displacement of artifacts had occurred. We found the majority of artifact plunges for both assemblages to be  $< 45$  degrees, with data being skewed positively and with means and standard deviations  $< 23$  degrees (Figure 7). Most artifacts in both components were lying closer to horizontal than vertical, with no significant difference between the assemblages. Both components were

minimally affected by postdepositional processes. Lithic data from Components 1 and 2 indicate little postdepositional movement and represent independent assemblages left behind by successive site visits.

*Faunal Remains and Site Formation*

The analyzed faunal assemblage from the 2011 excavations at Dry Creek includes 137 specimens from Component 1 and 54 from Component 2, totaling 192 identified specimens (NISP). Both components are composed mostly of comminuted specimens, generally lacking cortical surfaces, limiting taxonomic identification and precluding identification of typical surface-bone modifications (e.g., cutmarks, tooth marks, percussion damage). Despite these limitations, 57 (41.6 percent NISP) Component 1 specimens were Dall sheep (*Ovis dalli*) maxillary molar-enamel fragments. None of the Component 2 assemblage was identifiable to taxon, but four specimens (7.4 percent NISP) were molar enamel fragments assigned the

Table 5. Measures of Abundance and Description of the Dry Creek Fauna from Components 1 and 2.

Stratum	Taxon	NISP	Element	NISP
Component 1	<i>Ovis dalli</i>	57 (41.6%)	Molar-enamel fragments	62 (45.3%)
	Indeterminate	80 (58.4%)	Indeterminate	75 (54.7%)
	Component totals	137 (100.0%)	Component total	137 (100.0%)
Component 2	Medium-to-large mammal	17 (31.4%)	Molar-enamel fragments	4 (7.4%)
			Indeterminate	13 (24.1%)
	Indeterminate	37 (68.5%)	Indeterminate	37 (68.5%)
	Component totals	54 (100.0%)	Component total	54 (100.0%)

broader classification of medium-to-large mammal (Table 5). We scored three additional attributes (i.e., burning, cortical bone, and root etching) that inform on behavior and bone preservation.

We expected faunal data from Components 1 and 2 to document two different sets of behaviors and levels of preservation if they represented two different cultural occupations and two different depositional events separated by more than 2,000 years. In contrast, if the components resulted from the same occupation and depositional event, we expected to find overlapping trends in faunal data. In Component 1 there are significantly more than expected specimens expressing no burning, but in Component 2 there are significantly more than expected bones with 100 percent charring ( $\chi^2 = 152.495$ ,  $df = 3$ ,  $p < .001$ ). These patterns indicate different levels in bone burning between the components. Expected counts of cortical bone and root etching are too low for reliable  $\chi^2$  analysis. Nevertheless, we found that Component 1 specimens preserved more cortical bone and less root etching than expected, whereas Component 2 preserved less cortical bone and more root etching than expected. Different levels of preservation in the components indicate taphonomic patterns unique to each component and little to no mixing between them.

### Discussion

Our excavations and analyses tested the hypothesis that the Nenana complex occupation (Component 1) at Dry Creek cannot be confidently separated from the overlying Denali complex occupation (Component 2) stratigraphically, chronologically, or technologically (Dumond 2001; Odess and Shirar 2007; Thorson 2006). Our results clearly indicate that this hypothesis needs to be rejected.

Stratigraphic integrity is maintained at Dry Creek. We found clear stratigraphic boundaries separating Loess 2 from Sand 1 as well as Sand 1 from Loess 3. Though minor signs of cryoturbation are present in these lower strata, such post-depositional features only minimally affected the units and were confined to disturbances within individual strata. Macrofaunal bioturbation was rare, isolated, and mappable. Mesofaunal bioturbation was present in Loess 2 and Loess 3, but there were no significant signs of soil and sediment displacement at the microscopic level and no signs of microdebitage displacement. Across our newly excavated blocks, we found complete stratigraphic separation between components, with Component 1 being separated from Component 2 by at least 15–20 cm of sediment, which encompassed culturally sterile Sand 1 between the lower limits of Loess 3 and upper limits of Loess 2. Artifacts, therefore, were found in well-circumscribed, separated components. In short, we found no signs in the field or laboratory indicating significant disturbance or mixing of Loess 2 and Loess 3, containing Components 1 and 2, as proposed by Thorson (2006) and others (Dumond 2001; Odess and Shirar 2007).

Until now, site chronology at Dry Creek was based on chronometric dates from naturally occurring materials, thus dating geological contexts only. The six new AMS dates reported here were on charcoal from features interpreted to represent hearths. Together they indicate that the ages of Components 1 and 2 are 13,485–13,305 cal B.P. and 11,060–10,590 cal B.P., respectively (i.e., the  $2\sigma$  ranges of modeled hearth ages). In other words, in the areas where our excavations were conducted, where both components occur in stratigraphic succession, they are separated by 2000–2800 years of time. Additionally, the presence of

well-circumscribed features and associated cultural materials clearly indicates that two distinct cultural components are preserved, again belying suggestions that cultural materials have moved postdepositionally.

Our analyses of the lithic assemblages established clear technological and typological differences between Components 1 and 2. Component 1 materials indicate reduction activities focused on production and maintenance of flake-based technologies, but Component 2 artifacts indicate mostly secondary reduction activities directed at maintenance of unifacial, bifacial, and microblade-osseous-composite tool technologies. Moreover, we observed clear differences in raw-material selection, with the Component 1 assemblage comprised of nearly equal amounts of quartzite, rhyolite, basalt, and CCS, whereas the Component 2 assemblage is dominated by CCS and chalcedony. Taphonomic analyses of the assemblages further suggest no size-sorting between the components and orientations that are chiefly horizontal in both, indicating minimal vertical movement, either up or down, of materials between components.

Faunal analyses highlight differences between components. Component 1 bones were less burned than those from Component 2. Component 1 specimens were generally better preserved, while bones from Component 2 were not; thus, site formation processes varied between components.

We found no evidence to support critiques of the Dry Creek stratigraphy and stratigraphic separation of Components 1 and 2. The hypothesized postdepositional movement of Component 2 materials down through the profile to the position of Component 1 (Dumond 2001; Odess and Shirar 2007; Thorson 2006) has found absolutely no support from our results. To the contrary, our findings strongly support Powers's original separation of the components into two distinctive complexes (Powers and Hoffecker 1989; Powers et al. 1983). The two components have different lithic assemblages, different faunal assemblages, different preservation problems, and their own respective hearth features. They are consistently and clearly separated stratigraphically and chronologically. The subtle postdepositional deformation processes evident in the two components also reflect different depositional regimes.

## Conclusions

With the newly collected data from our 2011 reinvestigation of the famous Dry Creek site in central Alaska, we tested the hypothesis that the deepest stratigraphic layers of the site, specifically Loess 2, Sand 1, and Loess 3, were affected by postdepositional processes so strong that the geoarchaeological separation of Dry Creek's late Pleistocene archaeological record into two components was incorrect (Thorson 2006). None of our results support this revision of the site's early record. Instead, we found clear stratigraphic and chronological separation between components as well as clear technological and faunal differences. Dry Creek's Component 1 represents a unique cultural occupation of the site, one significantly different from overlying Component 2, at least in the area where we excavated. On this basis, therefore, we unequivocally reject the hypothesis that the two cannot be separated. The Dry Creek site was visited during the terminal Pleistocene during at least two different times: once between 13,485 and 13,305 cal B.P. and again between 11,060 and 10,590 cal B.P. The site appears to have been abandoned during a 2000–2800-cal-year period of time that overlaps with the global Younger Dryas chronozone (12,900–11,700 cal B.P.); however, it is important to remember that our studies provide chronological control over only one of three of the original Component 1 activity areas and one of the 14 original Component 2 activity areas. Coupled with Bigelow and Powers's (1994) dates, the age of formation of Paleosol 1 is 12,730–10,590 cal B.P. During Component 1 times, visitors to the site manufactured and maintained flake-based and biface-based technologies around hearth features, where they cooked medium-to-large-bodied mammals, such as Dall sheep. After the hiatus, site visitors repaired tools, including side scrapers, burins, and lanceolate bifaces, and manufactured microblades to maintain microblade-osseous composite tools also around hearths. Data presented here support the notion of a separate and early non-microblade Nenana techno-complex in the Nenana Valley region of central Alaska.

Before this investigation, we were uncertain of exactly when people first visited the Dry Creek site. Given new congruent dates on hearth charcoal

from two hearth features, we now know that Dry Creek Component 1 predates other cultural occupations in the Nenana Valley by several centuries (Goebel et al. 1996; Graf and Bigelow 2011; Holmes et al. 2010; Pearson 2000). In comparison with the nearby upper Tanana basin, only the lowest component at Swan Point and lowest subcomponent of Broken Mammoth predate Dry Creek Component 1 (Holmes 2011; Yesner 2007). The lowest occupations at FAI-2043 and Mead are contemporaneous with Dry Creek Component 1, although dates on hearth charcoal from Mead suggest a slightly younger time range (Gaines et al. 2011; Potter et al. 2014). Now more than 10 non-microblade assemblages from sites in the Nenana and Tanana valleys have been found in well-stratified contexts dating to the Allerød. At about 13,500–13,000 cal B.P., people in central Alaska were making biface-based technologies, not selecting microblade-osseous-composite technologies (Gaines et al. 2011; Graf and Bigelow 2011; Holmes 2011; Potter et al. 2014; Sattler et al. 2011). They were employing an industry Powers and colleagues (Hoffecker et al. 1993; Powers and Hoffecker 1989) defined as the Nenana complex. A similar pattern exists at the Ushki Lake sites in Kamchatka, Russia, where non-microblade assemblages containing small bifacial projectile points also date to this timeframe (Dikov 1977; Goebel et al. 2003, 2010). Why millennial shifts occurred in lithic industries, from microblade to non-microblade and back to microblade technologies, is still unknown. Either different human groups with different ways of making a living visited the region at different times, or the shifts reflect adaptive switches from pre-Allerød through post-Allerød times.

Some have argued that successful human occupation of Beringia came with the spread of shrub-tundra (Hoffecker and Elias 2007). Pollen records from across central Alaska indicate the presence of shrub-tundra vegetation (reflected by *Salix* and *Betula* expansion) after 14,000 cal B.P. (Anderson et al. 2004; Bigelow and Edwards 2001; Bigelow and Powers 2001; Tinner et al. 2006). New dates at Dry Creek and the appearance of the many coeval and subsequent cultural occupations reflect sustained population following

emergence of shrub-tundra resources. Perhaps eastern Beringian climatic conditions prior to the Allerød were too harsh to sustain human population beyond intermittent exploration of the region.

Based on a short chronology for Clovis (Waters and Stafford 2007), new mid-Allerød-aged dates from Dry Creek now make it a pre-Clovis site. Combined with data emerging from numerous other pre-Clovis-aged sites in central Alaska as well as Northeast Asia, such as Yana and Berelekh (Pitulko, Basilyan, and Pavlova 2014; Pitulko, Nikolskiy, et al. 2014), Beringia now has more well-dated pre-Clovis sites than any other region in the Americas. Given this, we need to pay close attention to its rich archaeological record. We think that answers to important archaeological and ecological questions regarding late Pleistocene human dispersals to the New World lie in detailed geoarchaeological, chronological, technological, and subsistence studies of Beringia's rich archaeological record, including sites such as Dry Creek. Now more than ever, the Dry Creek site provides an important datum for Beringian archaeology and peopling of the Americas research.

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*Supplemental Materials.* Supplemental materials are linked to the online version of the paper, accessible via the SAA member login at [www.saa.org/members-login](http://www.saa.org/members-login).

~~Supplemental Text 1. The Putative Component 1 Microblade Core Tablet (Kelly E. Graf) and Procedures for Radiocarbon Sample Preparation, Pretreatment, and Assay (Brendan J. Culleton and Douglas J. Kennett).~~  
 Supplemental Video 1. Display of the three-dimensional distribution of artifacts from block B.  
 Supplemental Video 2. Display of the three-dimensional distribution of artifacts from block A.



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