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New investigations at Bonfire shelter, Texas examine controversial bison jumps and bone beds

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Bonfire Shelter (41VV218) is a nationally significant site in the Lower Pecos region of the West Texas borderlands that contains a record of episodic use by hunter-gatherers spanning at least twelve millennia. At least two major bison hunting episodes are evident at Bonfire Shelter, one associated with Paleoindian Plainview and Folsom projectile points (Bone Bed 2), and another associated with Late Archaic Castroville and Montell points (Bone Bed 3). The approximately 12,000-year-old layers comprising Bone Bed 2 may represent the oldest and southernmost bison jump in North America, but this interpretation is the subject of recent debate. In addition, older deposits containing Rancholabrean fauna but lacking stone tools (Bone Bed 1) date to approximately 14,000 years ago and are proposed by previous researchers to be at least partially the result of human activity. This article reviews the issues surrounding Bone Bed 2 and Bone Bed 1 and presents new radiocarbon dates, artifacts, features, along with some initial observations and ongoing plans for renewed field investigations at Bonfire Shelter carried out by the Ancient Southwest Texas Project at Texas State University.

KEYWORDS Bonfire shelter, Paleoindians, bison kill, Plainview, Folsom, megafauna

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Bonfire shelter enjoys an almost iconic status among North American hunter-gatherer archaeologists, and particularly those focused on Paleoindians. Located in the Lower Pecos Canyonlands of West Texas – about a mile from the border with Mexico – the inconspicuous shelter contains deep deposits reaching back into the Late Pleistocene. Excavations in 1963–1964 (Dibble and Lorrain 1968) and 1983–1984 (Bement 1986) established the significance of the site, and resulted in the identification of three layers with abundant faunal remains. Two dense layers of bison bone were interpreted by Dibble and Lorrain (1968; also Dibble 1970) to be the result of bison jumps carried out by prehistoric hunters. A third and older layer consisting of Pleistocene fauna was also suspected to be a result of human activity. The faunal layers were designated Bone Bed 1 (Late Pleistocene), Bone Bed 2 (Paleoindian period), and Bone Bed 3 (Archaic period); each is widely separated by natural sediment with lesser amounts of archaeological material. A fourth major occupation represented by sparse artifacts associated primarily with plant remains is evident stratigraphically above the bone beds, and was designated the Fiber Layer (Late Prehistoric).

Bonfire Shelter is remarkable in a number of ways, but there are two particular reasons that it looms large in the minds of Paleoindian archaeologists. First, it may preserve evidence of the oldest and southernmost bison jump in North America; however, there is disagreement as to whether the roughly 12,000-year-old layer of bones (Bone Bed 2) represents one or as many as three hunting events, and whether or not they truly represent bison jumps as opposed to more conventional activities (Bement 2007; Byerly et al. 2007; Meltzer et al. 2007; Prewitt 2007). If they do represent jumps, it is an unprecedented adaptive strategy for North American Paleoindians. Second, a lower layer (Bone Bed 1) includes remains of horse, mammoth, and other Pleistocene megafauna of uncertain origin. Previous researchers (Bement 1986; Dibble and Lorrain 1968) have argued that the disposition of these roughly 14,000-year-old remains also reflect human activity, but this has never been satisfactorily demonstrated. If the lowest deposits were to be confirmed as human-related, the site would rank among the earliest in America. If only for these two reasons, Bonfire Shelter has the potential to yield transformative information regarding the antiquity and adaptations of the earliest human occupants of North America, and the site warrants renewed examination.

Beginning in 2017, the Ancient Southwest Texas project (ASWT) at Texas State University initiated new investigations at Bonfire Shelter aimed at addressing these two questions in particular. The investigations are continuing, and the results of this work will be the subject of future publications. Here we provide an overview of the site, the extent of current research, and discuss key issues surrounding the competing interpretations of Bone Bed 2 and the implications of those interpretations for reconstructing Paleoindian social organization in the region, and the origins of Bone Bed 1, including a strategy for determining the extent to which human behavior contributed to the accumulation of Pleistocene fauna in the shelter interior, which appear to date earlier than the Clovis period. Some preliminary results of fieldwork, including new chronometric dates, description of stratigraphy, features, and artifacts, are also presented.

The context and characteristics of Bonfire Shelter

Bonfire Shelter (41VV218) is one of several rock shelters formed in the Devils River Formation limestone along Eagle Nest Canyon, in western Val Verde County, Texas (Figure 1). The site falls within the Lower Pecos Canyonlands, a physiographic zone in Southwestern Texas characterized by limestone box canyons and abundant rock

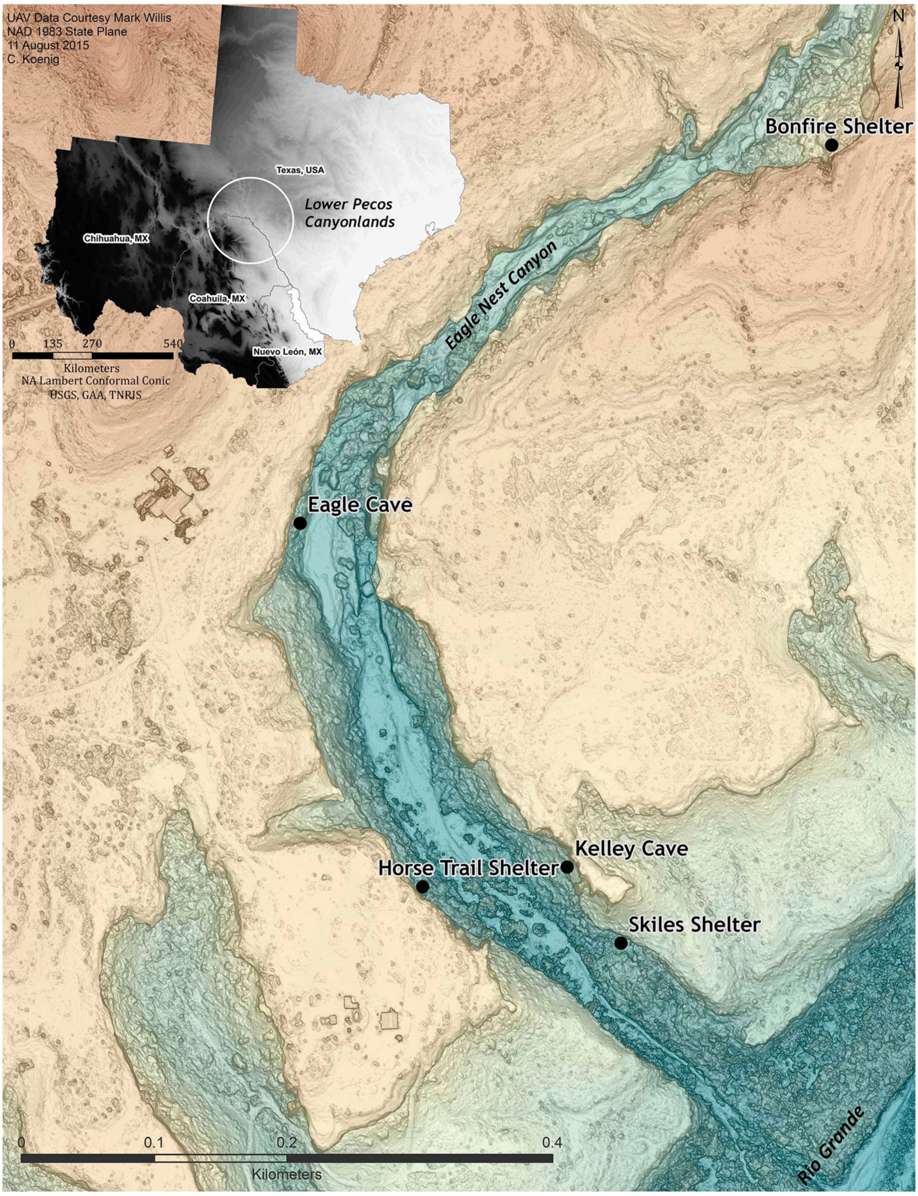


FIGURE 1. Digital Elevation Model showing the location of Bonfire Shelter in Texas and within Eagle Nest (Mile) Canyon. The canyon ends at an abrupt head cut with a plunge pool just beyond the northern margin of the figure.

shelter sites near the confluence of the Pecos River and the Rio Grande. Eagle Nest Canyon is a 20–30 m deep narrow gorge ending in a steep headcut about 1.5 km (1 mile) north of its confluence with the Rio Grande, giving it its alternate name of Mile Canyon. Bonfire Shelter is located about 300 boulder-strewn meters upstream from Eagle Cave (41VV167; Koenig et al. 2017b), the largest shelter in the canyon. Other prominent sites within the canyon (all downstream from Bonfire Shelter) include Horse Trail Shelter (41VV166; Castañeda et al. 2017), Skiles Shelter (41VV165; Koenig et al. 2017c), Kelley Cave (41VV164; Rodríguez and Black 2017), and the open-air Sayles' Adobe site (41VV2239; Pagano and Frederick 2017).

Unlike Eagle Cave, made conspicuous by the yawning arch of its east-facing mouth, Bonfire Shelter's northwest aspect is all but concealed by a vegetation-covered accumulation of talus derived from a massive collapse of its brow (Figure 2). By all indications, this collapse occurred long before any human occupation of the shelter (Dibble and Lorrain 1968). The massive boulders of the collapsed brow effectively limit entrance to the shelter by foot (or by hoof) to narrow passages at the north and south ends. Coupled with the orientation of the opening, the boulders limit direct sunlight to the shelter interior to narrow shafts of light in late afternoon, leading excavators to colloquially describe the interior as "Ice Box Cave" during winter excavations (Black 2001). The cool environment of the shelter interior would have provided obvious advantages for prehistoric meat processing activities.

Protected behind the brow collapse and behind the dripline of the current brow is approximately 1,750 m^2 of interior space, a 97 × 18 m crescent-shaped area oriented roughly north to south (Figure 3). The densest archaeological deposits occur in the southern half of the shelter in the area of a talus cone, with Bone Bed 1 concentrated in deep deposits toward the back wall in the shelter interior.

The talus cone area

The location of the densest concentrations of bison in Bone Beds 2 and 3 appears to be the result of the shelter rim morphology immediately above. A sizeable notch has formed along the rim, with a short, eroded channel creating a funnel for sediment transport from the uplands above (Figure 2). A talus cone has accumulated below the notch on the floor of the southern end of the shelter (Figure 3). Among the colluvial layers of the talus cone are multiple strata of dense bison bone, presumably also derived from the notch above. It appears that the notch was utilized as the focal point for a bison jump or jumps in the Late Archaic period. A layer of *Bison bison* up to 80 cm thick is identified as Bone Bed 3, which is associated with projectile points comparable to Castroville and Montell styles and dated to around 2,500–2,000 BP. These remains caught fire at some point after deposition, resulting in heavily calcined and distorted bone and burned and potlidded artifacts (Figure 4), and giving the site its name.

Lying roughly one meter underneath Bone Bed 3, and clearly stratigraphically separated from it, are the thickest portions of Bone Bed 2. Bone Bed 2 consists of a relatively less dense accumulation of *Bison antiquus* or *occidentalis* remains associated with lanceolate points identified as Plainview and Folsom. Wide morphological

FIGURE 2. View south along the brow of Bonfire Shelter. The notch in the rim is visible on the right, just above the apex of vegetation covering the collapsed brow. The shelter interior is visible in the center of the image.

variation among the points identified as Plainview has led some to propose that other point types are represented (e.g. Kerr and Dial 1998), including Lubbock and Midland. Both Bonebed 2 and Bone Bed 3 are thickest and densest in the talus cone, and thin out with regard to both stratum thickness and bone density

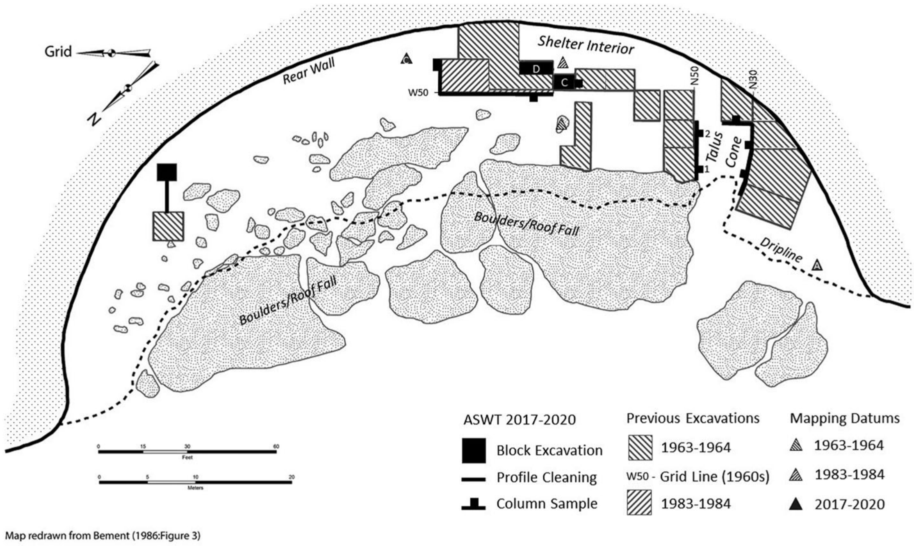


FIGURE 3. Plan view of Bonfire Shelter, indicating interior features and locations of previous and current fieldwork. Column Samples 1 and 2 are identified in the Talus Cone area.

toward the Shelter Interior. Questions regarding the origin, deposition, and human behavior associated with Bone Bed 2 are addressed in a following section of this paper.

The shelter interior

We refer to the area north of the talus cone and along the back wall of the shelter as the Shelter Interior (Figure 3). Unlike more open rock shelters in which the interior floor slopes toward the mouth, the enormous colluvial boulders of the collapsed brow near the mouth of Bonfire Shelter cause the modern floor to slope inward toward the back wall. Stratigraphy indicates this was also the case in the past, and at times this slope, along with the talus cone to the south, created a shallow topographic depression within the shelter floor (Bement 1986).

The Shelter Interior contains deep deposits with complex stratigraphy derived from both endogenic and exogenic sediments. Previous researchers (Bement 1986; Dibble and Lorrain 1968; Robinson 1997) observed that endogenic roof spall (*eboulis*) deposition prevailed during cooler regimes, while exogenic eolian and alluvial sediment deposition has prevailed during dryer periods. Vestiges of both Bone Bed 3 and Bone Bed 2 can be traced into the Shelter Interior, generally thinning in faunal element density to the north. Though never thoroughly investigated, Archaic period features occur sporadically in strata between Bone Beds 2 and 3. One previously undocumented thermal feature dating to the Early Archaic (described below) has been identified by ASWT.

Stratigraphically below Bone Bed 2 in the Shelter Interior lies Bone Bed 1. Bone Bed 1 consists of multiple strata, each characterized by a variety of Rancholabrean fauna including horse (*Equus francisci*), mammoth (*Mammuthus sp.*), bison (*Bison*

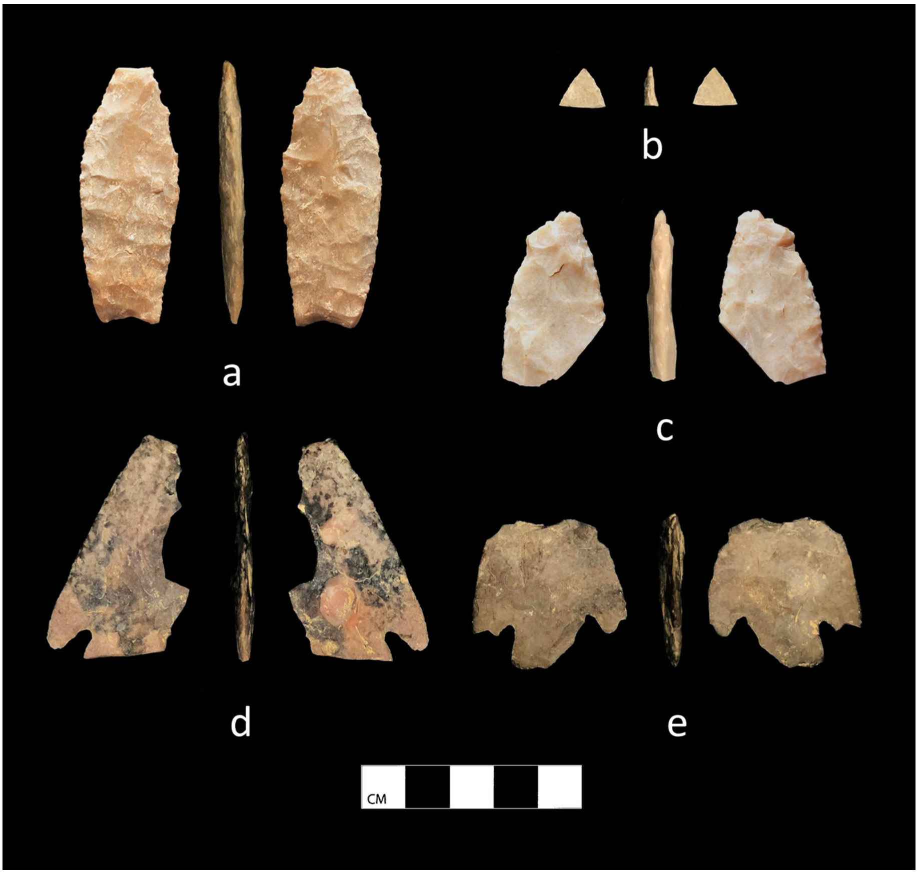


FIGURE 4. Projectile points recovered from the Talus Cone area during ASWT investigations; a. FN 60236, a lanceolate point identified as Plainview recovered from Bone Bed 2, b. FN 60137, a point fragment recovered from Bone Bed 2 during wall cleaning; c. FN 60280, a medial point fragment recovered from backfill south of the Talus Cone; d-e. FN 60158 and FN 60027, thermally damaged notched points identified as Castroville recovered from Bone Bed 3.

antiquus), camel (*Camelops hesternus*), pronghorn (*Capromeryx sp.*), as well as smaller fauna (e.g. fox, rodent, snake). Although Bone Bed 1 lacks the relatively abundant flaked stone tool assemblages that characterize other cultural layers in the shelter, previous researchers suspected a cultural origin for Bone Bed 1 based on bone breakage patterns and association with large blocks of limestone (Bement 1986; Dibble and Lorrain 1968). A single radiocarbon date of 12,460 ± 490 RCYBP (13,402–16,100 calBP) obtained by Bement (1986), indicates that Bone Bed I predates the commonly-accepted age range for the Clovis period. In light of new evidence for pre-Clovis occupations from the Gault and the Debra L. Friedkin sites in Central Texas (Collins and Bradley 2008; Waters et al. 2011) and the recent discovery of intact Paleoindian deposits at Eagle Cave less than 1 km to the south (Koenig et al. 2017a:89), the Late Pleistocene deposits at Bonfire shelter warrant careful reevaluation.

Bone Bed 2: competing interpretations

Dibble and Lorrain (1968), along with Bement (1986), Prewitt (2007) and others (e.g. Bousman et al. 2004; Holliday 1997; Turpin 2004) interpret Bone Bed 2 as multiple layers of bone from an estimated 120 Pleistocene bison (*B. antiquus* or *B. occidentalis*) representing at least three distinct Paleoindian jump events. Though artifacts suggest a range of time periods is represented, only the upper layer (Unit C of Bone Bed 2) has been dated. Four radiocarbon dates on charcoal cluster between 11,500 and 12,000 calBP in median probability (Table 1). The charcoal is derived from a small unlined hearth stratigraphically associated with Unit C (Figure 6), but only indirectly associated with bone (Dibble 1970; Dibble and Lorrain 1968). In this regard, Bonfire represents an anomaly. Although landform-assisted hunting can be traced into the Paleoindian Period, Bonfire represents the only known Paleoindian bison jump in which herd behavior was exploited to maneuver prey over a potentially lethal precipice. Furthermore, this hunting technique is primarily known from the Northern Plains, and even there

TABLE 1.

RADIOCARBON DATES FOR FEATURES AND STRATA DESCRIBED IN TEXT. ALL DATES CALIBRATED WITH OXCAL 4.3 (BRONK RAMSEY 2017) ACCESSED VIA THE OXFORD RADIOCARBON ACCELERATOR UNIT'S (ORAU) ONLINE SERVER, USING INTCAL 13 ATMOSPHERIC CALIBRATION CURVE.

Sample No.	Provenience	Material	RCYBP	Cal BP 2σ	Median Probability	Source
Tx-131	Bone Bed 3	Charcoal (14C)	2,510 ± 100	2,770–2,350	2,574	Dibble and Lorrain 1968
Tx-106	Bone Bed 3	Charcoal (14C)	2,780 ± 110	3,210–2,729	2,913	Dibble and Lorrain 1968
D-AMS 027372	Bone Bed 3, Strat TC-5	Charred bone (AMS)	2,516 ± 24	2,740–2,494	2,590	ASWT
D-AMS 031259	ASWT-F-1, SI Strat SI-15	Charcoal (AMS)	5,943 ± 47	6,889–6,668	6,772	ASWT
D-AMS 031257	ASWT-F-1, SI Strat SI-15	Charcoal (AMS)	6,034 ± 36	6,979–6,786	6,882	ASWT
D-AMS 031258	ASWT-F-1, SI Strat SI-15	Charcoal (AMS)	5,950 ± 42	6,885–6,675	6,779	ASWT
Tx-657	Bone Bed 2, Hearth 1	Charcoal (14C)	9920 ± 150	12,025–10,875	11,452	Dibble 1970
Tx-658	Bone Bed 2, Hearth 1	Charcoal (14C)	10,100 ± 300	12,659–10,795	11,749	Dibble 1970
Tx-153	Bone Bed 2, Hearth 1	Charcoal (14C)	10,230 ± 160	12,525–11,335	11,941	Dibble and Lorrain 1968
AA-346	Bone Bed 2-Component A	Charcoal (AMS)	10,280 ± 430	13,002–10,770	11,960	Bement 1986
D-AMS 034555	Bone Bed 2, Strat TC-11	Charcoal (AMS)	10,115 ± 51	11,999–11,405	11,735	ASWT
AA-344	Bone Bed 1, Strat H-1	Charcoal (14C)	12,460 ± 490	16,184–13,435	14,673	Bement 1986
D-AMS 034547	Bone Bed 1, Strat SI-24	Seed (AMS)	12,112 ± 69	14,145–13,770	13,971	ASWT

the technique does not appear to have been common until several thousands of years later. Byerly and others (2007) found that apart from Bonfire Shelter, the southernmost unequivocal bison jump is either Roberts Buffalo Jump, Colorado (5LR100; Witkind 1971) or the Certain Site, Oklahoma (34BK46; Bement and Buehler 2005), both greater than 650 km (415 miles) to the north; the earliest is the Middle Archaic deposit at Head-Smashed-In, Alberta (DkPj-1) (Reeves 1978), some 4,000 years later than Bone Bed 2 at Bonfire (but see Hofman 2010).

In contrast to earlier interpretations, Byerly et al. (2005, 2007; also Meltzer et al. 2007) argue that Bone Bed 2 represents a single event involving fewer animals, and that natural processes have eroded and redeposited bones from that single event into three layers. Dibble and Lorrain (1968), based on the generous method of extending the calculated MNI to unexcavated portions of the shelter, estimated that a total of around 120 individual bison are present as a result of three kill events. Based on a more conservative method of estimation, Byerly and others conclude that around 24 bison are represented in the excavated portions of Bone Bed 2, a number more in line with other Paleoindian bison kills (Frison 2004). Further, Byerly and others cast doubt on the use of Bonfire Shelter as a bison jump, arguing (following Binford 1978) that the relative frequencies of individual skeletal elements is more consistent with a secondary butchering locality than a kill site, though a GIS analysis presented in their initial article (Byerly et al. 2005) indicated the setting was conducive to a jump drive. They propose the possibility that a more conventional bison hunt took place somewhere nearby, perhaps utilizing a head cut within the canyon floor or the steep canyon head that lies immediately upstream from Bonfire Shelter, and Paleoindian hunters transported select portions of the carcasses into the shelter for processing.

The bison jump hypothesis espoused by Dibble and Lorrain and associated authors, and the secondary butchering hypothesis espoused by Byerly and associated authors are summarized in Table 2. These detailed alternate interpretations provide a framework of testable hypotheses that drive new field investigations at Bonfire Shelter. Resolving the issues is important because, if the original excavators' interpretation is correct, Bonfire Shelter contains the oldest example of this human behavior anywhere in the Americas by several thousand years, and the only American example of hunting Ice Age megafauna in this manner. Further, organized game drives often incorporate considerable planning, organization, and cooperation among hunters, and the use of this technique has significant implications for the social organization of America's earliest hunter-gatherers.

Musings on the implications of a Paleoindian bison jump

Large-scale bison hunting (defined here as kills that number from 50 to 100 or more individual animals) appears to be associated with several necessary social and natural conditions (Bement 2018; Brink 2008; Carlson and Bement 2013; Frison 1970, 1978, 1998, 2004; Zedeño et al. 2014). Bison drives and jumps require more than a single hunter-gatherer band, and thus are most likely associated with seasonal aggregations or other forms of cyclical nucleation. Both the bringing together of otherwise autonomous social groups and the planning and organization

TABLE 2.

SUMMARY OF COMPETING HYPOTHESES FOR EXPLAINING THE ORIGIN AND NATURE OF BONE BED 2 IN BONFIRE SHELTER.

Hypothesis	No. of Behavioral Events	Total No. of Bison Involved	Nature of Bone Bed 2 Deposits	Projectile Point Associations	Interpretation of Activities	Primary Authors
Bison Jump	3	120	Three discrete strata observable, each representing behavioral events separated in time.	Plainview variants in upper Bone Bed 2 (subunits a and b); Folsom in lower Bone Bed 2 (subunit a).	Primary location of kills by jumping, and associated butchering of animals driven from the rim above.	Dibble and Lorrain 1968; Dibble 1970; Prewitt 2007; Bement 2007
Secondary Butchering	1	24	A deposit representing a single behavioral event, eroded and redeposited to create illusion of multiple behavioral events.	Primarily Plainview, with Folsom either contemporary or unrelated.	Secondary butchering location associated with a conventional kill that occurred elsewhere.	Byerly et al. 2005, 2007; Meltzer et al. 2007

of the hunt have implications for hierarchies of coordination and emergent, if expedient, social hierarchy (Carlson and Bement 2013). Though no evidence of drive lanes, walls, cairns, or other infrastructure has been found in association with Bonfire Shelter (Byerly et al. 2007), most bison jumps in later prehistory involve extensive infrastructure, which requires additional labor and coordination investment. Historic accounts of bison drives on the Northern Plains describe people acting as decoys and as facets of the infrastructure itself (Barsh and Marlor 2003; Verbicky-Todd 1984), which might account for the lack of such facilities at Bonfire Shelter. Even the communal drives that lacked physical infrastructure that were observed historically for hunter-gatherers in Australia required considerable preparation and communication over large distances, which was coordinated by organizers known as "band leaders" (Balme 2018:53). While it may have been possible for smaller groups to execute landscape-assisted kills (e.g. the arroyo trap kills of the Beaver River complex sites reported by Carlson and Bement 2018), the large amount of both processing labor and procured resources provided an incentive for large group aggregation (Kornfeld et al. 2010). Whether the drive required a relatively larger or smaller number of hunters, the logistics and organization of what can be reasonably expected to have been a fairly complex event would have required considerable coordination and a degree of hierarchical organization.

Though such an event requires significant investment, the payoff for a successful jump would have been staggering. Frison (1970) notes that successful jumps require minimum herd size of 50–100 animals which, given our understanding of changing herd dynamics from the Pleistocene to the Holocene (Guthrie 1980), may play a limiting role in the timing of the emergence of this technique. A single mature *Bison antiquus* bull is estimated to weigh as much as 1,600 kg, about half of which is edible mass (Ashley 2002; Hauer 2018). Assuming an average individual weight of 900 kg in a cow/calf herd (and thus 450 kg of meat), and a herd of around 100 animals (Dibble and Lorraine estimate 120 animals in Bone Bed 2; Byerly and others' estimate is considerably lower), a kill the scale of that from Bonfire Shelter could be expected to yield as much as 45,000 kg of edible mass. At 1,430 calories per kg of lean meat, the result is as much as 64 million calories. For a diet of ~3,000 cals/day, this amount is more than 21,000 person-days of energy from bison protein alone. If there were 50 people involved in a single event, each individual could potentially take away more than 12 months' worth of energy (an annual salary). If divided into three events (as envisioned by Dibble and Lorrain 1968) of equal size, the yield would be 6,600 person-days of energy, with each individual among 50 people gaining access to over 4 months of caloric energy. Of course, this yield is limited by preservation and the logistics of transport – assuming the meat was dried into jerky (~20% of wet weight), each person's share would have weighed 90–180 kg. These figures and calculations are coarse, but they suggest that even a fractional harvest of available meat resulting from the kill would sustain a lot of people for a long time. The collection of hides, horns, and other collateral resources presumably added even more economic value to the endeavor.

The number of individual events represented in Bone Bed 2 at Bonfire is debated, but it is clear that it does not represent a frequent or even semi-annual phenomenon. The faunal remains represent between one and, at most, a small handful of kills. Though the proposed bison jump appears to be a rare behavior at best (perhaps reflecting the difficulty of coordination), similar landform-assisted hunting techniques are consistent with interpretations of other Paleoindian kills. Perhaps driving a herd off a cliff is a logical extension of utilizing topographical features such as arroyo traps, dunes, and slopes (e.g. Bement and Carter 2016; Frison 1978; Meltzer 2006). If bison were indeed driven through the notch on the rim of Bonfire Shelter, it can be regarded as essentially an arroyo trap ending in a drop rather than a headcut. Despite the apparent rarity, the possibility remains that there were multiple jump sites in the region; there are many available cliffs in the Lower Pecos region and it may be that Bonfire is the one site we know of where this kind of behavior has been preserved.

Bone Bed 1: enduring ambiguity

Although contemporary sediments appear to underlie the talus cone archaeological deposits, Bone Bed 1 has been identified only in the Shelter Interior. Dibble's 1968 report describes Bone Bed 1 as horizontally bedded, disarticulated, and containing Late Pleistocene faunal deposits of ambiguous origin within a matrix of dense roof spall eboulis and interbedded silty lenses. Like Bone Beds 2 and 3, Bone Bed 1 consists of multiple strata, though in the case of Bone Bed 1 these strata appear to be of heterogeneous origin and perhaps cover a greater span of time. Further, they include a more diverse range of fauna.

Despite considerable investigation, no definitive explanation for the presence of fauna in Bone Bed 1 has emerged. The interior of the shelter seems an unlikely habitat for large herbivores, suggesting that the animals were either attracted to some resource inside, such as standing water, and later died, or were transported whole or in pieces by predators or scavengers that occupied the cave, possibly including humans. Bonfire Shelter is not an entirely dry shelter and water appears to have temporarily accumulated at points in the past, though the porous surface of the deposits would not have allowed water to pool for any significant amount of time. Further, even during the relatively dry Holocene there are alternate sources of water in the canyon, including a plunge pool about 300 m to the north and in the Rio Grande about 1 km to the south. Non-human carnivore or scavenger activity is a possible explanation for the faunal remains, and this was entertained both by Dibble and Lorrain (1968) and Bement (1986). Prehistoric carnivore dens are known to preserve faunal accumulations elsewhere in the region (e.g. Friesenhahn Cave [Graham et al. 2013]), and several elements recovered by Bement (1986) exhibit gnawing and puncture marks consistent with carnivore activity. Unlike Friesenhahn Cave, other than gray fox (Urocyon cinereoargenteus), no carnivore osteological or fecal remains have been recovered from Bonfire Shelter.

Despite their unsuccessful search for artifacts, Dibble "over cautiously" suggested that "humans were 'possibly' present at [the] time and responsible for [the] accumulation" of the fauna (Dibble and Lorrain 1968:28). Bone fragmentation around large limestone spalls, a lack of carnivore bones, the presence of small bits of charcoal, and the lack of compelling non-cultural explanations for the presence of the fauna provided justification for additional research. Solveig Turpin and Leland Bement returned to Bonfire Shelter in 1983–1984, excavating a 4 × 3.4 m block through Bone Beds 2 and 1. They defined four discrete substrata within Bone Bed 1, which were designated E/F/G, H-1, H-2, and I, from top to bottom. Bone Bed 2 strata sampled in the block were designated A, B, and C, top to bottom. Notably, no lithic artifacts were recovered during the 1980s excavations, though they identified elements bearing potential cut-marks and use-wear in Bone Bed 1 and Bone Bed 2.

Bement (1986) reports a potential butchering feature in Stratum E/F/G. Horse remains clustered with a small assortment of bison, mammoth, and camel bone occur as fragments around an anomalous limestone boulder. High caloric yield limb elements were reported to be most abundant in the cluster (Bement 1986:32–34). Bement (1986) reports two additional potential butchering features in Stratum H-1. A spiral-fractured horse femur exhibiting significant polish and a v-shaped incision, a spiral-fractured horse metatarsal with v-shaped incisions, and a green-broken mammoth tibia with v-shaped incisions were clustered around a large limestone block. A secondary cluster of mammoth bone was observed slightly to the north including a compressed cervical vertebra with angular indentations, a pelvis ischium section with scalloped/crushed edges, and numerous unidentifiable fragments with a limestone cobble directly overlying the ischium. Bement suggests that the vertebra may have been used as a butchering anvil. Two juvenile horses and a juvenile mammoth are represented (Bement 1986:38–51). Both Dibble and Bement argue that large limestone blocks surrounded by spiral-fractured bone and potential expedient tools observed in Bone Bed 1 (Stratum E/F/G and H-1) were analogous to similar features identified as butchering stations in the definitively cultural Bone Bed 2 and 3 (Bement 1986:29–59).

Bement also reported abundant evidence for non-human carnivore activity in Bone Bed 1, including elements from strata H-1 and I that exhibit conical punctures consistent with saber-toothed cat and/or wolf dentition, as well as U-shaped grooves consistent with carnivore gnawing. Ultimately, Bement reached a similar conclusion to Dibble and Lorrain (1968), proposing that the Bone Bed 1 deposits were largely the result of predation and that some of this predation was likely by humans using the rock shelter as a trap (Bement 1986:60–64). However, he conceded that without manufactured tools or hearth features the arguments for human activity is "supported solely on circumstantial evidence" (Bement 1986:63).

The significance of determining the origins of Bone Bed 1

Overviews subsequent to the early excavations at Bonfire Shelter have settled for referring to Bone Bed 1 as potentially cultural (e.g. Turpin 2004) or limiting discussions of archaeology to Bone Beds 2 and 3 (e.g. Bousman et al. 2004, Holliday 1997, Huckell and Judge 2006) leaving the interpretation of Bone Bed 1 as ambiguous and the question of its origins unresolved. The confirmation of human activity contributing to Bone Bed 1 would carry at least two significant implications. First, assuming the single radiocarbon date accurately reflects the age of the activity, Bonfire Shelter would provide evidence for human presence earlier than the known age range for Clovis. Second, it would provide direct evidence for the human exploitation of Pleistocene horse and camel, which is undocumented on the Southern Plains and Southwest, and with one possible exception (Wally's Beach, AB [DhPg-8]; Kooyman et al. 2006, Waters et al. 2015), throughout North America. Along with the utilization of rock shelters, these subsistence choices would suggest a distinctly different suite of behaviors among very early Paleoindians relative to Clovis populations which do not appear to have regularly exploited horse or camel.

Renewed investigations at Bonfire Shelter

In an effort to generate more definitive answers to the uncertainties surrounding the interpretation of Bonfire Shelter, the Ancient Southwest Texas Project (ASWT) at Texas State University initiated new fieldwork at the site in 2017. Renewed investigations at Bonfire Shelter by ASWT are oriented toward four major research goals: (1) establishing a detailed chronostratigraphic sequence for the site deposits; (2) determining the origin and number of events associated with Bone Bed 2, specifically regarding it being a result of one or more drives or jumps from the rim above; (3) determining the origins of Bone Bed 1, specifically regarding whether or not human agents played a role in the introduction or modification of faunal remains; and (4) preserving the site by stabilizing the surface and exposed deposits, including backfilling open excavation units and controlling surface runoff into and within the shelter (Kilby and Black 2017).

Only a portion of the previous excavations at Bonfire Shelter were ever backfilled. The largest and deepest excavation units in the Shelter Interior remain open, which facilitates recording stratigraphic information and collecting dating samples without compromising the integrity of the site. Bement and Turpin backfilled large portions of the talus cone excavation units with backdirt from their own excavations in the Shelter Interior (Bement 1986). Other preservation measures aimed at stabilizing the talus cone were taken by Elton Prewitt in the 1990s, and by Stephen Black of ASWT in the 2000s.

New research activity is focused primarily on the Talus Cone area and the open units of the Shelter Interior (Figure 3). The ASWT approach to the site minimizes new excavation by focusing upon re-exposing, recording, and sampling existing profiles, thus following the "Low Impact, High Resolution" philosophy espoused by ASWT in the investigation of Eagle Cave (Koenig et al. 2017a). Our approach employs Structure from Motion photogrammetry and traditional Total Data Station georeferencing to record three-dimensional provenience, context, and object orientation information (De reu et al. 2014; Koenig et al. 2017a; Willis et al. 2016). Total Data Station data are tied to an arbitrary canyon-wide grid system that ties Bonfire Shelter to other sites within Mile Canyon, along with their site and mapping datums from previous projects. In Bonfire Shelter, we utilized the mapping datum established by Bement (1986) at his N500/W500 grid point to establish 8 new subdatums (A-H) for Total Data Station and Structure from Motion mapping. Subdatums A and C served as primary mapping points for mapping and data collection (Figure 3).

The only new block excavation at the site occurs within Bone Bed 1, described below. We removed wall slump and debris from the interior of the shelter, and removed approximately 30 m^2 of backfill from 1964 excavation units along the north side of the talus cone in 2017. In 2018, a comparable amount of backfill was removed to expose the profiles on the south side of the talus cone. Judgmental sample screening of backfill and slump debris through 0.635 cm (0.25 inch) mesh produced bone fragments and lithic artifacts, including the medial fragment of a biface described below.

Investigation of the talus cone

The 2017 exposure of the north side of the talus cone along Dibble's N50 grid line revealed a stratigraphic sequence that includes Bone Bed 2 and Bone Bed 3 as well as the underlying, intervening, and overlying deposits (Figure 5). We identified a total of 15 strata (TC 1-15), reflecting pulses of sediment deposition ranging from the accumulation of fine sediments originating from the notch above to the catastrophic collapse events that impacted the underlying deposits. On the north side of the talus cone, Bone Bed 2 appears to span two discrete strata, and immediately underlies a significant collapse event represented by a substantial boulder and associated debris. It is thus far unclear whether this colluvial event was associated with the deposition of Bone Bed 2, or occurred shortly after. In 2018, ASWT crew exposed the profile along the N30 and W60 grid lines on the south side of the talus cone. Bone Bed 3 is largely obscured by stabilization materials in these profiles; however, Bone Bed 2 is fully exposed. We were able to correlate our stratigraphic units with those identified by previous excavators due in large part to the detail and accuracy of stratigraphic profiles illustrated in Dibble and Lorrain (1968). Preliminary observations support the recognition of three discrete strata within Bone

Stratum	*Description*	*Dibble and Lorraine 1966*
TC-1	Sandy loam; light brownish gray (10YR 6/2), debris derived from notch, stabilization materials, and disturbed surface material.	Zone 3
TC-2	Sandy loam; pale brown (10YR 6/3), poorly sorted limestone gravel in massive matrix.	Zone 3
TC-3	Ashy silt loam; white (10YR 8/1), massive accumulation of bison bone, much of it reduced to calcined powder, burned lithic artifacts.	Bone Bed 3
TC-4	Ashy silt loam; light gray (10YR 7/1), massive accumulation of bison bone, boulders, and smaller rock, all subjected to intense heat.	Bone Bed 3
TC-5	Silty; light bluish gray (Gley 10B 7/1), discontinuous lens of fibrous ashy powder, perhaps representing burned pooled tissue.	Bone Bed 3
TC-6	Sandy loam; brown (10YR 4/3), scorched/oxidized surface underlying Bone Bed 3.	Scorched earth layer
TC-7	Sandy loam; weak red (2.5YR 5/2), reduced/oxidized expressed variably in thin layer, thickens to east.	Zone 2b
TC-8	Sandy loam; brown (10 YR 5/3), massive poorly sorted colluvial gravel and cobbles.	Zone 2b
TC-9	Sandy loam; pale brown (10YR 6/3), poorly sorted colluvium, including large boulder in center of profile.	Zone 2b
TC-10	Sandy loam, light yellowish brown (10YR 6/4), colluvial gravel and cobbles, some rocky lenses.	Zone 2b
TC-11	Sandy loam; pale brown (10YR 6/3), massive colluvium with abundant gravel and cobbles; abundant bison bone, unburned artifacts.	Bone Bed 2
TC-12	Silt loam; light brownish gray (10YR 6/2), massive colluvium wit abundant gravel, cobbles, and boulders; occasional bison bone.	Bone Bed 2
TC-13	Sandy loam; yellowish brown (10YR 5/4), massive colluvium including gravel and cobbles; surface underlying Bone Bed 2.	Zone 2b
TC-14	Loam; brown (7.5YR 5/4), massive colluvium including gravel, reddened due to increased clay content.	Zone 1
TC-15	Sandy loam; yellowish brown (10YR 5/6), massive colluvium including gravel and small cobbles with little fine sediment in between.	Zone 1

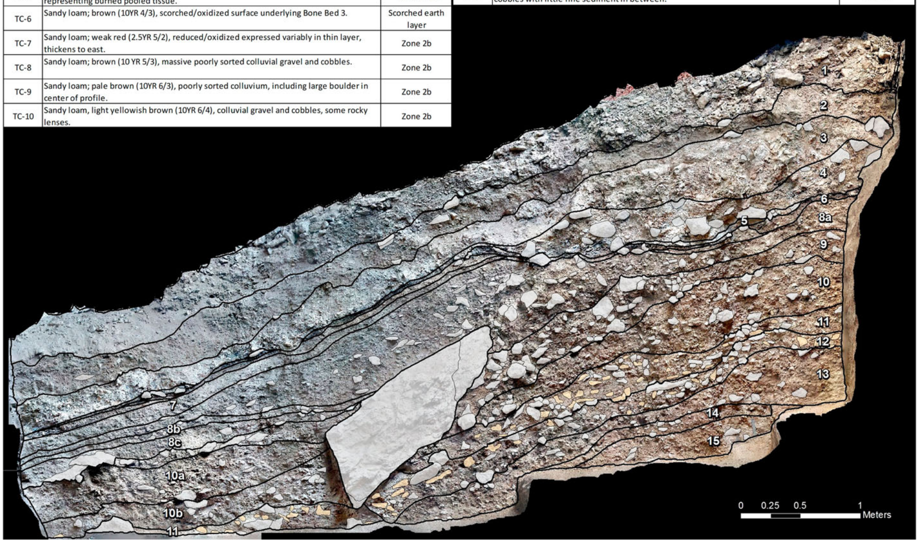


FIGURE 5. Profile and stratigraphy on the north side of the talus cone, corresponding to the N50 grid line of Dibble and Lorrain (1968:24), facing grid south. Bone Bed 3 is represented by Strata 3–6; Bone Bed 2 is represented by Strata 11–12.

Bed 2 on the south side of the talus cone, with a heavily burned stratum (Dibble's Component B) separating underlying Component A deposits and overlying Component C deposits containing unburned bone (Figure 6). Notably, a horizon of oxidized sediment underlying Unit B of Bone Bed 2 suggests that the bone burned in place at that location. As with Bone Bed 3, the origin of the fire remains unclear.

Sampling methodology included the collection of five 50 × 50 cm column samples from the profiles in the talus cone. Though column samples are collected in full and not screened in the field, four additional stone tools were encountered in the process of collecting column samples from the profile along Dibble's N50 gridline, including a newly discovered and nearly complete lanceolate projectile point (FN 60236), along with another lanceolate point tip (FN 60137) from Bone Bed 2, and two Castroville point fragments (FN 60027 and FN 60158) from Bone Bed 3, both subjected to intense heat (Figure 4; Table 3). As Bone Bed 2 is of particular interest here, a more detailed description of those artifacts follows.

The lanceolate point from Bone Bed 2 (FN 60236; Figure 4a) was recovered in place during the collection of Stratum 11 sediments from Column Sample 2, within 10 cm of bison rib fragments in the same stratum. The point is complete except for the tip, though it appears to have been heavily refurbished along one lateral margin. It is heavily ground on the base and lateral basal margins, with the grinding truncated on the refurbished margin. A slight but perceptible curvature

FIGURE 6. Portion of the exposed profile on the south side of the talus cone, corresponding to Dibble and Lorrain's (1968) Pit C roughly along their N30 grid line. Three subunits of Bone Bed 2 designated by Dibble and Lorraine as (bottom to top) Component A, B, and C are visible here, along with oxidation indicating that Component B burned in place.

TABLE 3.

PROJECTILE POINTS AND FRAGMENTS DESCRIBED IN TEXT.

			Provenience		Dimensions (mm)				Material
Catalog No.	Description	Projectile Point Type	Location	Stratum	Length (max)	Width (max)	Width (base)	Thick. (max)	
FN 60236	Lanceolate point	Plainview	CS02	11	59.53*	23.37	13.62	5.83	Edwards Plateau chert
FN 60137	Point tip fragment	undetermined	CS01	11	9.11*	10.8*	n/a	3.15*	Edwards Plateau chert
FN 60280	Biface fragment	undetermined	N20/W60	backfill	39.87*	22.94*	n/a	5.93	Edwards Plateau chert
FN 60158	Notched point	Castroville	CS01	3	54.96*	32.43*	19.24*	4.52	gray/black chert (burned)
FN 60027	Notched point	Castroville	CS01	2/3	36.59*	38.23*	14.57*	5.57	gray chert (burned)

*Incomplete.

suggests it was manufactured from a flake blank. While somewhat indistinct, the overall shape (unshouldered lanceolate with slightly excurvate sides and shallow concave base) and dimensions (Table 3), along with irregular but generally perpendicular flaking, basal grinding, and minor thinning of the base are consistent with the Plainview type (Justice 1987; Knudson 2017), and clearly distinguish it from Folsom (also found in Bone Bed 2). A small tip of a second projectile point (FN 60137; Figure 4b) was recovered in place among bison bone fragments in Stratum 11 in the wall of Column Sample 1, approximately 4 m west and upslope of FN 60236.

In addition to the point fragments recovered from the column samples on the north face of the talus cone, the medial portion of an apparently lanceolate biface (FN 60280; Figure 4c) was recovered from backdirt in Dibble's N20/W60 unit south of the talus cone. This unit was partially backfilled in the 1960s (and is thus not one of the units backfilled with sediment from the Shelter Interior in the 1980s), suggesting that the fragment originated in the talus cone area. The fragment appears to be a broken projectile point, supported by impact damage to the distal end and a dual-faceted break toward the proximal end. The relatively narrow width compared to that of Castroville and Marcos points from Bone Bed 1, along with the lack of evidence for burning suggests this fragment fits best with the Bone Bed 2 artifact assemblage. If FN 60280 is taken to be a projectile point fragment from Bone Bed 2, this artifact, the tip fragment (FN 60137), and the nearly complete specimen (FN 60236) bring the total number of known projectiles associated with Bone Bed 2 to 14.

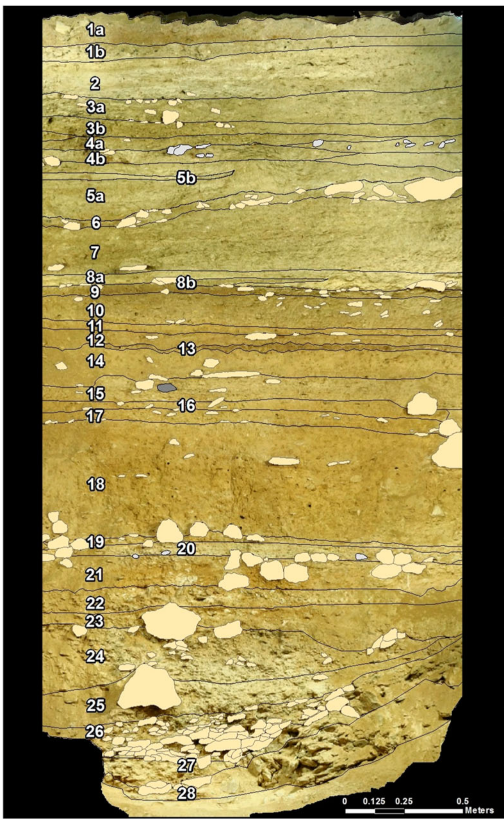
Charcoal located less than a meter away from the lanceolate point in the same stratum yielded a date of 10,115 ± 51 BP (D-AMS 034555, charcoal), calibrated mean probability 11,739 BP, which is consistent with previous dates for the upper portion of Bone Bed 2 (Table 1). Thus far, direct dating of the bone beds is severely hampered by poor collagen preservation in the bison bone, and this has hindered our efforts to discern whether or not the components of Bone Bed 2 can be temporally distinguished through chronometric dating. Efforts toward producing dateable samples from Bone Bed 2 and Bone Bed 1 are a continuing priority for ASWT.

Our observations of the bone beds in the talus cone suggest that Bone Bed 3 might represent a single event (in contrast to Dibble's interpretation, but consistent with that of Lorrain in the same volume [Dibble and Lorrain 1968]). Bone Bed 2 is somewhat less clear. The stratigraphy appears most consistent with multiple events as originally interpreted by Dibble and Lorrain (1968), but questioned by Byerly et al. (2007). However, thus far, the multiple events scenario does not seem to be supported by age or seasonality differences among the faunal remains (Ramsey 2020). Detailed analysis of the samples and data collected will allow us to better evaluate these initial perceptions, and ultimately to arrive at more conclusive interpretations of Bone Bed 2. Specifically, granulometric analysis of sediments and continued efforts toward chronometric dating should aid in determining the number of events. Intensive zooarchaeological, taphonomic, and spatial analysis will help determine if the faunal remains represent a catastrophic assemblage derived from the notch above, or a secondary butchering area for animals killed elsewhere.

Investigation of the shelter interior

Clearing the previous excavation trenches in the shelter interior revealed exposures of each of the three bone beds, in addition to intervening strata. In particular, the west wall of the trench along Dibble's W50 grid line provides nearly 20 m of continuous exposure of the shelter deposits. We identified 28 discrete strata (SI 1-28; Figure 7), representing variation in depositional processes within the rock shelter over the past 15,000 years. We were able to correlate these strata to those identified in previous excavations. A previously unreported thermal feature containing charcoal and burned limestone (ASWT-F-1) was identified between Bone Beds 2 and 3, and apparently represents a sparse occupation of the shelter dated to 6,811 years ago (the average of three calibrated radiocarbon dates; Table 1).

Much of the renewed effort in the Shelter Interior is focused on Bone Bed 1. Our observations indicate that at the conclusion of the 1980s excavations, plaster-



Stratum	Description	Dibble and Lorraine 1966	Bement 1986
SI-1	Silt loam; very pale brown (10YR 7/3), loose with uncommon roof spalls, sheep dung in 1b.	Zone 3	
SI-2	Silt loam; light gray (10YR 7/2), laminated with occasional small platy roof spalls.	Zone 3	
SI-3	Silt loam; light brownish gray (10YR 6/2), massive with platy roof spalls; blocky roof spalls in 3a.	Zone 3	
SI-4	Silt loam; gray (10YR 6/1), occasional small roof spalls, frequent faunal remains in 4b.	Bone Bed 3	
SI-5	Silt loam; light gray (10YR 7/2), laminated with few roof spalls, occasional silt lenses (5b).	Zone 2b	
SI-6	Silt loam; light brownish gray (10YR 6/2), massive with abundant platy and blocky roof spalls.	Zone 2b	
SI-7	Silt loam; light brownish gray (10YR 6/2), laminated with abundant fine platy roof spalls.	Zone 2b	
SI-8	Silt; very pale brown (10YR 8/3), laminated with occasional fine lenses (8b)	Zone 2b	
SI-9	Silt loam; yellowish brown (10YR 5/4), discontinuous lens with roof spalls.	Zone 2b	
SI-10	Silt loam; brown (10YR 5/3), with abundant roof spalls.	Zone 2b	
SI-11	Silt; brown (7.5YR 5/3), slightly reddened lens with few spalls.	Zone 2b	
SI-12	Silt loam; brown (10YR 5/3), with occasional roof spalls.	Zone 2b	
SI-13	Silt loam; dark yellowish brown (10YR 3/4), discontinuous wavy lens with no roof spalls.	Zone 2b	
SI-14	Silt loam; yellowish brown (10YR 5/4), with occasional roof spalls.	Zone 2b	
SI-15	Silt; pale brown (10YR 6/3), with dense fine roof spalls; Feature ASWT-F-1.	Zone 2b	
SI-16	Silt; yellowish brown (10YR 5/4), with few roof spalls.	Zone 2b	
SI-17	Silt loam; yellowish brown (10YR 5/4), with abundant fine roof spalls.	Zone 2b	
SI-18	Silt loam; yellowish brown (10YR 5/4), massive with occasional large roof spalls.	Zone 2b	
SI-19	Silt loam; pale brown (10YR 6/3), with occasional blocky roof spalls; occasional faunal remains.	Bone Bed 2	A
SI-20	Silt loam; very pale brown (10YR 7/3), laminated with abundant platy roof, occasional blocky roof spalls; frequent faunal remains.	Bone Bed 2	B
SI-21	Silt loam; light yellowish brown (10YR 6/4), with play and blocky roof spalls; occasional faunal remains.	Bone Bed 2	C
SI-22	Silt loam; pale brown (10YR 6/3), with abundant fine spalls with gypsum encrustation.	Zone 2a	D
SI-23	Silt; brownish yellow (10YR 6/6), banded with occasional small and large spalls; occasional faunal remains.	Bone Bed 3	E/F/G
SI-24	Silt; light gray (10YR 7/2), with dense rounded platy roof fall; occasional faunal remains.	Zone 3	H1
SI-25	Silt; light gray (10YR 7/2), with abundant rounded platy roof fall; occasional faunal remains.	Zone 3	H1
SI-26	Silty gravel; light gray (10 YR 7/1), mostly angular platy roof spalls and boulders with very little matrix.	Zone 3	H2
SI-27	Silty gravel; light gray (10 YR 7/1), mostly angular platy roof spalls with very little matrix.	Zone 3	I
SI-28	Rock; light gray (10 YR 7/1), densely packed roof fall.	Zone 3	

FIGURE 7. Profile and stratigraphy on the west side of the Shelter Interior, corresponding to the W50 line of Dibble and Lorrain (1968:24), facing grid west. Bone Bed 3 is represented by Stratum 4; Feature ASWT-F-1 is located in Stratum 15; Bone Bed 2 is represented by Strata 19–21; and Bone Bed 1 as described by Dibble and Lorraine (1968) is represented by Stratum 23; Bone Bed 1 as described here and by Bement (1986) is represented by Strata 23–25.

jacketed faunal remains, and intact Bone Bed 1 deposits were shallowly buried beneath a layer of geotextile cloth. In the intervening years, the open block has endured severe erosional impacts including, most significantly, the partial collapse of the western wall. This area functioned as the main entry point for visiting archaeologists, tour groups, and wildlife. The ongoing erosion compounded by decades of periodic trampling have resulted in significant damage to the shallowly buried faunal remains.

The southern portion of the main excavation block is the only location where Bone Bed 1 deposits remained accessible; other areas were fully excavated or remained buried beneath more than 3 m of intact archaeological sediments. In this area we initiated approximately 6 m^2 of excavation in two adjacent blocks on previously exposed surfaces that had been left at or just above Bone Bed 1 strata. Block C was located within the southern entry point to the main trench. Block D was located slightly to the north and east off the main path. Faunal remains recovered from Block C were significantly more deteriorated than those in Block D. This preservation bias may be a function of the position of Block C within the entry way to the main trench and lower elevation, increasing exposure to hydrological activity and trampling.

Excavation in these units has thus far yielded a total of 86 faunal elements. Stratum SI-23 (Bement's Stratum E/F/G) yielded 46 elements including mammoth (12), bison (4), and horse (3). Stratum SI-24 (Bement's Sratum H1) has yielded 40 elements including mammoth (7), bison (1), and horse (8). A possible *Capromeryx* (dwarf pronghorn) element was identified in Stratum 25 (Bement's H-2). The reported frequencies represent preliminary field identifications only; over half of the recovered elements remain unidentified and require further analysis. These early results generally concur with Bement's (1986) findings. Pleistocene horse is the most prevalent taxon in the assemblage followed by mammoth. Limestone cobbles were observed in all strata. No evidence of cut marks, spiral fractures, polish, or other modification was observed; however, the remains recovered were extremely deteriorated; cortical surfaces were unstable and cancellous interiors crumbled to dust despite stabilization efforts. Consistent with previous excavations, no lithic artifacts were recovered or observed in any of the Bone Bed 1 strata. A hackberry seed (*Celtis sp.*) recovered adjacent to a mammoth element in Stratum SI-24 yielded a radiocarbon date of 12,112 ± 69 BP (D-AMS 034547, calibrated mean probability 13,971 BP) helps refine the single previous date submitted by Bement (1986), and supports a roughly 14,000-year-old age for the stratum (Table 1).

Our ongoing efforts are aimed at evaluating the evidence for cultural activity in Bone Bed 1 based on lithic artifacts, geoarchaeological approaches to assemblage formation, as well as the spatial and taphonomic analysis of faunal remains. The poor condition of the newly recovered faunal remains from Bone Bed 1 constitutes a challenge for taphonomic analyses. We believe that lithic artifacts would provide the most reliable evidence of human activity, and seek to identify evidence of flaked stone tools (as well as unflaked lithic tools such as hammers and anvils) associated with Bone Bed 1. Given Bonfire Shelter's proximity to abundant bedrock and alluvial sources of high quality lithic raw material, it is difficult to imagine flaked stone tools not being used by people engaged in predation or butchering activities at the site. As such, the presence of lithic artifacts would provide unequivocal evidence of human activities in the formation of Bone Bed 1. In an effort to investigate Bone Bed 1 in a manner that expands and complements previous searches for artifacts, bulk samples were collected from a 50 cm^2 column sample as well as areas adjacent to major faunal elements and are being water-screened and microscopically examined for <1 mm micro-debitage. If lithic tools were used in the butchering process but transported away from the activity area, it is expected that some detritus from edge breakage or resharpening should remain. Given the bulk of sediments that have been excavated from Bone Bed 1 thus far with no discovery of unequivocal artifacts, identification of lithic microartifacts may provide the clearest evidence for cultural activity.

Future research

The ASWT 2017–2019 field seasons represent a successful initiation of new research at Bonfire Shelter. Critically, we got a handle on the complicated stratigraphy of the site and were able to associate the layers we see with those identified by previous researchers. We successfully cleared existing exposures of Bone Beds 2 and 3, and exposed new deposits in Bone Bed 1, recording them in a level of detail that is unprecedented for the site. We procured new radiocarbon dates that confirm the ages of the key archaeological deposits. We collected and continue to collect archaeological, geological, and environmental samples that promise to shed new light on the deposits, and potentially resolve contested issues regarding their interpretation.

As a caveat for the observations presented here, we are just getting started, and interpretations will surely evolve as we collect and analyze more data. The ASWT work thus far represents the initial steps of an ongoing research program aimed at understanding the deposits of Bonfire Shelter and their significance for understanding the prehistory of the region. Restoration and stabilization efforts will continue as new research progresses, and will culminate with the backfilling of all excavation units from current and previous investigations to protect the remaining deposits in Bonfire Shelter.

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References cited

Ashley, Bruce. (2002) Edible Weights of Wildlife Species used for Country Food in the Northwest Territories and Nunavut. Manuscript No. 138, Wildlife and Fisheries Division, Department of Resources, Wildlife and Economic Development, Government of Northwest Territories, Yellowknife.

Balme, Jane (2018) Communal Hunting by Aboriginal Australians: Archaeological and Ethnographic Evidence. In *The Archaeology of the Large-Scale Manipulation of Prey*, edited by Kristen Carlson, and Leland C. Bement, pp. 42–62. University of Colorado Press, Lousville.

Barsh, Russel Lawrence, and Chantelle Marlor (2003) Driving Bison and Blackfoot Science. *Human Ecology* 31 (4):571–593.

Bement, Leland C. (1986) Excavation of the Late Pleistocene Deposits of Bonfire Shelter, Val Verde County, Texas. *Texas Archeological Survey Archeology Series* 1, University of Texas, Austin.

Bement, Leland C. (2007) Bonfire Shelter: A Jumping off Point for Comments for Byerly et al. *American Antiquity* 72:366–372.

Bement, Leland C. (2018) An Introduction to Large-Scale Manipulation of Prey. In *The Archaeology of the Large-Scale Manipulation of Prey*, edited by Kristen Carlson, and Leland C. Bement, pp. 3–15. University of Colorado Press, Lousville.

Bement, Leland C., and Kent J. Buehler (2005) The Certain Site Southern Plains Archaic Bison Kills. *Oklahoma Archaeology* 53:16–18.

Bement, Leland, and Brian Carter (2016) Folsom Bison Hunters on the Southern High Plains of North America. In *Stones, Bones, and Profiles: Exploring Archaeological Context, Early American Hunter-Gatherers, and Bison*, edited by Marcel Kornfeld, and Bruce B. Huckell, pp. 291–311. University Press of Colorado, Boulder.

Binford, Lewis R. (1978) *Nunamiut Ethnoarchaeology.* Studies in Archaeology. Academic Press, New York.

Black, Steve (2001) Bonfire Shelter. Texas Beyond History https://texasbeyondhistory.net/bonfire/index.html. Accessed April 2019.

Bousman, Britt C., Barry W. Baker, and Anne C. Kerr (2004) Paleoindian Archaeology in Texas. In *The Prehistory of Texas*, edited by Timothy K. Pertulla, pp. 15–97. Texas A&M Press, College Station.

Brink, Jack (2008) *Imagining Head-Smashed-In: Aboriginal Buffalo Hunting on the Northern Plains*. Athabasca University Press, Edmonton, Alberta.

Byerly, Ryan M., Judith R. Cooper, David J. Meltzer, Matthew E. Hill, and Jason M. LaBelle (2005) On Bonfire Shelter: as a Paleoindian Bison Jump: An Assessment Using GIS and Zooarchaeology. *American Antiquity* 70:595–629.

Byerly, Ryan M., David J. Meltzer, Judith R. Cooper, and Jim Theler (2007) Exploring Paleoindian Site Use at Bonfire Shelter (41VV218). *Bulletin of the Texas Archaeological Society* 78:126–147.

Carlson, Kristen, and Leland Bement (2013) Organization of Bison Hunting at the Pleistocene/Holocene Transition on the Plains of North America. *Quaternary International* 297:93–99.

Carlson, Kristen, and Leland Bement (2018) The Development of Late Paleoindian Large-Scale Bison Kills. In *The Archaeology of the Large-Scale Manipulation of Prey*, edited by Kristen Carlson, and Leland C. Bement, pp. 135–160. University of Colorado Press, Louisville.

Castañeda, Amanda, Charles Koenig, and Charles Frederick (2017) Horse Trail Shelter (41VV166). In *Lower Pecos Canyonlands Academy Guidebook*, edited by Ken Lawrence, pp. 65–72. Texas Archeological Society, San Marcos, Texas.

Collins, M. B., and B. A. Bradley (2008) Evidence for Pre-Clovis Occupation at the Gault Site (41BL323), Central Texas. *Current Research In the Pleistocene* 25:70–72.

De reu, Jeroen, Philippe De Smedt, Davy Herremans, Marc Van Meirvenne, Pietre Laloo, and Wim De Clercq (2014) On Introducing an Image-Based 3D Reconstruction Method in Archaeological Excavation Practice. *Journal of Archaeological Science* 41:251–262.

Dibble, David, and Dessamae Lorrain (1968) Bonfire Shelter: A Stratified Bison Kill Site, Val Verde County, Texas. *Texas Memorial Museum Miscellaneous Paper No. 1*, University of Texas, Austin.

Dibble, David S (1970) On the Significance of Additional Radiocarbon Dates From Bonfire Shelter, Texas. *Plains Anthropologist* 15:251–254.

Frison, George C (1970) The Glenrock Buffalo Jump, 48CO304. Memoir 7. *Plains Anthropologist* 50 (2):1–45.

Frison, George C. (1978) *Prehistoric Hunters of the High Plains*, Academic Press, New York.

Frison, George C (1998) Paleoindian Large Mammal Hunters on the Plains of North America. *Proceedings of the National Academy of Sciences* 95 (24): 14576–14583.

Frison, George C. (2004) *Survival by Hunting: Prehistoric Human Predators and Animal Prey.* University of California Press, Berkeley.

Graham, Russel W., Ernest L. Lundelius, and Laurence Meissner (2013) Friesenhahn Cave: Late Pleistocene Paleoecology and Predator-Prey Relationships of Mammoths with an Extinct Scimitar Cat. In *Late*

Cretaceous to Quaternary Strata and Fossils of Texas: Field Excursions Celebrating 125 Years of GSA and Texas Geology, GSA South-Central Section Meeting, Austin, Texas, April 2013, GSA Field Guides Vol. 30, edited by Brian B. Hunt and Elizabeth J. Catlos, pp. 15–31. Geological Society of America, Boulder, Colorado.

Guthrie, R. Dale (1980) Bison and Man in North America. *Canadian Journal of Anthropology* 1:55–73.

Hauer, Gerald (2018) Expected Meat Yield from a Bison Bull Carcass. Canadian Bison Association, at https://www.canadianbison.ca/application/files/2414/8778/3203/ExpectedMeatYieldfromaBisonBullCarcass.pdf. Accessed October 2018.

Hofman, Jack L. (2010) Allen Complex Behavior and Chronology in the Central Plains. In *Exploring Variability in Early Holocene Hunter-Gatherer Lifeways*, edited by S. Hurst and J. L. Hofman, pp. 135–152. University of Kansas Publications in Anthropology 25, University of Kansas, Lawrence.

Holliday, Vance T. (1997) *Paleoindian Geoarchaeology of the Southern High Plains*. University of Texas Press, Austin.

Huckell, Bruce B., and W. James Judge (2006) Paleo-Indian: Plains and Southwest. In *Handbook of North American Indians, Vol. 3, Environment, Origins, and Population*, edited by Dennis Stanford, Bruce D. Smith, Douglas H. Ubelaker, and Emoke J. E. Szathmáry, pp. 148–170. Smithsonian Institution Press, Washington, DC.

Justice, Noel (1987) *Stone Age Spear and Arrow Points of the Midcontinental and Eastern United States*. Indiana University Press, Bloomington.

Kerr, Anne C., and S. W. Dial (1998) Systematic Analysis of Unfluted Lanceolate and Early Bifurcate Stem Projectile Points. In Wilson-Leonard: An 11,000-Year Archaeological Record of Hunter-Gatherers in Central Texas, edited by Michael B. Collins, pp. 447–505. *Studies in Archeology 31*, Texas Archaeological Research Laboratory, University of Texas, Austin.

Kilby, J. David, and Stephen L. Black (2017) ASWT 2017 Fieldwork at Bonfire Shelter. Manuscript on file at Ancient Southwest Texas Project, Texas State University, San Marcos.

Knudson, Ruthann (2017) The Plainview Assemblage in Context. In *Plainview: The Enigmatic Paleoindian Artifact Style of the Great Plains*, edited by Vance T. Holliday, Eileen Johnson, and Ruthann Knudson, pp. 29–78. University of Utah, Salt Lake City.

Koenig, Charles W., Mark D. Willis, and Stephen L. Black (2017a) Beyond the Square Hole: Application of Structure From Motion Photogrammetry to Archaeological Excavation. *Advances in Archaeological Practice* 5:54–70.

Koenig, Charles W., Christina Nielsen, Charles D. Frederick, Stephen L. Black, Victoria Roberts, Jerod Roberts, and Eva Panagiotakopulu (2017b) Eagle Cave (41VV167). In *Lower Pecos Canyonlands Academy Guidebook*, edited by Ken Lawrence, pp. 73–105. Texas Archeological Society, San Marcos.

Koenig, Charles W., Stephen L. Black, and Charles D Frederick (2017c) Skiles Shelter (41VV165). In *Lower Pecos Canyonlands Academy Guidebook*, edited by Ken Lawrence, pp. 40–48. Texas Archeological Society, San Marcos.

Kooyman, B., L. V. Hills, P. McNeil, and S. Tolman (2006) Late Pleistocene Horse Hunting at the Wally's Beach Site (DhPg-8), Canada. *American Antiquity* 71 (1): 101–121.

Kornfeld, Marcel, George C. Frison, and Mary Lou Larsen (2010) *Prehistoric Hunter-Gatherers of the High Plains and Rockies*. Left Coast Press, Walnut Creek, California.

Meltzer, David J. (2006) *Folsom: New Archaeological Investigations of a Classic Paleoindian Bison Kill*. University of California Press, Berkeley.

Meltzer, David J., Ryan Byerly, and Judith Cooper (2007) An Alternative Interpretation of Paleoindian Site Use at Bonfire Shelter. *Bulletin of the Texas Archaeological Society* 78:159–160.

Pagano, Victoria, and Charles D. Frederick (2017) The Developing Tale of Sayles' Adobe (41VV2239). In *Lower Pecos Canyonlands Academy Guidebook*, edited by Ken Lawrence, pp. 49–56. Texas Archeological Society, San Marcos.

Prewitt, Elton R (2007) To Jump or to Drag: Reflections on Bonfire Shelter. *Bulletin of the Texas Archaeological Society* 78:149–158.

Ramsey, James (2020) Bonfire Shelter: A Zooarchaeological Reevaluation of Bone Bed 2. Unpublished Master's Thesis, Department of Anthropology, Texas State University, San Marcos.

Reeves, B. O. K. (1978) Head-Smashed-In: 5500 Years of Bison Jumping in the Alberta Plains. In *Bison Procurement and Utilization: A Symposium*, edited by Loren B. Davis and M.C. Wilson. Memoir 14. Plains Anthropologist 23:151–174.

Robinson, David G. (1997) Stratigraphic Analysis of Bonfire Shelter, Southwest Texas: Pilot Studies of Depositional Processes And Paleoclimate. In *Southern Plains Bison Procurement and Utilization from Paleoindian to Historic*, Memoir 29. Plains Anthropologist 42(159):33–43.

Rodriquez, Dan, and Stephen L. Black (2017) Kelley Cave (41VV164). In *Lower Pecos Canyonlands Academy Guidebook*, edited by Ken Lawrence, pp. 57–64. Texas Archeological Society, San Marcos.

Turpin, Solveig A. (2004) The Lower Pecos River Region of Texas and Northern Mexico. In *The Prehistory of Texas*, edited by Timothy K. Pertulla, pp. 266–280. Texas A&M Press, College Station.

Verbicky-Todd, E. 1984. Communal Buffalo Hunting Among the Plains Indians: An Ethno-graphic and Historic Review, Occasional Paper No. 24, Archaeological Survey of Alberta, Edmonton.

Waters, M. R., S. L. Forman, T. A. Jennings, L. C. Nordt, S. G. Driese, J. M. Feinberg, J. L. Keene, et al. (2011) The Buttermilk Creek Complex and the Origins of Clovis at the Debra L. Friedkin Site, Texas. *Science* 331 (6024):1599–1603.

Waters, Michael R., Thomas W. Stafford, Brian Kooyman, and L. V. Hills (2015) Ice Age horse and Camel Hunting at the Southern Margin of the Ice-Free Corridor: Reassessing the Age of Wally's Beach, Canada. *Proceedings of the National Academy of Sciences* 112(14):4263–4267.

Willis, Mark D., Charles W. Koenig, Stephen L. Black, and Amanda M. Castaneda (2016) Archaeological 3D Mapping: The Structure From Motion Revolution. *Journal of Texas Archeology and History* 3:1–36.

Witkind, Max. (1971) An Archaeological Interpretation of the Roberts Buffalo Jump Site, Larimer County, Colorado. Master's Thesis, Department of Anthropology, Colorado State University, Fort Collins.

Zedeño, Maria Nieves, Jesse A. M. Ballenger, and John R. Murray (2014) Landscape Engineering and Organizational Complexity among Late Prehistoric Bison Hunters of the Northwest Plains. *Current Anthropology* 55:23–58.