BISON ANTIQUUS OCCURRENCE AND PLEISTOCENE-HOLOCENE STRATIGRAPHY, CAÑADA DEL BUEY, PAJARITO PLATEAU, NEW MEXICO

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Abstract — A *Bison* (probable *Bison antiquus*) distal humerus fragment was found within a Pleistocene colluvial deposit on a hillslope above Cañada del Buey near White Rock, New Mexico. The *Bison* fossil was preserved within a buried soil with an inferred age of ca. 50-100 ka, based on soil properties and on stratigraphic position below a deposit of ca. 50-60 ka El Cajete pumice. This represents the second oldest dated *Bison* in New Mexico, and one of the few occurrences of this genus in the northern mountains of the state. It is also only the second record of a Pleistocene vertebrate from Los Alamos County, and is a rare occurrence of a pre-25 ka *Bison* fossil in good stratigraphic context. Hillslopes in the study area are underlain by a sequence of truncated Pleistocene and Holocene soils that are inferred to represent colluvial deposition and soil formation followed by erosion in the mid-Pleistocene, the late Pleistocene, and the mid- to late Holocene. The surface soil is developed in deposits that overlie 600-800 yr-old Ancestral Puebloan sites. Colluvium is dominated by relatively fine-grained (fine to very fine sand) slopewash colluvium deposited by overland flow, but also includes rocky colluvium on hillslopes below mesas. The fine-grained colluvium is likely derived mainly from reworking of eolian deposits. Episodic colluvial deposition appears to, at least in part, accompany and follow episodic eolian events, with intervening periods dominated by erosion and the development of truncated soils.

INTRODUCTION

A recently discovered distal humerus fragment of *Bison* (probably *Bison antiquus*) near White Rock, New Mexico, provides an opportunity to examine a rare bison fossil in good stratigraphic context, in a buried soil horizon below a deposit of ca. 50-60 ka El Cajete pumice. The fossil was found during archaeological investigations conducted at Los Alamos National Laboratory (LANL) in 2002 by Dr. Bradley Vierra, the archaeologist in charge of the project. This is the second recorded Pleistocene fossil from Los Alamos County, and is also one of only two bison records in New Mexico with dates older than about 25 ka. The *Bison* site was examined as part of geomorphic studies conducted for LANL in support of archaeological investigations within the White Rock land transfer parcel, located within the Cañada del Buey watershed (Fig.1). The fossil locality is situated on an east-facing colluvial slope approximately 0.5 km west of the town of White Rock. The fossil was preserved in late Pleistocene colluvium overlying older Pleistocene colluvium and Pliocene Cerros del Rio basalt. The preservation of this specimen in a colluvial deposit is somewhat unusual. In this paper we discuss the Pleistocene and Holocene stratigraphy of the White Rock parcel and the associated setting of the *Bison* fossil.

METHODS

A surficial geologic map of the study area was prepared at a scale of 1:1200. The mapping focused on units with potential archaeological significance. Soil descriptions follow Birkeland (1999), and soil horizon nomenclature is from Birkeland (1999) and Soil Survey Staff (1999). Buried soil horizons were numbered based on the overall stratigraphy for the study area, rather than for individual profiles (e.g., some profiles may have the surface soil profile sitting directly on buried soil b2 or b3 horizons, or the b1 soil may sit directly on the b3 soil). Carbonate stage for soils follows nomenclature developed by Gile et al. (1966). Preliminary age estimates for deposits are based on soil descriptions, and comparison of the degree of soil development to previously dated sites on the Pajarito Plateau and to soils described during the present investigation where radiocarbon dates were obtained. A colluvial deposit in Fence Canyon with a calibrated (cal) radiocarbon age of ca. 5.0 ka (Stop 1-4c, Reneau and McDonald, 1996, p. 62-64), at the same general elevation as the White Rock parcel, was used as a key reference for the degree of soil development in a mid-Holocene unit on that part of the plateau. The presence of the ca. 50-60 ka El Cajete pumice (age from Toyoda et al., 1995;

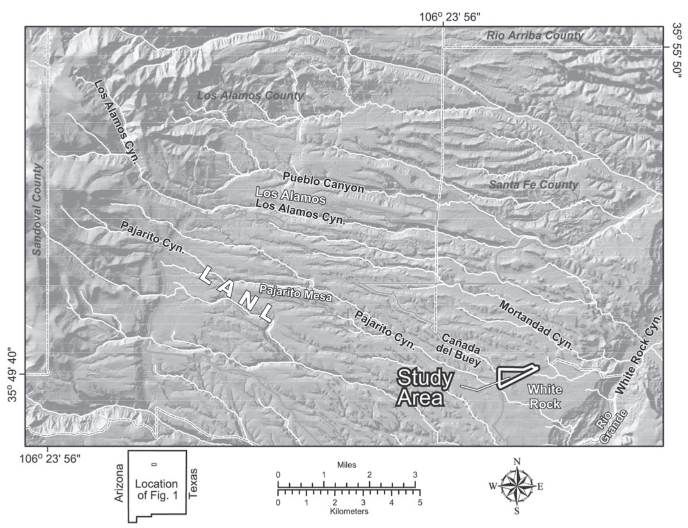

FIGURE 1. Digital elevation model (DEM) map of Pajarito Plateau showing study area.

and Reneau et al., 1996b) interbedded with colluvial sediments provided an upper age constraint for the *Bison* fossil.

STRATIGRAPHY

Cañada del Buey is located on the Pajarito Plateau, an area of gently east-sloping mesas and intervening narrow canyons (Fig. 1). The study area is in the eastern part of the plateau at an elevation of 1950 to 2000 m, in an area of relatively low relief. The modern climate is semiarid, with mean annual precipitation of about 350 mm (Bowen, 1990). Vegetation is dominated by piñon-juniper woodlands (McKown et al., 2003).

The study area includes part of the Cañada del Buey stream channel and adjacent floodplains, colluvial slopes, and alluvial fans (Fig. 2). Bedrock beneath most of the area is Pliocene basalt of the Cerros del Rio volcanic field (unit Tb). The early Pleistocene Tshirege Member of the Bandelier Tuff (unit Qbt), which overlies the Cerros del Rio basalt, is also present along the northern margin, and as an isolated mesa in the western part of the study area. Most of the study area is covered by locally derived colluvial, alluvial fan, or slopewash deposits of varied ages. Geologic maps of this area have been prepared by Griggs (1964), Rogers (1995), and Dethier (1997).

Surficial geologic units

Unit Qal consists of young alluvium in the main stream channel of Cañada del Buey and tributary drainages, and adjoining floodplains and stream terraces. Sediment ranges in size from silt to coarse sand and gravel, and is dominated by coarse sand in the main channels and very fine sand on the floodplains (Drakos et al., 2000). The upper sediment layers along the main channel and floodplains (approximately 0.5 to 2.0 m thick) are largely historic in age and typically sit directly on basalt or welded tuff boulders, although older sediment may be locally present at depth. Higher stream terraces (unit Qt) along Cañada del Buey are generally above the level of historic flooding, and are inferred to be late Holocene to Pleistocene in age. The stream terraces are in part overlain by colluvium (unit Qc).

Unit Qf consists of young alluvial fans that emanate from side drainages, typically below eroding areas of colluvium. Qf is dominated by stratified fine to very fine sand, and also includes coarse sand and fine gravel layers. The upper parts of these deposits are historic in age, and older deposits are commonly present at depth. Greater than 1 m of late Holocene sediment is present in some Qf units.

Unit Qe (mapped as Qe+Qc) includes a thin eolian deposit on the small mesa in the western part of the study area and a colluvial deposit surrounding an eroded roomblock from the Ancestral Puebloan site LA 12587 (Fig. 2; also see Drakos and Reneau, this volume). Outside of the colluvial mound surrounding the roomblocks, recent (<800 yr BP) eolian or reworked eolian deposits are typically less than 20 cm thick, with a maximum thickness of 17 to 24 cm at SP21 and SP21A on the mesa edge north of the site. Unit Qe is dominated by very fine sand and silt.

Unit Qc consists of relatively fine-grained (fine to very fine sand) slopewash colluvium deposited by overland flow, and also includes rocky colluvium on hillslopes below mesas. Qc likely includes alluvial apron surfaces and underlying deposits, eolian deposits, and/or locally reworked eolian sediment. Qc deposits

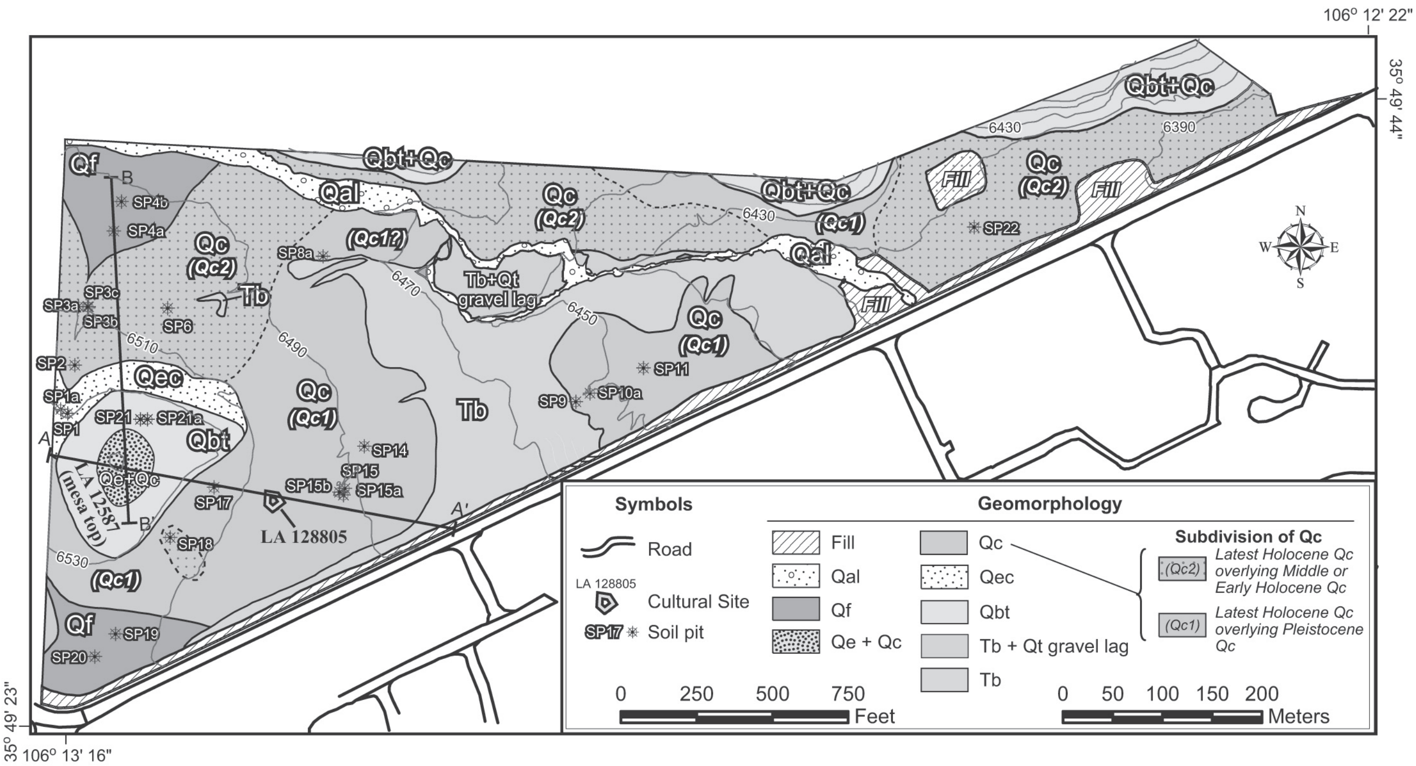

FIGURE 2. Geomorphology, cross section and soil pit locations, Cañada del Buey study area. See Figures 3 and 4 for cross sections A-A' and B-B'.

have a wide range in age, and typically have buried soils that indicate pauses in deposition, in part accompanied by local erosion. Several soil profiles include surficial and buried deposits that indicate at least two episodes of colluvial deposition since mid-Holocene time, with a lower colluvial layer likely deposited around 2 to 4 ka, and an upper colluvial layer that was likely deposited within the past 1000 yrs (Drakos and Reneau, 2003). However, in many locations, the upper colluvial layer overlies late Pleistocene or early Holocene to latest Pleistocene deposits. A thin (typically less than 10 cm thick), very young colluvial layer, likely deposited within the past 100 yrs, was observed at several locations. Although unit Qc is characterized by spatial complexity in its depositional history, it can be subdivided into units Qc1 and Qc2, based on the presence or absence of middle Holocene colluvium beneath the pervasive latest Holocene colluvium. Unit Qc1 is characterized by latest Holocene (<1 ka?) Qc overlying Pleistocene or early Holocene Qc (Fig. 3). In the area east of the Bandelier Tuff mesa, the late Holocene Qc becomes thinner downslope from approximately 0.7 m thick at the base of the mesa to less than 0.1 m thick at SP15, the *Bison* fossil locality (Fig. 3).

Unit Qc2 is characterized by latest Holocene (<1 ka?) Qc overlying inferred middle Holocene Qc. Middle Holocene deposits in unit Qc2 are approximately 1 m thick at SP6, and are overlain by approximately 0.2 to 0.7 m of late Holocene deposits (Fig. 4). In general, Qc1 underlies east- and southeast-facing slopes in areas of relatively thin colluvial deposits overlying bedrock units Tb and Qbt (Figs. 2, 3). Unit Qc2 underlies aggrading toe slopes below embayments in the Qbt mesa north of the study area and the north-facing slope between the small Qbt mesa and Cañada del Buey within the western part of the study area (Fig. 2).

Sediment in unit Qc with estimated ages younger than ca. 5 ka, based on comparison with the Fence Canyon reference section, ranges in thickness from 6 cm to >1 m. Its soils lack stage I carbonate or Bt horizons. The thickest deposit is in the eastern part of the study area, where 1.1+ m of late Holocene colluvium is present at location SP22, within site LA 12765 (Drakos and Reneau, 2003). Farther west, 70-80 cm of colluvium younger than ca. 4 ka is present on the south side of the isolated Bandelier Tuff mesa (SP17 and SP18, Fig. 2). The total thickness of Holocene or possibly latest Pleistocene sediment (< ~10-15 ka) reaches about 1.7 m in a gullied area in the northwestern part of the parcel (SP3a, Fig. 2).

Bedrock and pumice units

Unit Qec is the ca. 50-60 ka El Cajete pumice, a rhyolitic plinian fallout deposit (Bailey et al., 1969). Unit Qec lapilli are recognized in the field by their distinctive biotite phenocrysts. Postdepositional development of "Bt lamellae" is a feature that is commonly observed in El Cajete pumice deposits (Reneau et al., 1995). Within the study area, Qec lapilli are typically pebble sized, and the deposits include eolian very fine sand and silt that has infiltrated after the Qec eruption. It is present in a relatively

TABLE 1. Summary of soil morphology for *Bison* site.

Horizon	Depth (cm)	Gravel (%)	Dry Color (Matrix)	Moist Color (Matrix)	Texture	Structure	Dry Consistence	Wet Consistence	Argillans	CaCO3	CaCO3 Stage	Lower Horizon Boundary	Age Estimate	Notes
Location 15, North facing gully wall at Bison antiquus bone site														
AC	0-6	<2	7.5YR3/3	7.5YR2.5/3	sicl	m	lo	s,p	no	non	-	cs	historic	possible recent local slopewash
ABwb2	6-17	<2	7.5YR4/3	7.5YR3/2	sicl	sfsbk	sh	ss,ps	no	non	-	cs		correlative to pre-El Cajete soil?
Btb2	17-30	<2	7.5YR4/3	7.5YR3/2	sicl	2-3msbk	sh-h	s,ps	1nbrpopf	non	-	cs		***Bison sp.*** **bone horizon, est age 50 100 ka**
Btkb2	30-55	<2	7.5YR5/3	7.5YR4/3	sicl	2-3msbk	sh-h	s,p	2nbrpfpo	ev	I+	gs	50-100 ka	abrupt increase in carbonate suggest second buried soil?
BCb2	55-71	<2	10YR5/4	10YR4/4	l	1-2msbk	so, sh-h	ss,ps	no	e	-	gs		abundant cicada burrows, sh-h, mai structure soft dry consistance
Coxb2	71-88+	<2	10YR5/4	10YR4/4	ls	1msbk	so-lo	so,po	no	es	-			fewer cicada burrows
Location 15a, Flat surface 6 m south of gully near bison bone locale, south-central Parcel														
AC	0-6	<2	7.5YR 5/4	7.5YR 4/3	sl	1mgr	lo-so	ss, ps	no	none		cs	<1 ka (historic?)	fs-cs; young slopewash colluvium
Ab2	6-17	<2	7.5YR 4/3	7.5YR 3/3	scl	1fsbk-2mgr	sh	s, ps	no	none		cs		vfs
Btb2	17-37	<2	7.5YR 5/4	7.5YR 4/3	sicl	3msbk	h	s, p	2mkpobrpf	none		cs	50-100 ka	
Btkb2	37-50+	<2	7.5YR 5/4	7.5YR 4/3	sicl	3f-msbk	h	s, p	2npobr	es-ev	1+	-		
Location 15b, South gully wall, 5 m west of bison bone locale, south-central Parcel														
AC	0-9	10-20	8.75YR 6/3	8.75YR 4/4	ls	1f-mpl	so-lo	so, po	no	e-		vas	ca. 50-60 ka	Qec pumice + fines (fs)
Ab2	9-22	<2	7.5YR 4/3	7.5YR 3/3	scl	2f-msbk	sh-h	s,p	vnpobr	none		cs		very few thin bridges and pore fillings
Bk1b2	22-52	<2	7.5YR 5/3	7.5YR 4/3	sl	2msbk	h	ss, ps	no	es-ev	1+	as	50-100 ka	filaments and coatings on ped faces
Bk2b2	52-104	<2	7.5YR 5/3	7.5YR 4/3	scl	2msbk	sh-h	ss, ps	vnpobr	es-ev	1-	vas		few CaCO3 coatings on ped faces; vfs, eolian?
Btkb3	104-114+	<5	7.5YR 8/2	7.5YR 5/4	sl	3m-cabk	vh	so, ps	2n-mkbrpo	ev	3-	-	> 100-200 ka	7.5YR 6/6 mottles, clay films remnant from Bt horizon, largely impregnated with $CaCO_3$

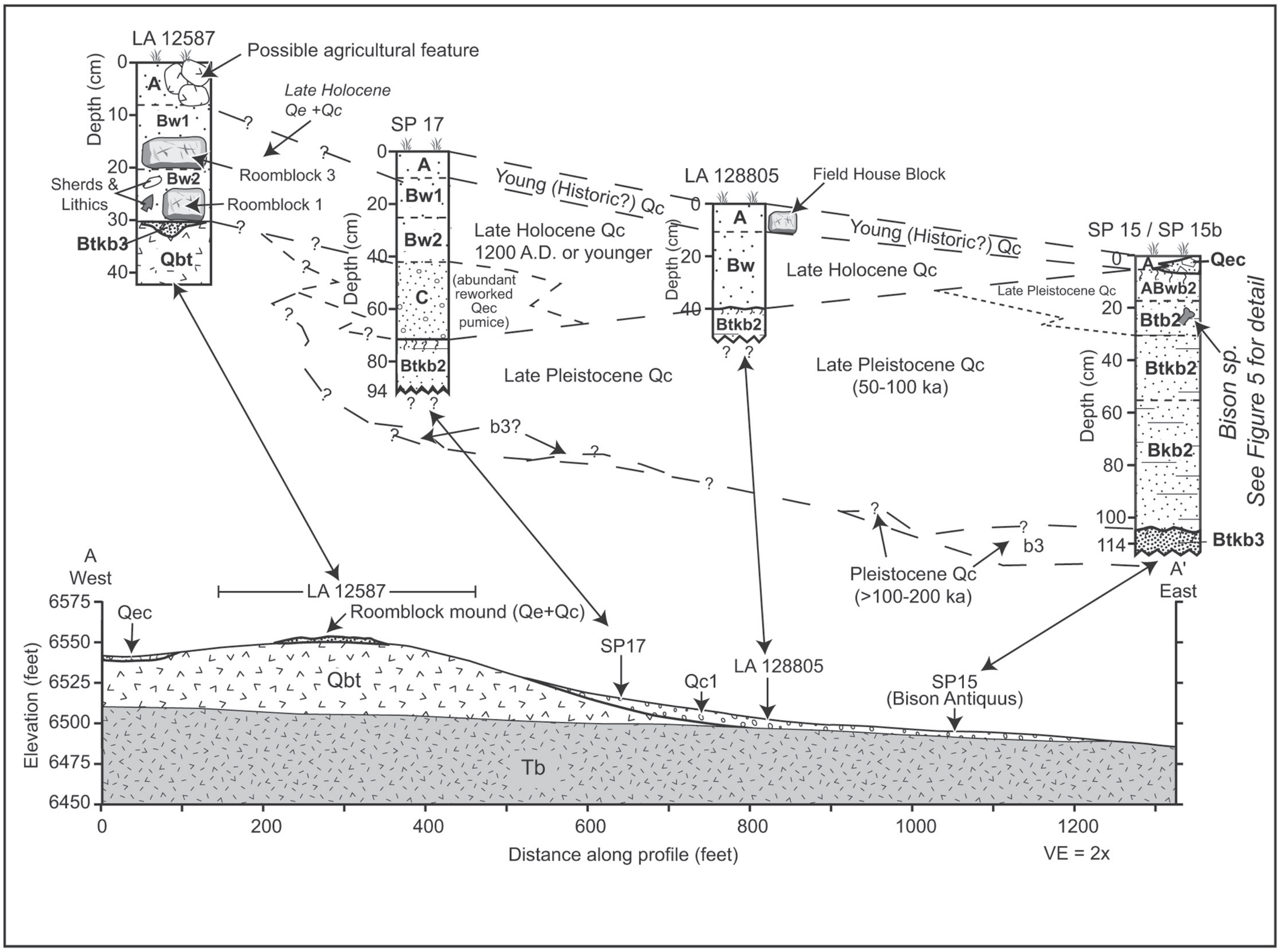

FIGURE 3. Cross section A-A' (bottom), soil profiles and correlations (top) showing *Bison* occurrence and stratigraphic relationships in unit Qc1. See Figure 1 for cross section and soil description locations.

thick (≥ 50 cm) layer within Qc on the north side of the isolated Bandelier Tuff mesa in the western part of the study area (locations SP1 and SP1a, Fig. 2), but has been largely eroded from the rest of the parcel. Thin remnants of primary Qec were observed within Qc farther east, in the vicinity of the *Bison* site (site SP15b, Fig. 3 and Table 1).

The Tshirege Member of the Bandelier Tuff (unit Qbt) in the mapped area consists of <60 m of slightly welded rhyolitic pyroclastic flows erupted at 1.25 Ma (Dethier, 1997; age from Phillips, 2004). There are no soils or only thin soils present in much of this unit, particularly along the edges of mesas. Where present, mesa top soils are formed in thin, discontinuous deposits predominantly of very fine sand (locations SP21 and SP 21a, Fig. 4), and represent either eolian or locally reworked eolian sediment. Thin deposits overlying Qbt are in part late Holocene in age (likely less than 1 ka) based on the degree of soil development (Drakos and Reneau, 2003, and this volume).

Unit Tb is Pliocene basalt of the Cerros del Rio volcanic field. Flows near the site have been dated at 2.3-2.5 Ma, and have a subaerial thickness of <30 m (Dethier, 1997). No soils or only thin soils are present throughout the area of exposure of this unit. In other areas discontinuous colluvial or eolian sediments overlie unit Tb.

Soil stratigraphy of hillslope deposits

Hillslopes in the study area are underlain by a sequence of truncated Pleistocene and Holocene soils that are inferred to represent colluvial deposition and soil formation in the middle Pleistocene (buried soil "b3"), the late Pleistocene (buried soil "b2"), and the mid- to late Holocene (buried soil "b1") (Figs. 3, 4). Truncation of the buried soils indicates that a period of erosion followed each episode of landscape stability and soil formation. The b3 soil exhibits 5YR color, moderately thick clay films, maximum stage III carbonate morphology and, based on comparison with previous soils investigated on the Pajarito Plateau, has an estimated age of at least 100-200 ka (McFadden et al., 1996); it may actually be developed in deposits with a wide range in age, although this

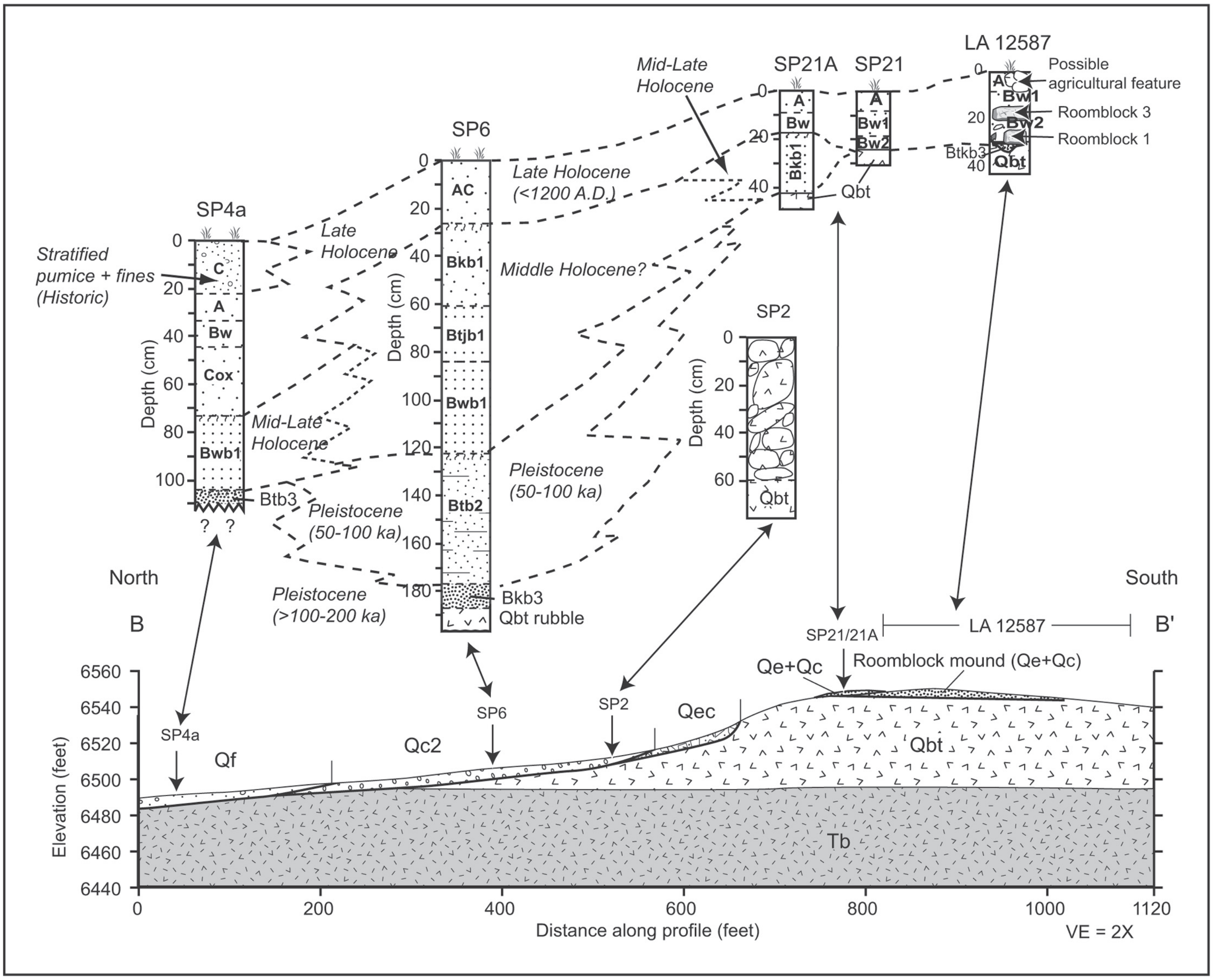

FIGURE 4. Cross section B-B' (bottom), soil profiles and correlations (top) showing stratigraphic relationships between alluvial fan (Qf), hillslope (Qc2), and mesa top (Qe+Qc) deposits, Cañada del Buey. See Figure 1 for cross section and soil description locations.

cannot be determined at present. The b2 soil exhibits 7.5YR color, thin to moderately thick clay films, and stage I to I+ carbonate morphology. In a study of calcic soils of the southwestern U.S., soils formed in gravelly alluvial deposits develop stage II morphology over a time period of 10 ka to 100 ka (Machette, 1985). The b2 soil is older than the ca. 50-60 ka El Cajete Pumice and, based on carbonate morphology and stratigraphic position overlying the b3 soil, is younger than 100 ka. The b1 soil exhibits 7.5YR-10YR color, lacks clay films or has rare, thin films (e.g. Btjb1 horizon in SP6, Fig. 4), and maximum stage I carbonate morphology. Well-developed Bt horizons, with many moderately thick clay films and 7.5YR color, overlying stage I carbonate horizons, were observed in ca. 6.7-7.4 cal ka colluvial deposits in Rendija Canyon at a site where older upslope soils were a possible clay source (Drakos and Reneau, 2004). Incipient Bt horizon development observed in Cañada del Buey b1 soils is therefore consistent with a middle Holocene age, likely less than 7 ka. Based on correlation with the ca. 5.0 cal ka Fence Canyon soil profile with stage I carbonate, the b1 soil has an estimated age of 4 to 6 ka. The surface soil typically exhibits an A-Bw profile, and is developed in deposits that overlie 600-800 yr-old Ancestral Puebloan sites. At some locations, the surface soil consists of an A, AC, or C horizon only, and is interpreted to be historic in age (Figs. 3, 4).

The predominance of fine-grained colluvial deposits is likely due to reworking of eolian deposits as a significant source of colluvial sediment. In between eolian events, erosional processes dominate, during which time much of the sediment is stripped from hillslopes and soils are truncated. Deposition of fine-grained colluvium likely enhances the probability of fossil preservation within a colluvial deposit.

Stratigraphy of *Bison* locality

The *Bison* fossil was located on an east-facing colluvial slope in unit Qc1 overlying basalt bedrock, in late Pleistocene colluvium that overlies a remnant older Pleistocene buried soil developed in a thin colluvial deposit (Fig. 3). The late Pleistocene colluvial deposit is overlain by thin, inferred historic-age colluvium that is reddened (note AC horizon with 7.5YR hue, location SP15, Table 1), suggesting that it is derived from reworking of older soils. The piece of fossilized bone was found at a depth of about 20-30 cm eroding out of a gully wall stratigraphically below the ca. 50-60 ka El Cajete pumice (Fig. 3; Table 1, note Qec pumice at location SP15b). The Qec deposit at SP15b is an eroded remnant of primary El Cajete pumice with eolian very fine sand and silt in the matrix. The bone was situated in a reddened (7.5YR) Btb2 horizon with a soil profile that exhibited a stage I+ carbonate in the underlying Btkb2 horizon (Table 1). Based on the stratigraphic position of the bone horizon below the El Cajete pumice, the fossil is > ca.50-60 ka. As discussed above, the Bt and Btk horizon development, with maximum stage I+ carbonate, moderately thick clay films and 7.5YR hue, is consistent with an age of <100 ka. The *Bison* fossil therefore has an estimated age of ca. 50-100 ka.

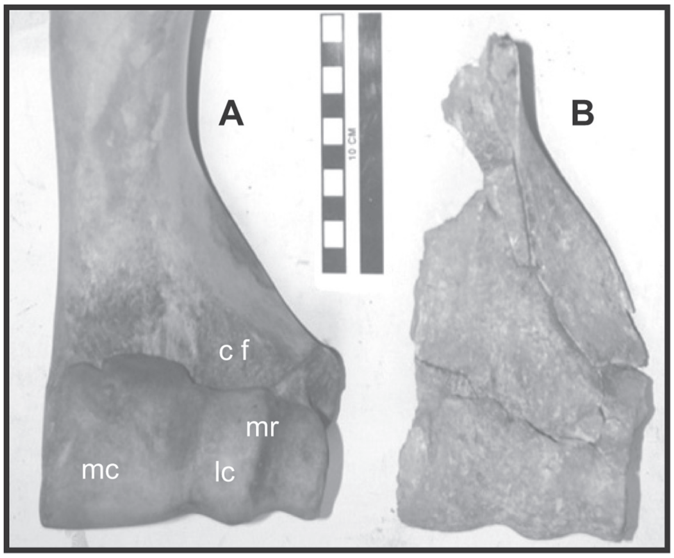

FIGURE 5. Photographs of the left distal humerus of *Bison*. **A.** *Bison bison*, recent male specimen from Fort Wingate Military Reservation, McKinley County, New Mexico (NMMNH 2364-mammalogy) ; **B.** *Bison sp*. fossil, extinct species (most likely *B. antiquus*), from Canada del Buey (NMMNH 37623-vertebrate paleontology; NMMNH locality L-5214). mc = medial condyle; lc = lateral condyle; cf = coronoid fossa; mr = medial ridge

PALEONTOLOGY

Bison sp.

A partial distal end of a left humerus of an extinct species of *Bison* (New Mexico Museum of Natural History-NMMNH catalogue number 37623; Fig. 5B) was found in the Cañada del Buey site (NMMNH locality L-5214). In a previous reference to this same fossil, the site was called White Rock for its proximity to the town of White Rock in Los Alamos County (Morgan and Lucas, 2005a). The specimen is very similar in morphology to a distal humerus from an extant American bison (*Bison bison*) skeleton from Fort Wingate Military Reservation in McKinley County, northwestern New Mexico (Fig. 5A). The distal articular surface of the fossil humerus compares closely to the humerus of *B. bison* in having the medial condyle noticeably deeper (proximo-distally) than the lateral condyle, a deeply excavated (concave) coronoid fossa just proximal to the articular surface, and the presence of a distinct medial ridge on the lateral condyle that extends as a low ridge proximally for a short distance into the coronoid fossa before curving laterally toward the edge of the shaft (Fig. 5). The size and overall features of the fossil are superficially similar to the distal humerus of a large extinct horse (*Equus*), but the horse differs in having the medial and lateral condyles about the same depth, a much shallower coronoid fossa, and a less distinct medial ridge on the lateral condyle that does not extend into the coronoid fossa as a low ridge.

The species of *Bison* are identified by characters of their bony horn cores (McDonald, 1981), and thus the partial humerus from Cañada del Buey can only be referred to *Bison* sp. However, its occurrence in a late Pleistocene site (50-100 ka; late Rancholabrean land mammal age) and smaller size compared to *B. latifrons* suggest that NMMNH 37623 is more likely to be *B. antiquus*, an extinct species typical of late Pleistocene and early Holocene sites in New Mexico and elsewhere in western North America (McDonald, 1981). The much larger *B. latifrons* is more characteristic of medial Pleistocene sites (100-300 ka; early Rancholabrean land mammal age). Although the fossil appears to be similar in size to, or even somewhat smaller than, the recent male *B. bison* humerus (Fig. 5A), this is misleading because the fossil is incomplete and weathered. The medial edges of the shaft and the articular surface are both broken in the fossil (Fig. 5B). In features that are comparable (e.g., the breadth of the humeral shaft just proximal to the articular surface), the fossil is actually somewhat larger than the recent *B. bison*, which places it in the size range of *B. antiquus*.

The Cañada del Buey *Bison* represents the second known record of a Pleistocene vertebrate fossil from Los Alamos County. The first is a lower jaw of a small horse (*Equus*), found in 1966 by collectors from the Frick Laboratory of the American Museum of Natural History on the mesa top east of Potrillo Canyon, west of White Rock Canyon, 1 to 2 km west of Pajarito Springs (Morgan and Lucas, 2005a). According to the original notes written on the fossil by Ted Galusha, this horse jaw was collected from the early Pleistocene Bandelier Tuff, and thus would be considerably older than the bison humerus (inferred age of 50-100 ka). The Cañada del Buey humerus is the second oldest dated *Bison* known from New Mexico. The oldest record is a partial skull and horn core of *B. latifrons* from the Los Duranes Formation in a gravel pit in Bernalillo, Sandoval County (Smartt et al., 1991). According to Connell and Love (2001) and Connell (2004), the Los Duranes Formation is bracketed by dates of 156 ka on the Albuquerque volcanoes basalt (Peate et al., 1996) and 98 ka on the Cat Hills basalt above the Los Duranes Formation (Maldonado et al., 1999). Other dated records of *Bison* in New Mexico are younger than 25 ka, of which the identifiable specimens are all referable to *B. antiquus*.

Late Pleistocene records of *Bison* are uncommon in the mostly mountainous terrain of northern New Mexico (Morgan and Lucas, 2005b). The Cañada del Buey site is one of the higher elevation records of *Bison* in the state at 1975 m. Other late Pleistocene *Bison* occurrences in this region from elevations above 1830 m include Navajo Lake in San Juan County, Abiquiu in Rio Arriba County, Mesa Vibora in Taos County, Folsom in Colfax County, and Snow Ranch in Santa Fe County. *Bison* is a grazing ungulate, and during the late Pleistocene was more common in the extensive grasslands and savannas of the Great Plains in eastern New Mexico (Morgan and Lucas, 2005a).

CONCLUSIONS

Hillslopes in the study area are underlain by a sequence of truncated Pleistocene and Holocene soils that are inferred to represent colluvial deposition and soil formation in the middle Pleistocene, late Pleistocene, and the mid- to late Holocene, followed by erosion (Figs. 3, 4). A later period of colluvial deposition occurred within the past 800 yrs, likely contemporaneous with and/or postdating Ancestral Puebloan occupation, and a thinner colluvial layer, likely deposited within the past 100 yrs, was observed at several locations. Reworking of eolian deposits probably provided a source for much of the fine-grained colluvium in the study area. The presence of older early to middle Holocene colluvial deposits in other areas on the eastern Pajarito Plateau indicates that the record in the study area is incomplete, with likely loss of deposits of this age by erosion. For example, colluvial deposits dated at 6-8 cal ka have been found in Fence Canyon and in several other areas (Reneau and McDonald, 1996; Reneau et al., 1996a), but have not been clearly identified in the study area.

The *Bison* partial distal humerus was discovered on an east-facing slope within late Pleistocene colluvium stratigraphically below the ca. 50-60 ka El Cajete pumice. Fossil preservation was enhanced by the active, episodic colluvial deposition in this area. Although the *Bison* fossil is not identifiable to the species level, its size and inferred age of 50-100 ka suggest it is probably *B. antiquus*. This is one of very few bison records in New Mexico with a date older than about 25 ka. It is only the second recorded Pleistocene fossil from Los Alamos County, and one of about a half dozen records of *Bison* from the mountains of northern New Mexico at elevations above 1830 m.

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APPENDIX A. KEY TO SYMBOLS USED IN DESCRIPTIONS OF SOIL MORPHOLOGY (From Birkeland, 1999)

Structure		
Grade	**Size**	**Type**
1 = weak	vc = very coarse	sbk = subangular blocky
2 = moderate	c = coarse	abk = angular blocky
3 = strong	m = medium	pr = prismatic
	f = fine	pl = platy
		sg = single grain
		m = massive
Consistence		
Dry	**Wet - Stickiness**	**Wet - Plasticity**
lo = loose	so = non sticky	po = non-plastic
so = soft	vss = very slightly sticky	vps = very slightly plastic
sh = slightly hard	ss = slightly sticky	ps = slightly plastic
h = hard	s = sticky	p = plastic
vh = very hard		
Cutans (clay films)		
Abundance	**Thickness/(Distinctness)**	**Location/Type**
n.o. = none observed	n = thin (faint)	po = along pores
v1 = very few (< 5%)	mk = moderately thick	co = coating gravel, ped faces
1 = few (2 - 25%)	k = thick	br = bridging grains
2 = common (25 - 50%)		pf = along ped faces (as co + br)
3 = many (50 - 75%)		pr:pf along prismatic ped faces
4 = continuous (75+%)		bk:pf along blocky ped faces
		Lam = lamellae
Horizon Boundary		
Thickness	**Topography**	**Carbonate effervescence in HCl**
a =abrupt (< 2.5cm)	s = smooth	none = non-effervescent
c = clear (2.5 - 6cm)	w = wavy	e = slightly effervescent
g = gradual (6-12.5cm)	i = irregular	es = strongly effervescent
d = diffuse (> 12.5 cm)	b = broken	ev = violently effervescent
Texture		
s = sand	sil = silt loam	
ls = loamy sand	scl = sandy clay loam	
sl = sandy loam	sicl = silty clay loam	
l = loam	cl = clay loam	