Geoarchaeology of the Mockingbird Gap (Clovis) Site, Jornada del Muerto, New Mexico

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The Mockingbird Gap site is one of the largest Clovis sites in the western United States, yet it remains poorly known after it was tested in 1966–1968. Surface collecting and mapping of the site revealed a dense accumulation of Clovis lithic debris stretching along Chupadera Draw, which drains into the Jornada del Muerto basin. We conducted archaeological testing and geoarchaeological coring to assess the stratigraphic integrity of the site and gain clues to the paleoenvironmental conditions during the Clovis occupation. The 1966–1968 excavations were in stratified Holocene eolian sand and thus that assemblage was from a disturbed content. An intact Clovis occupation was found elsewhere in the site, embedded in the upper few centimeters of a well-developed buried Bt horizon formed in eolian sand, representing the regional Clovis landscape. Coring in Chupadera Draw revealed ~11 m of fill spanning the past ~11,000 ^{14}C years. The stratified deposits provide evidence of flowing and standing water on the floor of the draw during Clovis times, a likely inducement to settlement. © 2009 Wiley Periodicals, Inc.

INTRODUCTION

The Mockingbird Gap site, ~40 km southeast of Socorro, New Mexico, is one of the largest Clovis sites in the western United States, yet it remains poorly known 40 years after it was tested. Surface collecting and detailed mapping of the site showed that it is a dense accumulation of Clovis lithic debris that stretches for ~800 m along Chupadera Draw. A small portion of the site was excavated in the 1960s, but little was published on the work or the site (Weber & Agogino, 1997; Weber, 1997).

A visit to the site in 2004 suggested to us that there was potentially much to be learned from the site about the Clovis occupation, and that the adjacent reach of

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Chupadera Draw contains a long record of past environmental conditions. Accordingly, we carried out a program of archaeological testing and geoarchaeological coring (Huckell et al., 2006; Huckell, Holliday, & Weber, 2007). Our goals were basic and form the central theme of this paper: (1) to determine whether additional buried deposits of Clovis age remained for investigation, and the natural and cultural depositional history of those deposits; (2) to further investigate the stratigraphic record of Chupadera Draw and nearby landforms for clues to Paleoindian environments and landscapes; and (3) relatedly, to understand why the area was apparently so attractive to Clovis occupants. Along with the geoarchaeological research, we also began a study of the extensive collection of lithic artifacts recovered from the site (Hamilton et al., 2008; Huckell et al., 2008). The results of that research will be the subject of other publications.

Mockingbird Gap is the most extensive and richest (in terms of artifact density) Clovis site known in central New Mexico, but a number of other Paleoindian sites are associated with Chupadera Draw, including another Clovis site updraw (Weber field notes), and six Folsom, Cody, or Folsom/Cody sites above and below Mockingbird Gap (Elyea & Doleman, 2002; Elyea, 2004; Weber field notes). Another and related goal of our work, therefore, was to determine why early populations were attracted to the area of greater Chupadera Draw.

SETTING AND RESEARCH BACKGROUND

The Mockingbird Gap site covers an area of approximately 800 m × 80–150 m along a low ridge adjacent to Chupadera Draw, the principal drainage in the northern Jornada del Muerto basin (Figures 1, 2). Most of the basin area is a low-relief desert grassland receiving ~20 cm of rainfall annually (Weber, 1997), and Chupadera Draw flows only intermittently.

The Jornada del Muerto is a broad fault-block intermontane basin on the east flank of the Rio Grande Rift (Figure 1; Pazzaglia & Hawley, 2004; Hawley, 2005). The northern end of the basin is enclosed on the west by the Jornada basalt and by low hills (variously referred to as Cerro Colorado and Cerro de la Campana) that separate it from the Rio Grande Valley itself (Figure 1). To the northeast and east, the basin is flanked by Chupadera Mesa and the Oscura Mountains (Figure 1). To the southeast is the San Andres Range (Figures 1, 3). In the Pliocene and early Pleistocene, the basin was occupied by aggrading distributaries of the ancestral upper Rio Grande (Hawley, 1993). In the early to middle Pleistocene, eruptions of the Jornada volcanic field in the west-central part of the basin blocked drainage of the northern end (Figure 1; Hawley, 1978:96; Hawley, 1993:15). In the middle Pleistocene, incision of the Rio Grande isolated the Jornada basin floor above the stream channel. Subsequent processes of basin filling resulted in formation of a paleo-lake basin holding Lake Trinity in the middle to late Quaternary (Figure 1; Neal, Smith, & Jones, 1983; Hawley, 1993). At its highest elevation of ~1431 m, the lake covered ~200 km^2 with a maximum depth of 6.4 m (Kirkpatrick & Weber, 1996). Otherwise, little is known of the lake history. The Mockingbird Gap site is located ~15 km north of and 80 m higher than the highest shoreline of the paleo-lake (Figure 1).

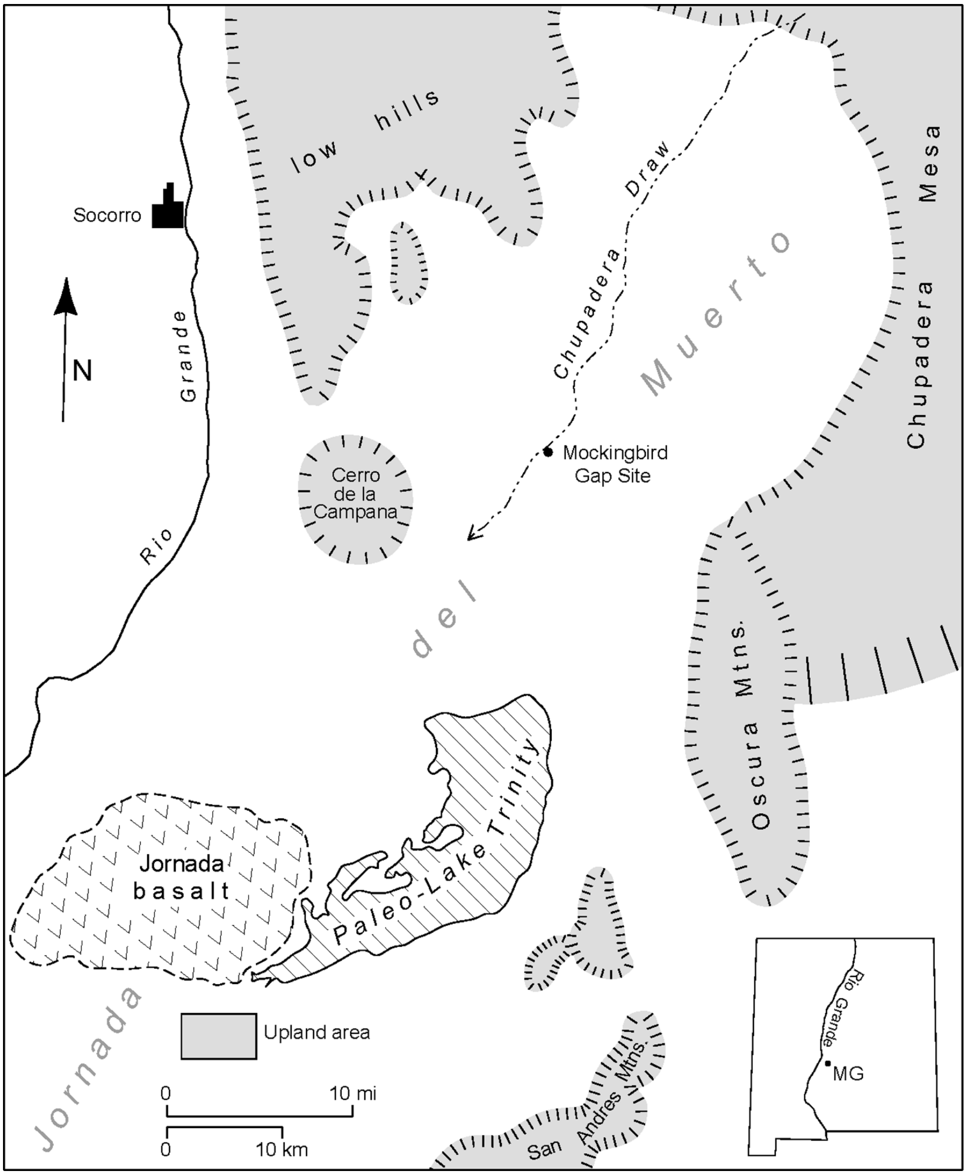

Figure 1. Central New Mexico and the northern Tularosa Basin, with the location of the Mockingbird Gap site, Chupadera Draw, paleo-Lake Trinity, the Jornada basalt flow, and other key physiographic and cultural features mentioned in the text. Inset shows the location of the Mockingbird Gap site (MG) in New Mexico.

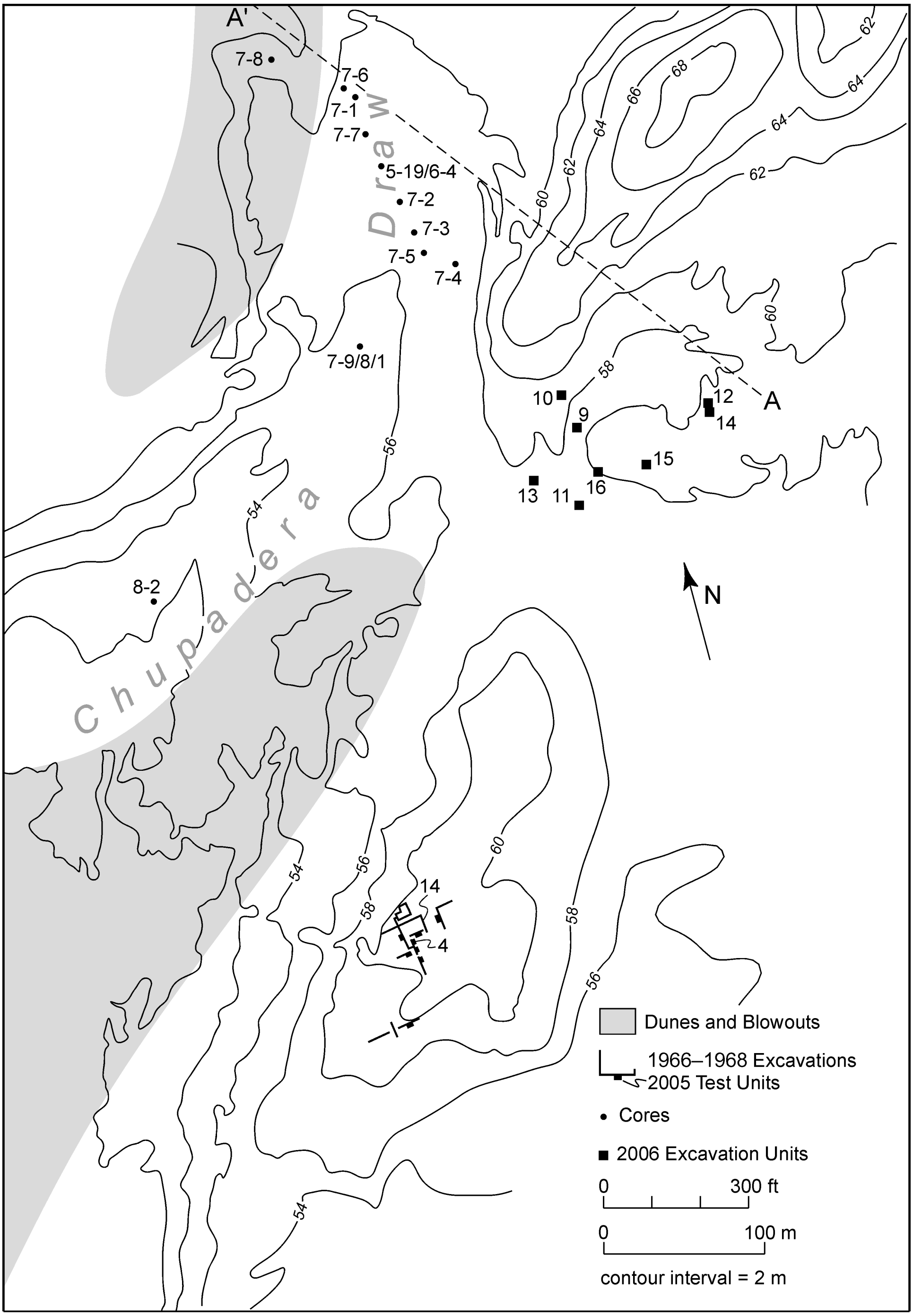

Figure 2. Topographic map of the Mockingbird Gap site (prepared by Weber) with locations of the 1966–1968 excavations on the south ridge (selectively numbered), the 2005 test pits on the south ridge (selectively numbered), the 2006 excavation units in the swale just south of the north ridge, the line of cores across Chupadera Draw from 2007, cores from 2008, and line-of-section A-A' (Figure 4). The prospect pit was beyond the limit of Weber's mapping. The pit is ~400 m northeast of core 7-9/8-1 on a bearing of 35°.

Figure 3. Coring at 07-4 (far southeast end of the 2007 line of cores; Figure 2). The south end of the north ridge is covered in sage brush and visible above the truck and extending to the left. The swale between the ridges is the sage-covered surface dropping down from and visible to the right of the North Ridge. The topographic landform Mockingbird Gap is visible on the skyline directly above the truck. The San Andres Mountains form the skyline to the right of the gap.

Chupadera Draw heads on Chupadera Mesa, 58 km north-northeast of the site, and flows southwest past the site, terminating on the playa floor of paleo-Lake Trinity, 15 km to the south-southwest (Figure 1; Weber, 1997). On maps the drainage is referred to as Chupadera Arroyo, but the term "arroyo" is misleading. An arroyo is an incised drainage or gully "characterized by steeply sloping or vertical walls in cohesive, fine grained sediments and by flat and generally sandy floors" (Cooke & Reeves, 1976:v). Though locally incised, other reaches of the draw (e.g., adjacent to the Mockingbird Gap site) have been aggrading and have wide, flat floors. At the site, the draw varies from 100 to 200 m in width (Figure 2) and is underlain by at least 11 m of late Quaternary fill, discussed below. The Chupadera drainage system is perhaps better described as a draw, which is a general term applied to a dry water course in parts of the western U.S. (e.g., Holliday, 1995).

The Mockingbird Gap site is located on two segments of a ridge composed of sand and gravel and also in an intervening swale along the east side of Chupadera Draw (Figures 2, 3, 4). Relief is relatively low across the site: ~10 m elevation across ~200 m between the crest of the north ridge and the swale (Figure 2) and <6 m elevation across 350 m between the crest of the south ridge and the swale (Figure 2).

The gravel ridge is a locally prominent landform rising up to 10 m above the floor of the draw and the flat landscape to the east (Figures 2, 3, 4). The age and origin of

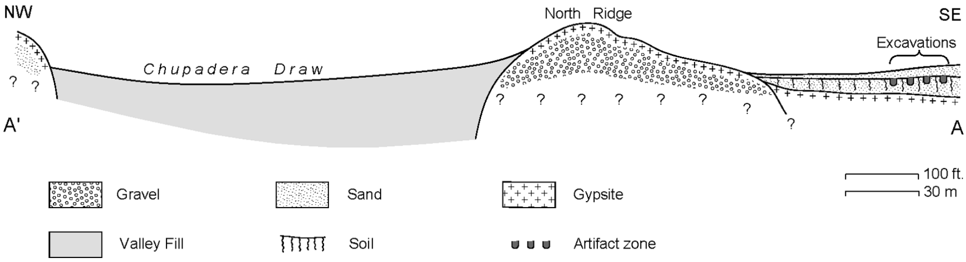

Figure 4. Generalized topographic and stratigraphic relations at Mockingbird Gap along section A-A′ (Figure 2) from the main intact occupation area in the swale (right) through the north ridge and across Chupadera Draw. Details of the draw stratigraphy in the 2007 cores are shown in Figure 7.

this ridge are unknown, although we hypothesize that it may be an ancestral channel of Chupadera Wash protected from erosion by the gravel acting as an armor. The sediment is clearly alluvial based on the rounded and sorted character of the clasts and local bedding, but it must be quite old (hundreds of thousands to perhaps millions of years old) given that (1) it is higher than the surrounding landscape (representing reversed topography) and (2) the upper ~2 m is engulfed by massive pedogenic gypsite and calcium carbonate (i.e., a compound calcic and gypsic horizon). Considerable time is required to lower the landscape such that channel deposits now form a promontory, and to form such a well-expressed soil feature.

The Mockingbird Gap site was discovered (by Weber) in 1959. George Agogino [Eastern New Mexico University (ENMU)] was contacted about the site in the mid-1960s. It was excavated as a field school by crews from ENMU in 1966, 1967, and 1968 under Agogino's direction with Weber as site geologist. Agogino also named the site, taking his inspiration from the prominent gap between the Oscura and San Andres Mountains ~40 km to the south-southeast (Figures 1, 3). The ENMU field work focused on a series of 2-m-wide exploratory trenches excavated on the south ridge segment (Figures 2, 5). Where results warranted, blocks of contiguous 2-m units were dug adjacent to the trenches. The site was determined to be largely Clovis, although scattered Archaic occupations and a small Ancestral Pueblo pithouse component were encountered. During and after the excavations, Weber conducted geological investigations on the site and along Chupadera Draw and also monitored and mapped the site, and meticulously plotted the locations of hundreds of points and other tools exposed in blowouts. Results were reported briefly (Weber & Agogino, 1997; Weber, 1997). No other work was conducted at the site until 2004.

METHODS

Research in and near the Mockingbird Gap was both geological and archaeological. The geologic investigations included examination and recording of the new archaeological excavation units, cores and augers, and two abandoned materials-quarry pits (both of which are beyond the northern limit of the archaeological site;

Figure 5. Eastern New Mexico University excavations at on the south ridge of the Mockingbird Gap site, 1966 or 1967. Trench 15 is at left, intersected by Trench 14 at lower right (Figure 2). View is generally west toward the Magdalena Mountains (Blackwater Draw site photo archive, Mockingbird Gap 034, Eastern New Mexico University). The eolian sand mantle is exposed in the trench wall and the top of the gypsite is exposed on the trench floor.

Figure 2). One pit is a gravel prospect excavated on the floor of Chupadera Draw, exposing the upper valley fill. Weber investigated the gravel prospect in 1973 and augered beneath it in 1974, recovering a radiocarbon sample (Table I; Figure 6). The other pit was excavated into the northwest side of the north ridge, 280 m due east of the prospect pit. All excavation units, quarry pits, cores, and augers were measured and described using standard geologic and pedologic nomenclature and conventions (AGI, 1982; Birkeland, 1999; Holliday, 2004).

From 2004 to 2008, 10 auger holes were dug and 36 cores were recovered in the area of the Mockingbird Gap site. The auger holes were dug using a standard hand-operated 3-inch-diameter bucket auger. The coring used a trailer-mounted, hydraulic soil-coring rig that recovered continuous cores 5 cm and 7.5 cm in diameter in 120 cm segments. Twenty-five cores came from Chupadera Draw to the northwest and north of the site (Figure 2). The first phase of our work (2004) focused on reproducing the stratigraphy in the prospect pit and old auger hole (cores 04-1, 04-2, 04-3, and 04-4; Figure 6). Most of the rest of the coring was down-draw southwest of the pit, aimed at examining the stratigraphy of and dating the fill in the draw. The first three cores (04-1, 04-2, 04-3) were begun from the floor of the draw near the prospect pit and penetrated only 175–310 cm below surface, refusing on gravel lenses or dense, dry clay (desiccated by long-term drought conditions) well above the dated zone (Figure 6). Core 04-4 was on a balk left in the borrow pit and penetrated to almost 7 m (Figure 6). In 2005, eleven cores (05-1 to 8, 17, 18, 19) and one auger hole (A05-10)

Table I. Radiocarbon ages from the Mockingbird Gap site.

Core	Lab No.	Depth (cm)	Fraction	Date	$\delta^{13}C$
Prospect Pit	W-3240	~470	Shell carbonate	11,400 ± 300*	
MG 04-2	A 13749	110–115	Residue	4675 ± 115	−19.4
	A 13840	140–150	Residue	5700 ± 125	−16.8
	A 13841	200–210	Residue	9835 + 190/−185	−19.5
	A 13842	270–280	Residue	7130 + 170/−165	−17.7
MG 04-4	A 13790	602–607	Residue	7665 ± 135	−16.3
	A 13791	612–619	Residue	9800 + 250/−240	−18.5
	A 13792	619–632	Residue	7950 ± 160	−16.1
	A 13928	635–648	Decalcified sediment	10,590 + 185/−180	−14.0
MG 05-1	A 14064	800–833	Decalcified sediment	11,420 + 185/−180	−21.7
MG 05-19	A 13929	635–645	Decalcified sediment	9925 + 155/−150	−24.0
	A 14066	718–734	Decalcified sediment	9805 + 205/−200*	−21.9
	A 14067	821–826	Decalcified sediment	9840 ± 145*	−13.8
	A 14068	849–853	Decalcified sediment	9580 ± 170*	−22.6
	A 13930	898–920	Decalcified sediment	10,590 + 95/−90	−22.8
MG 06-4	AA75449	680–690	Decalcified sediment	10,130 ± 52	−21.5
	AA75451	730–740	Residue	5751 ± 40*	−20.4
	AA75452	760–780	Residue	7163 ± 44*	−21.3
	AA75455	894	Residue	7516 ± 44*	−20.4
	AA75456	896–900	Residue	8077 ± 46*	−20.7
	AA75453	891	Residue	10,669 ± 54	−24.5
	AA75454	892	Residue	10,594 ± 57	−23.3
MG 07-02	A 14784	280–290	Decalcified sediment	7670 ± 80	−18.6
	A 14785	294–315	Decalcified sediment	6760 + 105/−100	−17.8
MG 07-5	A 14786	373–386	Decalcified sediment	7570 ± 75	−13.9
	A 14787	386–430	Decalcified sediment	8435 ± 120	−15.0
	A 14788	555–585	Decalcified sediment	9285 ± 140	−20.3
MG 07-6	A 14712	900–918	Decalcified sediment	10,660 ± 80	−22.1
MG 07-7	A 14789	295–320	Decalcified sediment	7710 + 180/−175	−20.3
	A 14711	385–405	Decalcified sediment	8630 + 120/−115	−21.3
MG 07-9	A 14713	745–765	Decalcified sediment	10,285 + 115/−110	−19.1
	A 14714	830–845	Decalcified sediment	11,245 ± 180	−22.1
	A 14790	857–876	Decalcified sediment	11,870 + 230/−225	−22.3
	A 14791	930–950	Decalcified sediment	11,665 ± 135	−23.5
	A 14715	1030–1052	Decalcified sediment	10,855 + 90/−85	−25.9

* Date rejected.

were placed in the draw down-drainage from the gravel prospect. Coring again proved difficult. Sand, gravel, or very dense, dry clay prevented the core barrel from penetrating to the Paleoindian-age deposits on most attempts, but cores 05-1 and 05-19 penetrated to or below 840 cm (Figures 2, 6, 7). Core 05-1 was near the prospect pit; 05-19 was down-draw to the southwest ~200 m (Figure 2). In 2006, only one core was recovered from the draw (06-4), but it was deep (1020 cm) and reproduced 05–19 (Figure 7). In 2007, coring conditions were better and nine cores were recovered

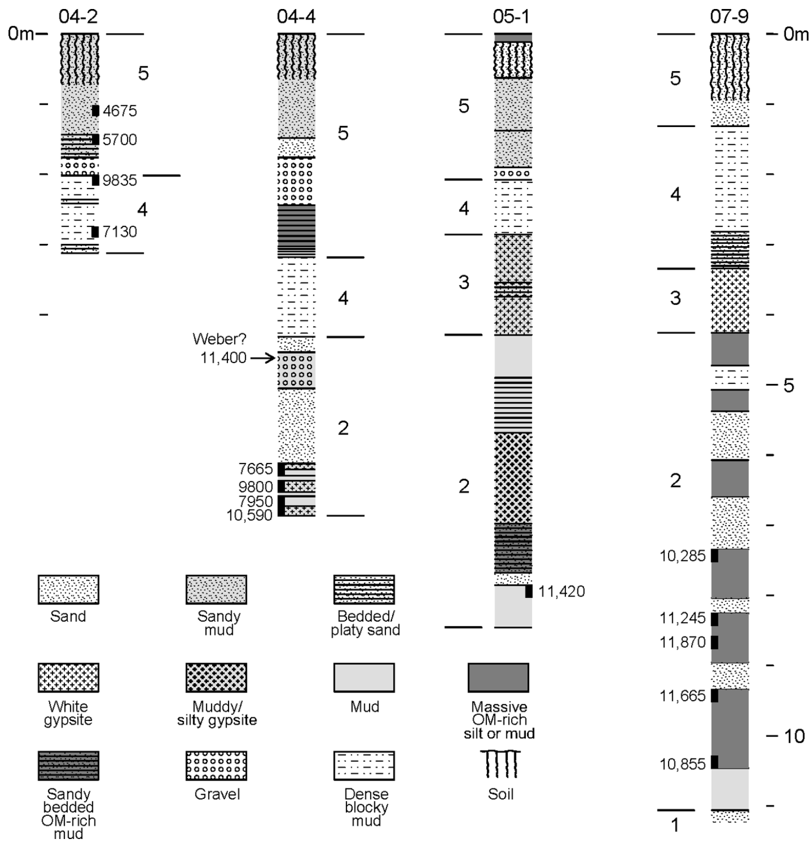

Figure 6. Stratigraphy and radiocarbon means of samples from selected cores in Chupadera Draw collected in 2004 and 2005 (northeast of section A-A′ and off of Figure 2). Core 04-4 was collected from a balk left in the prospect pit. The upper 5 m approximates stratigraphy recorded by Weber in 1974.

from the draw, six of them penetrating from 770 to 1120 cm depth. Eight of these cores provide a cross-section that includes 05-19/06-4 (Figures 2, 7). Two cores were recovered from the draw in 2008. Core 08-1 reproduced 07-9. Core 08-2 was to the southwest of 07-9/08-1 (Figure 2). Eleven cores (eight in 2005, three in 2006) were placed on the “flats” to the east of the gravel ridges and site proper. Also in 2005, nine auger holes (A05-1 to 9) were placed within the swale between the north and south ridge segments, where few artifacts have been found during the past ~40 years of collecting on the site. The augering was aimed at determining if there is a geologic explanation (e.g., burial or erosion) for the sparse occupation debris at the surface in this area of the site.

Archaeological excavations were concentrated in two areas: the south ridge around the 1966–1968 trenches, and in the swale between the north and south ridges

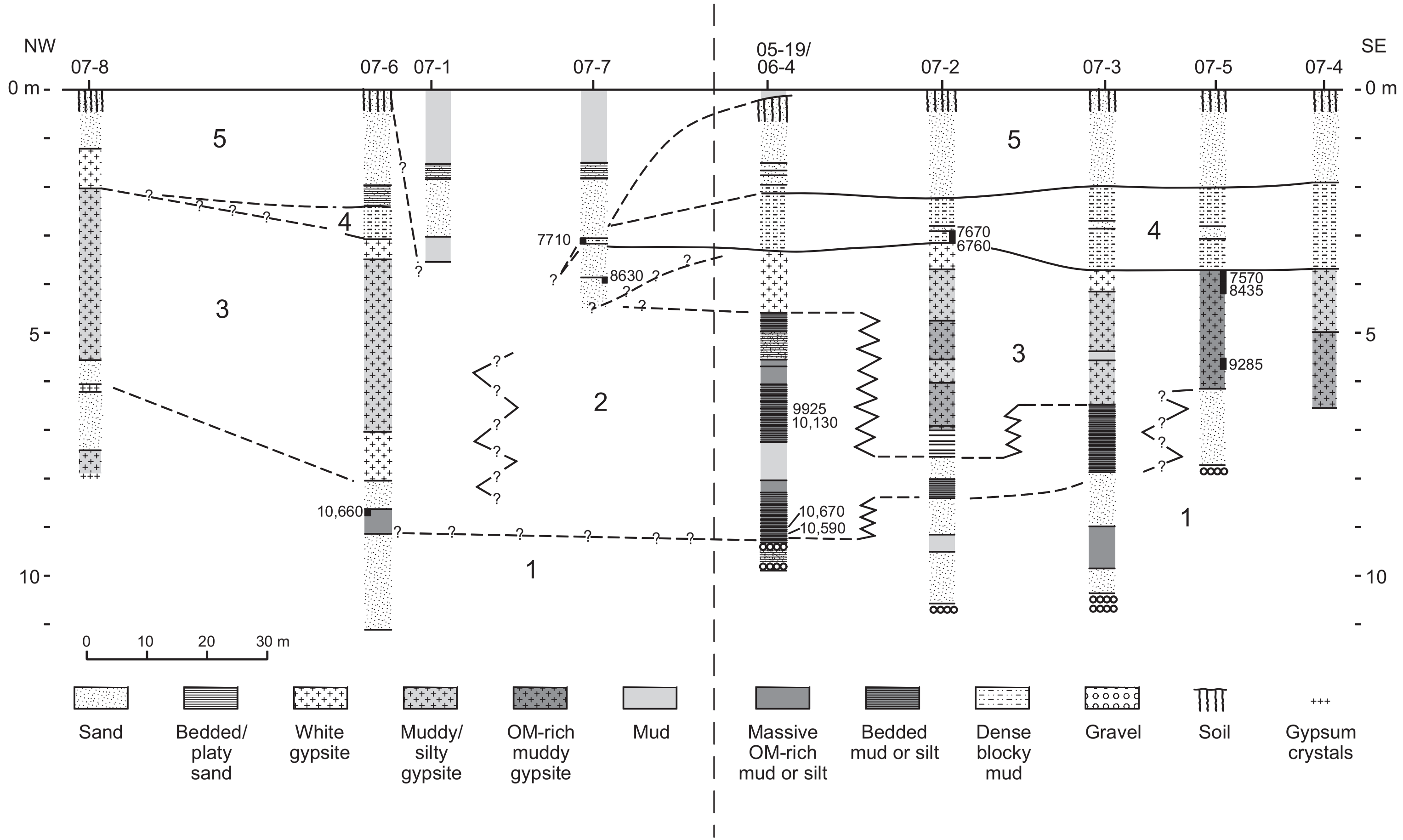

Figure 7. Stratigraphic cross-section of Chupadera Draw with radiocarbon means of samples collected from cores, based largely on coring in 2007 (Figure 2). Facies relations between strata 2 and 3 are uncertain.

(Figure 2). In 2005 and 2006, work was devoted to testing the areas where previous excavations and surface collections had been made. Our work on the south ridge (2005) focused on understanding the stratigraphic context of the artifact assemblage recovered by the ENMU crews. The original excavations were not back filled and, therefore, the walls had slumped in. We laid out eight 1.0 × 0.5 m units along the trench walls, excavated in arbitrary 10-cm levels from the point of break-in-slope to culturally sterile sediments, typically 0.4-0.6 m below ground surface. All sediments were passed through 1/8″ mesh screens. Photographs from the 1966–1968 excavations also assisted in understanding the geologic context of the archaeological remains. In 2006, test excavations in the swale were the focus. Over the years, Weber found a large quantity of Clovis artifacts in this area where wind deflated the sand sheet down to resistant units. No artifacts were found where the sand sheet was intact. The situation indicated the presence of a buried occupation zone. The augering in 2005 showed that locally within the swale is a stratified eolian sand sheet up to 100 cm thick, which could contain or bury occupation debris. Excavation in 2006 (eight 1.0 × 1.0 m units; Figure 2) and 2007 (fifteen 1.0 × 1.0 m units) were taken down through the sand sheet in arbitrary 10-cm levels to culturally sterile sediments, typically 0.4–0.6 m below ground surface. All sediments were passed through 1/8″ mesh screens.

One portion of the tested area proved particularly productive of artifacts, yielding more than 50 specimens—including one Clovis point fragment—from two 1-m × 1-m units placed just south of an area from which Weber had collected four Clovis point fragments. In 2007, the University of New Mexico Southwestern Summer Field School devoted five weeks of intensive excavation to this 20 m × 10 m locale, designated Locus 1214. Fifteen 1-m units, chosen by random sampling, were excavated to culturally sterile sediments, producing over 1000 stone artifacts, pieces of tooth enamel, and other materials.

Dating the evolution of the landscape at and around the Mockingbird Gap site was accomplished using radiocarbon dating. Radiocarbon ages were determined for soil organic matter (SOM) from buried soil horizons and organic-rich sediments (Table I). Radiocarbon dating of organic-rich sediments can be somewhat problematic owing to contamination by younger humic acids (Martin & Johnson, 1995; Abbot & Stafford, 1996; McGeehin et al., 2001), but with proper pretreatment and an understanding of the nature of the carbon accumulation (over some span of time), these materials can provide accurate, reproducible, stratigraphically consistent age control, especially in drier environments (e.g., Haas, Holliday, & Stuckenrath, 1986; Holliday et al., 1994; Holliday, Hovorka, & Gustavson 1996; Quade et al., 1998; Rawling, Fredlund, & Mahan, 2003; Mayer & Mahan, 2004). SOM samples underwent a standard acid-base-acid treatment to remove carbonate and isolate specific fractions of organic matter (after Abbot & Stafford, 1996). Radiocarbon ages were determined for the residue (NaOH insoluble) and humic acid (NaOH soluble) fractions using the liquid scintillation method at the University of Arizona Isotope Geochemistry Laboratory (A#s) and the NSF–Arizona Accelerator Mass Spectrometry (AMS) Laboratory (AA#s). Radiocarbon ages were corrected for isotopic fractionation and are presented in uncalibrated radiocarbon years before present (^{14}C yr B.P.).

GEOARCHAEOLOGY IN THE EXCAVATION AREAS

Since the Mockingbird Gap site was discovered in the late 1950s, Weber surface-collected and piece-plotted hundreds of Clovis artifacts, including complete and fragmentary projectile points, projectile point preforms (Hamilton et al., 2008), end scrapers, gravers, and other expedient flake tools. The artifacts are concentrated in two primary loci, one at the north end and one at the south end of the site, roughly corresponding to the north ridge and the south ridge (Figure 2). Preliminary spatial analysis suggests distinct clustering of artifacts within these loci (Hamilton et al., 2008), though whether this clustering is due primarily to erosional, cultural, or depositional processes is unclear. However, initial impressions formed by the authors from survey and limited test excavations suggest that these clusters are likely cultural deposits representing discrete areas of Clovis occupation, some of which have been exposed in places by erosion, but with limited evidence of significant horizontal movement in at least half of the occupational loci. Particularly in the northern part of the site, relatively level topography and perhaps only a single erosional event have acted to maintain spatial integrity of the deposits. This is reflected by the 2007 recovery of two refitting fragments of a flake tool, broken in antiquity, in the same 1 m × 1 m unit.

Deposits containing occupation debris are relatively thin (<100 cm) to nonexistent across most of the site. With the exception of low coppice dunes on its crest and northwestern flank, the north ridge is essentially devoid of sedimentary cover. Gravel and carbonate-cemented gypsite are exposed at the surface along with artifacts, except very locally where covered by modern eolian sheet sand and coppice dune sand. The south ridge has a discontinuous cover of eolian sediment consisting of a thin veneer of sand up to 15 cm thick with minimal post-depositional alteration (i.e., few roots, no bioturbation, no iron oxidation) resting on an older sand sheet up to 20 cm thick exhibiting a Bw(color)-Bk-BCk-Km/Ky sequence (Figure 8). These eolian deposits rest on a bed of crystalline gypsite (Figure 8). Artifacts recovered during the 1966–1968 excavations and during our testing in 2005 were found largely in the lower sand within the Bw/Bk horizon, though some material was also recovered in the surface sand. Artifacts tended to be concentrated in the lower part of the Bw and throughout the Bk horizons, although this may be in part a function of the smaller volume of sediment contained in the upper one or two levels due to the slope of the old excavation walls. The artifacts are clearly dispersed vertically over 30–50 cm in the excavated test units, probably due to bioturbation and eolian processes. Krotovina were visible in all the test pits and active rodent burrows are scattered across the surface of the area. The excavated area is within the largest and deepest extant sand deposit on the south ridge; the gravel, gypsite, and artifacts are exposed at the surface only where the sand was removed. The absence of weathering in the surface sand and the moderate degree of soil development in the lower sand sheet indicate that the lower layer is a Holocene deposit. The Paleoindian occupation surface, therefore, was not preserved on the south ridge. An alternative hypothesis—that the artifacts are in place in latest Pleistocene sand that was eroded and then overprinted with a Holocene soil—is unlikely because sand with associated Clovis archaeology in the UNM excavation area in the swale near the north ridge

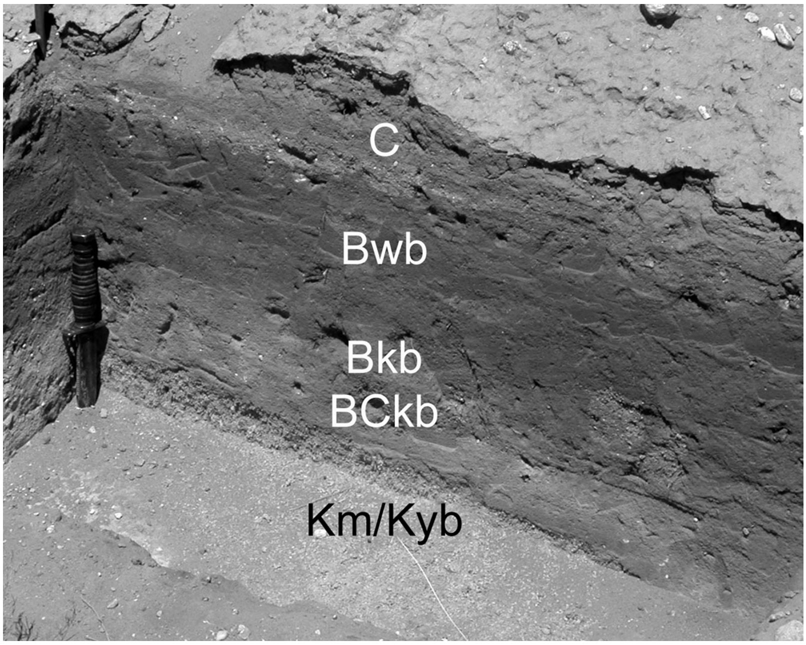

Figure 8. Soil stratigraphy exposed in 2005 in test unit 4 adjacent to ENMU trench 18 on the south ridge (Figure 2). Most of the occupation debris in this part of the site was in the buried Bw horizon. Gypsite crystals are visible on the floor of the pit and in the left corner by the knife.

has a well-developed soil (a Bt horizon; discussed below). Soil development in sand of similar age across the swale and the south ridge should be very similar given the flat landscape in each setting, the low relief between the two, and the similar parent material. Preservation of late Pleistocene sand on the south ridge would require wind erosion of the more resistant soil and preservation of easily erodible sand. The latter is very unlikely given the open, windy character of the region.

The excavations on the south ridge yielded Clovis as well as later Archaic and Ancestral Puebloan stone artifacts, and fragments of tooth enamel morphologically and metrically consistent with bison. The assignment of artifacts to Clovis is based on the character of the raw material, which is the same suite of jasper and chert materials as the diagnostic Clovis implements previously recovered, and because these artifacts primarily reflect bifacial reduction. Both characteristics help to differentiate them from the Archaic and Ancestral Pueblo assemblages, which are predominantly local, lesser-quality materials and are largely the product of hard hammer percussion reduction.

The swale between the north and south ridges has the most continuous and generally thickest surface cover of any area of the site. Our excavations at what we labeled Locus 1214 in 2006 and 2007 revealed that the area is covered by a sand sheet composed of two layers. On top is a younger deposit up to 40 cm thick with a Bw horizon over a thin Bg horizon (Figure 9; Table II), the latter quite unusual in such an arid and well-drained setting. Locally this surface sand is bedded and exhibits no evidence of weathering, suggesting localized, recent reworking of sand.

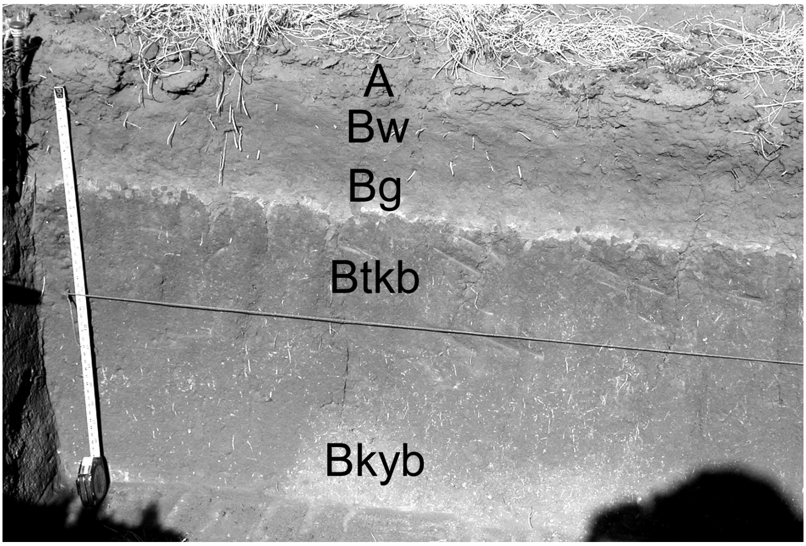

Figure 9. Soil stratigraphy exposed in 2006 in unit 9 (Figure 2) in the swale between the north ridge and south ridge. The Clovis occupation debris was largely on top of or within the upper few centimeters of the buried Bt horizon.

Table II. Description of Unit 9.

Depth (cm)	Soil Horizon	Description**
0–4	A	Reddish-brown (5YR 5/4d) fine sand; thick platy structure; clear, smooth boundary.
4–15	Bw1	Yellowish-red (5YR 4/6d) fine sand; weak, coarse sbk; clear, smooth boundary.
15–35	Bw2	Reddish-brown (5YR 5/4d) fine sand; weak, coarse sbk; abrupt, wavy boundary.
35–43	Bwg*	Brown (7.5YR 5/4d) fine sand; crack from underlying Btb propagate upward into Bw forming weak, coarse pr to weak, coarse sbk; some sand grains appear to be stripped of clay and Fe oxides; lower 1 cm is distinct 10YR 5/3d; abrupt, wavy.
43–59	Btkb	Reddish-brown (5YR 4/4d) fine sandy loam; thin, cont clay films on ped faces; coarse, strong pr; v few v. fine carb threads on ped faces; clear, smooth boundary.
59–80	Bkyb	Reddish-brown (5YR 5/4d) fine sand; coarse medium pr; few common carb threads & bodies; rare fine gyp crystals.

* Color for this horizon does not fall on the Munsell Gley page, but in the field the zone is distinctly more gray-green than overlying Bw.

** *Abbreviations:* Colors are Munsell; d = dry; sm = slightly moist; m = moist.
Structure: sbk = subangular blocky; ab = angular blocky; wk = weak;
Lithology: SCL = sandy clay loam; LS = loamy sand; SC = sandy clay; S = sand; f = fine; v = very.
gyp = gypsite; carb = carbonate.
bdy = boundary.

Buried beneath the surface layer is another sand layer up to 40 cm thick with a well-developed Btkb-Bkyb soil profile (Figure 9; Table II), indicating that the lower sand was in place for a significant amount of time. Both layers of sand are considered to be eolian because they are very well sorted, eolian sand is abundant in the area, and there is no obvious source for alluvial sand. The majority of all artifacts excavated from the swale came from within or from the top of the buried Bt horizon. Many of the artifacts had thin, continuous clay films, likely due to illuviation of clay during genesis of the Bt horizon. The Clovis occupation was likely on the stable surface represented by the soil.

The 2006 testing and 2007 excavations in Locus 1214 produced over 1000 artifacts, mostly flaked stone, including one Clovis point base and the basal corner of another, a few biface fragments, some 20 flake tools, and hundreds of flakes, along with pieces of tooth enamel and occasional splinters of large mammal bone (Huckell et al., 2008). Most of the flaked stone was debitage, representing a variety of different sources.

These artifacts are of materials consistent with those used in the manufacture of Clovis tools at the site. A green to black chert of variable quality is the dominant material, but its geological source is unknown, though assumed to be relatively local. Socorro jasper, actually a silicified rhyolite (Dello-Russo, 2004), is common in the collection and available from a number of individual sources south and west of Socorro, including the Black Canyon source some 12 km southwest of the city. Nonlocal materials include China chert from the northeastern Zuni Mountains, three pieces of the Grants Ridge/Mt. Taylor obsidian from the Grants area, and numerous flakes of Chuska chert from the Chuska Mountains on the Arizona–New Mexico border. Chert from the Zuni Mountains was transported over some 190 km, and Chuska chert over 315 km. Southern Plains sources, including Edwards Formation chert and Alibates agate is conspicuously absent from the excavated assemblage, though a single piece of Edwards debitage was recovered from the surface near the excavations. This raw material evidence suggests that the group occupying Locus 1214 previously foraged in the northwestern quarter of New Mexico.

STRATIGRAPHY AND GEOCHRONOLOGY OF CHUPADERA DRAW

Coring in Chupadera Draw west and northwest of the north ridge revealed stratified valley fill up to 11 m thick spanning the past ~11,000 ^{14}C years. The stratigraphy is complex, with considerable microstratigraphic variability, and was exposed mainly in cores (e.g., Table III). We grouped most of the fill into five lithostratigraphic units: strata 1 through 5 (Figures 6, 7; Table III). Stratum 1 is the deepest and generally the oldest unit encountered. It is dominantly fine to medium sand and well-sorted gravel with locally common interbeds of organic-rich silt, clay, or mud. It is up to 3 m thick (core 07-3) but the upper boundary is difficult to identify in most cores because it grades both vertically and laterally into the bedded to massive organic-rich muds of stratum 2. Interbedded sand and gravel (up to 1 m thick in core 06-4) forms the base of stratum 1. Total thickness of stratum 1 and the character of underlying units are unknown because the coring rig usually refused upon encountering the gravel. The well-rounded, well-sorted, and bedded character of the gravel demonstrates that these deposits are alluvial, probably from a competent stream. The bedded sand is likely alluvial as well. The sections with interbedded sand and organic-rich mud are suggestive of a floodplain setting.

Table III. Description of Core 05-19/06-4.

Strat.	Depth (cm)	Description**
5	0–18	Reddish-brown (5YR 4/4d) mud; massive; clear bdy.
	18–25	ABw horizon; dark reddish-brown (5YR 3/4sm; not quite red enough for 5YR) SCL; crumb and wk sbk structure; clear bdy.
	25–84	Bkw horizon; dark brown (7.5YR 4/3m), mud; wk sbk w/common carb threads; clear bdy.
	84–92	Massive dark gray (10YR 4/1) silt w/common gyp and carb; abrupt bdy.
	92–94	Brown (7.5YR 5/3m) silt lens; massive; abrupt bdy.
	94–152	Lenses of dark red-brown (5YR 3/4d) silty clay w/common gyp and carb bodies, and lenses of brown (7.5YR /3m) silt; all massive; lenses = 3–5 cm thick; abrupt bdy.
	152–212	Platy light brown (7.5YR 6/3m) fS to 190 cm; massive below 190; Mn-oxide lenses 185–187 cm; abrupt bdy.
4	212–217	Dense light gray (10YR 7/2m) LS w/common gyp and carb bodies; clear bdy.
	217–221	Massive brown (7.5YR 5/3m) silt lens; clear bdy.
	221–330	Dense dark red-brown (5YR 2/2m) mud w/common threads of carb and gyp; abrupt bdy.
	330–335	Platy dark red-brown (5YR 3/4m) clay w/distinct silt lens at top; common Fe-oxide mottles; abrupt bdy.
	335–353	Dense dark brown (7.5YR 3/4m) LS; abrupt bdy.
3	353–460	Dense, massive white (10YR 8/1sm) silty gyp w/carb; clear bdy.
2	460–490	Dense, massive dark gray (10YR 4/1sm) silt; clear bdy.
	490–510	Dense, massive v dark gray (10YR 3/1m) silt; clear bdy.
	510–520	Platy dark gray brown (10YR 4/2m) fSC w/Fe-oxide mottles; abrupt bdy.
	520–560	Wk platy gray brown (10YR 5/2m) vfS w/Fe-oxide mottles (2.5Y 7/2m); abrupt bdy.
	560–595	Dark gray (10YR 4/2sm) silty mud w/common Fe-oxide mottles (10YR 5/8m) and some dark red-brown (5YR 3/4m) mud-filled cracks; clear bdy.
	595–610	Silt, variegated dark gray (10YR 3/2sm) and gray (10YR 5/1sm); clear bdy.
	610–625	Light gray (2.5Y 7/2m) massive silt; clear bdy.
	625–630	Silt, variegated dark gray and light gray; clear bdy.
	630–634	White (10YR 8/1m) silt; clear bdy.
	634–655	Silt, variegated dark gray and light gray; abrupt bdy.
	655–668	Laminated light gray and dark gray mud; abrupt bdy.
	668–671	White (10YR 8/1m) silt; clear bdy.
	671–678	Pale yellow (2.5Y 7/4m) vfS; abrupt bdy.
	678–683	Black (10YR 2/1m) mud; abrupt bdy.
	683–688	Pale yellow (2.5Y 7/4m) vfS; abrupt bdy.
	688–698	Laminated black and light gray mud; abrupt bdy.
	698–718	Medium gray (10YR 6/1m) silt; abrupt bdy.
	718–734	Variegated light gray and dark gray mud; abrupt bdy.
	734–778	Dark gray (10YR 4/1m) mud w/common Fe-oxide mottles (10YR 5/8m); clear bdy.
	778–825	Very dark gray (10YR 3/1sm) mud; variegated with light gray (10YR 6/1sm) mud more common in lower half; clear bdy.
	825–853	Laminated black (10YR 2/1m) mud & fS; sand lenses 3–5 mm; muds up to 10 mm; abrupt bdy.
	853–866	Black (10YR 2/1m) mud w/few fS lenses; clear bdy.
	866–898	Dense dark gray (10YR 3/1m) clay w/common Fe-oxide mottles (10YR 5/8m); clear bdy.
	898–920	Finely laminated black and dark gray mud; abrupt bdy.
1	920–1020	Bedded sand and gravel.

** *Abbreviations:* Colors are Munsell; d = dry; sm = slightly moist; m = moist.
Structure: sbk = subangular blocky; ab = angular blocky; wk = weak;
Lithology: SCL = sandy clay loam; LS = loamy sand; SC = sandy clay; S = sand; f = fine; v = very.
gyp = gypsite; carb = carbonate.
bdy = boundary.

Stratum 2 consists of massive to laminated black to dark gray to gray muds (including silty mud and muddy clay), interbedded with gray to tan to yellow silt and medium to fine sand (Table III). Gypsum is locally common and even pervasive in the muds. It is expressed as discrete bodies and thus seems to be a secondary deposit within the mud. Stratum 2 is up to 4.5 m thick (core 05-19). As noted, the boundary with stratum 1 is gradational. Likewise, the upper boundary is gradational, but can be more readily identified on the basis of discrete, secondary gypsum in stratum 2 versus massive, primary gypsum characterizing stratum 3, and on the basis of dark colors characterizing stratum 2. The darker colors are indicative of higher amounts of organic matter in stratum 2. The low energy character of the sediments in stratum 2 and the indications of relatively high biomass leads to the interpretation that stratum 2 formed in an aggrading marsh or wetland. Interbeds of silt and sand are probably from low-energy flooding. The secondary gypsum must have formed under dry conditions, given the low solubility of the material. The presence of the gypsum in a wetland setting, therefore, is indicative of cyclic wet–dry conditions, possibly a fluctuating water table. In the absence of evidence for cuts and fills separating strata 1 and 2, the cross-section (Figure 7) suggests that locally the two units are facies of one another. The gravels and deepest alluvial sands of stratum 1 were encountered across the floor of the draw, but the interbedded sands and muds of stratum 2 are more localized. This suggests that stratum 1 was deposited across a broad, perhaps meandering, floodplain, whereas alluvial deposition associated with stratum 2 was of lower competence and more localized.

Stratum 3 consists of gypsum, calcareous gypsum, and gypsiferous (and locally calcareous) silt (Table III). These various lithologies comprise distinct layers within the stratum (Figure 7). Stratum 3 is locally up to 4.5 m thick (core 07-6). As noted, the lower boundary is gradational with stratum 2, but the upper boundary with stratum 4 is abrupt. The gypsum is massive and pervasive in all lithologies and appears to be primary; that is, the deposit is composed of gypsum that likely precipitated out of water on the floor of the draw (in contrast to secondary of pedogenic gypsum that represents a post-depositional accumulation within another deposit). The primary difference among the lithologies is the relative amount of clastic material (primarily silt). The deposit probably represents prolonged precipitation of gypsum under arid conditions. Gypsum is very common in the local, older basin fill and probably a common constituent of the ground water and dust. The origins of the clastic material are unclear, but the silt may be from dust (i.e., eolian deposition). Cores 07-8 and 07-6 yielded significant thicknesses of primary gypsum. How these deposits of stratum 3 relate to the palustrine and alluvial deposits of stratum 2 is not clear, based on the 2007 cores, but core 08-2 (Figure 2) suggests an interfingering facies relationship.

Stratum 4 is the most lithologically uniform, continuous, and ubiquitous unit in the valley fill. It is a few centimeters to almost 2 m thick. In cores, the lower and upper boundaries are abrupt. Across the draw the elevation of the lower boundary varies by as much as 50 cm. These two characteristics suggest that this unit accumulated following erosion. Stratum 4 is a deep red, very dense, blocky mud with a few thin lenses of medium sand and pervasive gypsum and carbonate in the form of discrete bodies within the matrix (Table III). The origins of the unit are unclear. The muddy, homogeneous character of the deposit and its ubiquity across the floor of the draw suggests that it accumulated under palustrine conditions and was subsequently oxidized. The gypsum is also post-depositional.

Stratum 5 rests disconformably on stratum 4. It varies from 2 to 4 m in thickness. It is dominantly a sand, including both massive sand and bedded sand, with discontinuous lenses of mud and gravel (Table III). Localized deposits of gravel and sand are indicative of cut-and-fill during aggradation. One obvious phase of channel incision is apparent on the cross-section (Figure 7) from cores 07-1 to 07-7. A soil with an A-Bw or A-Btw profile formed in upper stratum 5. The final phase of deposition was localized accumulation of mud, which included filling of a shallow channel in the area of cores 07-1 and 07-7.

Radiocarbon dating well documents the evolution of the dramatically different depositional environments of strata 1 through 5 from the terminal Pleistocene through the late Holocene (Figures 6, 7). Stratum 1 yielded a range of dates from ~11,870 (core 07-9) to ~10,500 (core 06-4) ^{14}C yr B.P. (Table I; Figure 7). The two oldest ages from 07-9 (~11,870 and ~11,665 ^{14}C yr B.P.) overlap at 1 standard deviation. Otherwise, the only reversal in stratum 1 is at the bottom of 07-9. In aggregate the radiocarbon ages from stratum 1 indicate that alluviation was under way ~11,000 ^{14}C yr B.P. but was giving way to the palustrine conditions of stratum 2 shortly thereafter. The palustrine conditions of stratum 2 persisted until at least ~9285 ^{14}C yr B.P. (core 07-5), when the earliest stages of primary gypsum deposition (and stratum 3) appeared. Dating stratum 2 presented some problems, probably owing to the saturated conditions we encountered during coring and the difficulties of collecting clean samples. In core 05-19 and its duplicate 06-4 (Table I; Figure 7), the zone from about 720 to 900 cm yielded a series of reversed dates. In this sequence we accepted only the oldest ages (Table I), assuming that introduction of younger carbon was much more likely than introduction of older carbon. The stratigraphic consistency of the remaining dates suggests that this approach was correct. In the prospect pit, Weber secured a radiocarbon age of ~11,400 ^{14}C yr B.P. on the carbonate fraction of calcareous plant remains (*Chara*) from the top of the stratum 2 muds, an early Clovis date. Our core 04-4 from the prospect pit penetrated the top ~100 cm of stratum 2 mud. We did not observe *Chara* in our core, but we secured radiocarbon samples on organic carbon from the lower stratum 2 mud (Figure 6; Table I). All resulting dates are younger than Weber's date, indicating that his sample may have been affected by the "hard water effect" (old carbon from groundwater fixed in the calcium carbonate). Stratum 3 deposition continued until ~7570 ^{14}C yr B.P. (core 07-5), overlapping with a base date on the dense stratum 4 mud at ~7670 ^{14}C yr B.P. (core 07-2) (Figure 7). Core 04-2 yielded a date of ~7130 ^{14}C yr B.P. from the base of stratum 4 (Figure 6; Table I). The same core yielded a date of ~9835 ^{14}C yr B.P. from the top of stratum 4, just over 2 m below surface (Figure 6; Table I). No other core yielded evidence of this lithology dating so early nor evidence of such old deposits at such shallow depth. Some older carbon must have been incorporated when this sample was at the surface. Stratum 5 deposition was locally underway by ~5700 ^{14}C yr B.P. (core 04-2) (Figure 6).

Much of the later Holocene apparently was a period of stability and formation of the soil in stratum 5.

Our data indicate that Chupadera Draw likely contained a competent flowing stream at ~11,000 ^{14}C yr B.P., that is, during late Clovis time (following Holliday, 2000a; Waters & Stafford, 2007). By ~10,600 ^{14}C yr B.P., the draw contained a marsh or wetland with only localized flowing water, indicating a substantial decline in discharge in the draw. Localized secondary gypsum in these palustrine deposits suggests that the floor of the draw may have been subjected to cyclic drying as it aggraded, due either to a fluctuating water table or fluctuations in runoff entering the draw. By ~9200 ^{14}C yr B.P., gypsum was being precipitated on the floor of the draw (and perhaps precipitated within stratum 2), indicative of more persistent and long-term aridification. These conditions persisted until at least ~7500 ^{14}C yr B.P.

The stratigraphic and geochronologic investigations in Chupadera Draw provide clear and unambiguous evidence that during the Paleoindian occupation of the area the drainage was very different than it is today and, moreover, was a very attractive resource for hunters and gatherers. During Clovis time, the draw was as much as 11 m deeper than it is today, providing over 15 m of relief between the south end of the north ridge and the floor of the draw immediately to the west. The draw contained flowing water during Clovis time and probably both flowing and standing water during Folsom time. The draw and its immediate environs almost certainly contained abundant aquatic and terrestrial resources throughout those times.

STRATIGRAPHY EAST OF THE GRAVEL RIDGES

Eight cores (05-9 to 16) were placed on the "flats" to the east of the gravel ridges and site proper. This coring was aimed at understanding the regional geologic setting and in particular to determine whether any late Pleistocene or Holocene alluvium or other channel fills were present. The coring showed that no such deposits are present. Massive gypsite is within 1 m of the surface in most areas cored, underlying eolian fines with at least one well-expressed buried Bt horizon. A well-expressed Bk or calcic horizon is common at the top of or above the gypsite and is probably genetically related to the Bt horizon. The Btb horizon in this area is likely a stratigraphic equivalent to the Btb with Clovis material exposed in the test excavations. The upper gypsite may be pedogenic as well. Below is more gypsite interbedded with dense, clayey, and silty mud layers. The origins of these deeper deposits are unclear, but they may represent old evaporites and mud layers.

DISCUSSION AND CONCLUSIONS

Our geoarchaeological investigations at the Mockingbird Gap site produced several significant results. Perhaps most significantly, the work demonstrated that Clovis occupation debris and a portion of the Clovis occupation surface are preserved in a buried context at Locus 1214 and elsewhere in the northern portion of the site. Coring also revealed a thick, dateable stratigraphic record preserved in Chupadera Draw adjacent to the archaeological occupations and, moreover, a record that provides strong clues that help explain why the site was such a popular campground.

The results of three seasons of field work at the Mockingbird Gap site show that significant deposits of Clovis age are locally buried beneath eolian sands at the site. On the south ridge in the area of the ENMU excavations, the stone artifacts and tooth enamel are not in primary context, but the area still has the potential for yielding evidence of Clovis tool manufacture and subsistence activity. To the north, the swale southeast of the northern ridge was the scene of considerable Clovis activity. Shallowly buried but minimally disturbed archaeological deposits exist here, in contrast to areas of Clovis occupation on the north ridge immediately north of the swale. With the exception of occasional pieces of fire-cracked rock and one potsherd at isolated surface locations, we found no evidence of younger occupations. The areal extent of Clovis occupation within this large area is uncertain, but potentially is extensive. The occupation surface is associated with a well-developed soil (Bt-Btk horizonation). The degree of development for a soil in a well-drained sandy setting in the greater Rio Grande Rift is indicative of perhaps 10,000 to 20,000 years of pedogenesis (Gile, Hawley, & Grossman, 1981; Holliday et al., 2006). The presence of clay films on many of the artifacts recovered during excavation is further indicative of pedogenesis post-dating the occupation, that is, likely continuing into at least the early Holocene. The eolian sand sheet that buries the Clovis surface is probably middle Holocene in age, based on the weak to moderate degree of soil development. Very recent sand, probably Historic based on lack or weathering and preserved bedded, locally covers the sand sheet.

The stratigraphy of the Clovis occupation at Mockingbird Gap bears some similarities to Paleoindian occupation surfaces in the Albuquerque Basin, ~120 km to the north. There, Folsom occupations are documented resting on well-expressed soils with Bt-Btk horizonation that were erosionally truncated and then buried by a Holocene sand sheet (Holliday et al., 2006). To the southeast, in the neighboring Tularosa Basin, an extensive, buried, terminal Pleistocene sand sheet with similar soil morphology is reported by Blair, Clark, and Wells (1990). A comparable soil-stratigraphic record is reported from the Chaco dunes in northwestern New Mexico (Hall, 1990; Wells, McFadden, & Schultz, 1990; Smith & McFaul, 1997) and from the Mescalero Dunes east of the Pecos River in southeastern New Mexico (Hall, 2002). These data are indicative of regional landscape stability on uplands in the late Pleistocene up to and including the time of the Clovis occupation. The presence of clay films on Clovis artifacts suggests that the stability at Mockingbird Gap persisted into the early Holocene. In the Albuquerque Basin, in contrast, the Folsom materials seem to be largely confined in eolian sand and resting on top of the Bt-Btk sequence (Holliday et al., 2006). On the Southern High Plains to the east, Folsom material in upland settings is likewise associated with eolian sediments, whereas Clovis occupations seem to be associated with stable surfaces (Holliday, 2000b, 2001).

The archaeological record of Mockingbird Gap seems to suggest a pattern of repeated re-occupation of the ridge bordering Chupadera Draw (Huckell et al., 2006). However, due to the absence of radiocarbon dates, as well as the limited extent of excavations, we are unsure whether the re-occupation occurred over the course of a number of years, or over multiple generations; that is, we may be dealing with a palimpsest of Clovis occupations. We lean toward the latter interpretation at this time. Interestingly, although the primary raw materials are available from within some 40 km of the site and could be seen as local, initial indications suggest a wide variety of projectile point forms, both in size (though, on average, on the small side for Clovis points), and in more stylistic characteristics, such as basal form and the extent of fluting. Further excavations and analyses of the surface assemblage may shed light on these issues.

Chupadera Draw provides a striking contrast to the site itself, with a thick, well-stratified, dateable record spanning Paleoindian and post-Paleoindian time. Further, during the Clovis occupation the draw was a steep-walled valley ~11 m deeper than it is today. To date, the evidence for an alluvial wetland/marsh on the floor of the draw is the best clue to explaining the intensive occupation at the site. Given the other Paleoindian sites scattered along the draw, a similar alluvial/wetland record is expected in the associated reaches.

A particularly noteworthy aspect of the lithostratigraphy and chronostratigraphy of the draw is its gross similarity to the Clovis site and the Lubbock Lake site on the Southern High Plains, both of which expose a sequential evolution of depositional environments from sandy/gravelly alluvial conditions (Clovis) to muddy lacustrine/palustrine conditions (Folsom and late Paleoindian) to a hardwater marsh setting (early Holocene/early Archaic) (Haynes, 1975, 1995; Holliday, 1985, 1997). And, similar to the High Plains record (Holliday, 2000b), the variation through time in depositional environments and lithologies at Mockingbird Gap is further indicative of a drying trend from terminal Pleistocene/Clovis time into the early Holocene.

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