Shallow Site Archaeology: Artifact Dispersal, Stratigraphy, and Radiocarbon Dating at the Barger Gulch Locality B Folsom Site, Middle Park, Colorado

Todd A. Surovell,[1,]* Nicole M. Waguespack,[1] James H. Mayer,[2] Marcel Kornfeld,[1] and George C. Frison[1]

[1]*George C. Frison Institute of Archaeology and Anthropology, Anthropology Department 3431, 1000 East University Avenue, University of Wyoming, Laramie, Wyoming 82071*
[2]*Department of Geosciences, University of Arizona, Gould-Simpson Building, 1040 E. Fourth Street, Tucson, Arizona 85721-0077*

Shallowly buried archaeological sites are particularly susceptible to surface and subsurface disturbance processes. Yet, because cultural deposition often operates on short time scales relative to geologic deposition, vertical artifact distributions can be used to clarify questions of site formation. In particular, patterns in artifact distributions that cannot be explained by occupation histories must be explained by natural processes that have affected sites. Buried only 10–50 cm beneath the ground surface for 10,450 ^{14}C yr, the Folsom component at Barger Gulch Locality B (Middle Park, Colorado) exhibits many signs of post-depositional disturbance. Through examination of variation in the vertical distribution of the artifact assemblage, we are able to establish that only a Folsom component is present. Using vertical artifact distributions, stratigraphy, and radiocarbon dating, we are able to reconstruct the series of events that have impacted the site. The Folsom occupation (~10,450 ^{14}C yr B.P.) was likely initially buried in a late-Pleistocene eolian silt loam. Erosion brought the artifacts to rest on a deflation surface at some time prior to 9400 ^{14}C yr B.P. A mollic epipedon formed in sediments that accumulated between 9400 and 7000 ^{14}C yr B.P. Some time after 5200 ^{14}C yr B.P., this soil was partially truncated, and artifacts that had previously dispersed upward created a secondary lag at its upper contact. This surface was buried again and artifact dispersal continued. © 2005 Wiley Periodicals, Inc.

INTRODUCTION

This is the second of two papers concerning the geoarchaeology of Barger Gulch Locality B, a shallowly buried Folsom site in Middle Park, Colorado. The companion paper by Mayer et al. (2005) concerns large-scale patterns of deposition, erosion, and soil formation in Barger Gulch and their relationship to site stratigraphy, as well as late Pleistocene and early Holocene paleoclimate, paleoecology, and human behavior. In this

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*Corresponding author; E-mail: Surovell@uwyo.edu.

Geoarchaeology: An International Journal, Vol. 20, No. 6, 627–649 (2005)

paper, we shift to the smaller scale of the site excavation area, focusing on the impact of site-formation processes on artifact distributions. Many papers about formation processes are arguably cautionary tales, presenting warnings about the deleterious effects of disturbance processes on artifact distributions (e.g., Matthews 1965; Johnson and Hansen, 1974; Stein, 1983; Villa and Courtin, 1983; Bocek, 1986; Johnson, 1989). Alternatively, in this paper we attempt to demonstrate how the vertical dispersal and distribution of artifacts can be used to clarify issues of site formation with respect to stratigraphy and radiocarbon dating, supplanting caution with analyses designed to integrate information derived from the geologic and archaeological records.

From the perspective of a buried artifact, the majority of the energy entering geologic systems on short time scales is from above—originating on or just beneath the ground surface. Most of the commonly identified disturbance processes, such as cryo-, faunal-, and floralturbation, are largely surface or near-surface phenomena (Johnson and Hansen, 1974; Johnson et al., 1977; Wood and Johnson, 1978; Stein, 1983; Erlandson, 1984; Bocek, 1986; Schiffer, 1987; Johnson, 1989; Bocek, 1992; Stein, 2001). Cultural formation processes, including various forms of earth moving, also operate at the ground surface. Therefore, artifacts resting on ground surfaces should be most susceptible to lateral and/or vertical displacement, and the effects of surface disturbance processes should generally decrease as a function of depth. Artifacts will most likely retain spatial integrity (defined as the preservation of spatial relationships among artifacts) if they are buried gently and rapidly, quickly attaining significant depth. The Roman city of Pompeii is perhaps the ideal case. Unfortunately, most archaeological sites are not "Pompeiis" (Binford, 1981; Schiffer, 1985), and surface processes commonly serve to move artifacts after deposition, particularly in shallow sites.

Barger Gulch Locality B is a Folsom site in the Southern Rocky Mountains of north central Colorado. Radiocarbon dating, geomorphology, and landscape setting suggest that the site has remained shallowly buried for approximately 12,500 cal yr. The occupation surface ranges in depth from 0 to 60 cm, averaging 30 cm beneath the modern ground surface, and the maximum thickness of the late Quaternary deposits is approximately 80 cm. Artifacts are found throughout the stratigraphic sequence from the surface into residuum of the Troublesome Formation (Miocene) bedrock. The stratigraphy, though at first appearing relatively simple (Surovell et al., 2001), is now known to be complex (Mayer et al., 2005), as might be expected in a situation where 12 millennia are represented by deposits less than 1 m thick. Likewise, the radiocarbon record is a blend of cultural and natural organic matter mixed by disturbance processes, with charcoal radiocarbon dates in stratigraphic association with the occupation ranging between 10,770 ± 70 and 7510 ± 60 ^{14}C yr B.P.

These attributes are expected of a shallow site where artifacts, sediments, and organic matter remain within reach of burrowing animals, roots, and zones of percolation, freezing, and thawing for thousands of years. Therefore, if there was a site where cautionary tales about site disturbance should be heeded, Barger Gulch Locality B is certainly one. However, physical, chemical, and biological formation processes should, to some extent, operate in a deterministic and predictable fashion. The regularity of vertical artifact-density profiles from many sites and numerous different geologic contexts lends credence to this statement (e.g., Van Noten et al., 1980;

Hofman, 1986; Jodry, 1987; Michie, 1990; Blackham, 2000; Mayer, 2002). Although it is not possible to perfectly recreate the starting position of an artifact that has been removed from its primary context, with some notion of the rate and directionality of artifact displacement, it is possible, in theory, to describe an artifact's starting position as a probability distribution. Similarly, the discard of artifacts onto a ground surface during an occupation should create a cultural deposit that is vertically constrained, with the exceptions of those deposited in excavated features and contexts where artifacts are particularly susceptible to trampling (Villa and Courtin, 1983; Gifford-Gonzalez et al., 1985). When we do not find vertically constrained concentrations of artifacts, one or two processes must be operating: (1) Multiple or long-term occupation occurred, resulting in the continual deposition of artifacts on a temporal scale similar to geologic deposition, and/or (2) disturbance processes have served to disperse artifacts. As we demonstrate, if occupation history is known, the impacts of disturbance can be determined. Furthermore, patterning seen in vertical artifact profiles that cannot be explained by cultural processes must be explained by natural processes, and in this light, the record of post-occupational vertical artifact dispersal can be used to clarify issues of site stratigraphy and dating. By providing a record of temporally constrained deposition, at least compared to the scale of many geologic processes, cultural deposition and subsequent artifact dispersals provide unique perspectives on the stratigraphic formation of archaeological sites.

SETTING AND BACKGROUND

The Barger Gulch site (5GA195) is situated at 2323 m asl (7620 ft) approximately 8 km east of the town of Kremmling, Colorado and within the geographic boundaries of Middle Park (Figure 1), one of a series of intermontane basins located west of the Front Range of the Southern Rocky Mountains. The basin forms the headwaters of the Colorado River with elevations ranging from 2230 m asl (7300 ft) on the western edge of the park where the Colorado exits Middle Park through Gore Canyon to over 3960 m asl (13,000 ft) on high peaks forming its southern and eastern boundaries. The site is named after Barger Gulch, a small but deeply incised spring-fed southern tributary of the Colorado River, its highest terrace surfaces typically sitting 30–40 m above current stream level. The stream cuts into the largely unconsolidated beds of the Miocene Troublesome Formation, which provided an important source of high-quality cherts, variously known as Kremmling and Troublesome Formation chert (Izett, 1968; Naze, 1986; White, 1999; Kornfeld and Frison, 2000; Kornfeld et al., 2001).

Archaeology

Over 6 km^2 in area, the Barger Gulch site contains a rich record of late Pleistocene and early Holocene archaeology, with eight Paleoindian localities identified to date (Surovell et al., 2003). A ninth Paleoindian locality, the Crying Woman site (5GA1208), is also located within the Barger Gulch drainage basin but is several kilometers upstream from our work and technically falls outside of the boundaries of the site

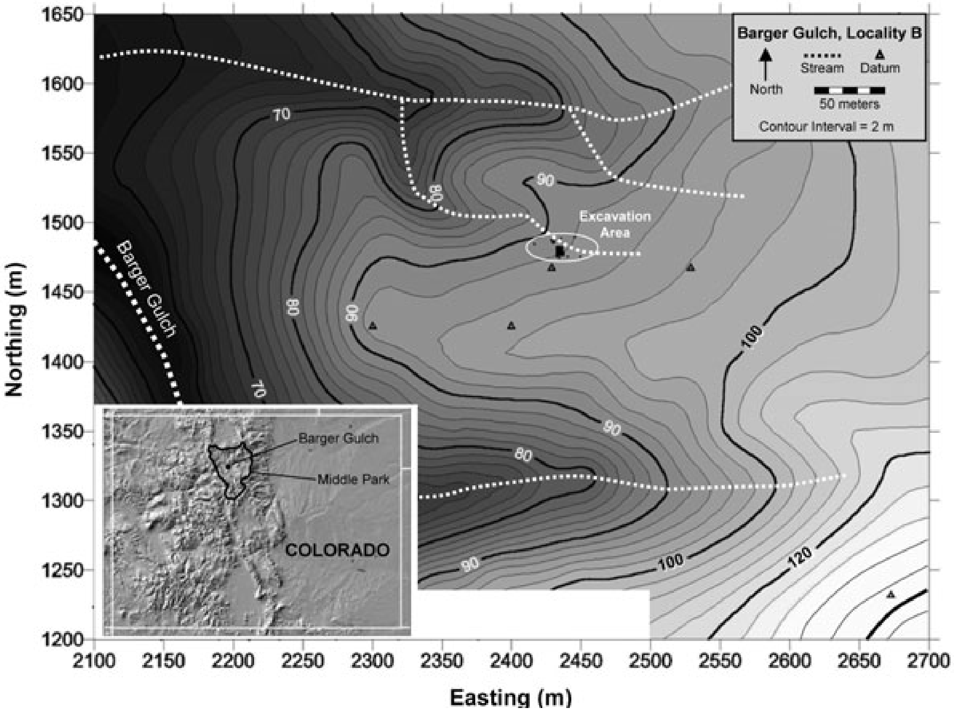

Figure 1. Site map with inset map of Colorado showing the locations of Middle Park and Barger Gulch.

(Naze, 1994). The high density of late Pleistocene and early Holocene archaeological sites in the Barger drainage is mimicked throughout the Middle Park region (Naze, 1986; Kornfeld, 1998; Kornfeld and Frison, 2000; Mayer et al., 2005).

Locality B is a Folsom campsite that sits on a high eastern terrace adjacent to a small intermittent first-order tributary of Barger Gulch. Over a period of five field seasons (1997–2002), we have excavated a total of 51 m^2, including a 40 m^2 contiguous excavation block. Each 1-m^2 excavation unit was divided into four 50 × 50 cm excavation quads. Excavation proceeded in 5-cm arbitrary levels, and all artifacts larger than 1 cm were mapped to the nearest 1 mm by total station.[1] Sediment was screened through ⅛ in. mesh. The current excavated assemblage totals 19,658 artifacts. Artifact densities for entire excavation units average 385 and range between 1 and 1804 pieces per m^2. All diagnostics recovered from excavations, including projectile points, preforms, channel flakes, and spurred endscrapers, suggest that only a Folsom component is present, but late-Holocene diagnostic surface artifacts have been recovered from areas > 80 m distant.

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[1] During the 2001 and 2002 field seasons, this criterion was dropped and all artifacts encountered *in situ*, regardless of size, were mapped in place.

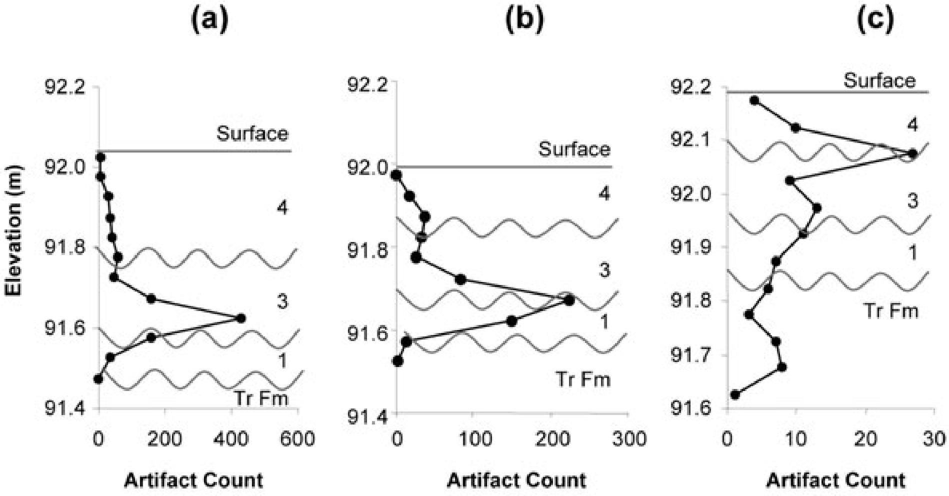

Figure 2. A selection of vertical artifact density profiles using 5-cm level artifact counts from the main excavation block at Barger Gulch Locality B superimposed on stratigraphic horizons (numbers 1, 3, 4) as recorded by excavators. (a) Vertical artifact density profile from excavation unit N1479, E 2435. This is a typical density profile for an excavation unit at Barger Gulch, showing a gradual increase in artifact density from the surface down to a single peak. Beneath this peak, artifact densities drop rapidly. (b) Vertical artifact density profile from excavation unit N1478, E 2433. This type of profile, with a deep primary peak and a higher secondary peak in artifact density is also common. (c) Vertical artifact density profile from excavation unit N1476, E 2435.This an atypical multimodal vertical density profile with a primary peak high in the excavation unit with lesser peaks below it. Abbreviation: Tr Fm = Troublesome Formation.

VERTICAL ARTIFACT DISTRIBUTIONS AND OCCUPATION HISTORY

Three related subjects are discussed in this study: vertical artifact distributions and dispersal, stratigraphy, and radiocarbon dating. We begin with the vertical distribution of artifacts and occupation history because the remaining analyses are based on these initial findings. All analyses follow from the 40 contiguous excavation units which form the primary excavation block.

Artifacts are found vertically throughout the deposits from the surface to the upper 10 cm of bedrock residuum (Troublesome Formation). Typically, artifact densities gradually increase with depth to their greatest frequencies, near the base of a buried A horizon (Stratum 3, discussed below). Below that depth, artifact densities drop rapidly (Figure 2a, b). Some vertical density profiles show a slight secondary mode approximately 10–20 cm above the primary mode (Figure 2b). Approximately 20% of the excavation units, however, break from this pattern, either not exhibiting a clear, sharp mode in artifact densities in the vertical dimension, or showing a primary peak in density located higher in the stratigraphic profile (Figure 2c).

These distributions beg the question of whether single or multiple archaeological components are present. It should be noted that we are not testing the hypothesis of a single Folsom occupation. The Folsom component could represent multiple occupations, although we have shown elsewhere that this is not likely (Surovell, 2003). Instead, we are asking whether there is an archaeological component or multiple components present in the site that do not fall within the Folsom period. Where comparative data are available, vertical artifact dispersal of this magnitude is common in Folsom sites (e.g., Jodry, 1987:68–80; Root, 2000; William, 2000; Mayer, 2002), but this fact alone cannot be used to support the hypothesis of a single component. Likewise, the absence of non-Folsom diagnostics does not necessarily rule out the possibility of post-Folsom site occupation. Furthermore, the presence of multimodality in some vertical artifact profiles charcoal radiocarbon age post-dating the Folsom period might support the hypothesis that multiple components are present. Previous studies of disturbance processes and artifact dispersal provide a foundation for developing predictions for distinguishing between the single- and multiple-component hypotheses (Johnson and Hansen, 1974; Johnson et al., 1977; Benedict and Olson, 1978; Van Noten et al., 1980; Villa, 1982; Villa and Courtin, 1983; Bocek, 1986; Hofman, 1986; Jodry, 1987; Schiffer, 1987; Michie, 1990; Bocek, 1992; Hofman, 1992; Blackham, 2000). Three tests incorporate artifact mass, inclinations, and diagnostic counts as a function of vertical dispersal distance. The final test considers the vertical distance separating pairs of refitted and conjoined artifacts.

If a single component is present, we expect to find: (1) a clear trend with respect to the distance of vertical dispersal and artifact mass; (2) a single zone of flat-lying artifacts with artifacts dispersed from that zone showing greater long-axis inclinations; (3) that the vertical distribution of Folsom diagnostics mimicks the vertical distribution of the assemblage as a whole; and (4) artifact refits should link artifacts from the occupation surface to levels above and below it. If multiple components are present, we expect to find: (1) no trend with respect to the distance of vertical dispersal and artifact mass; (2) multiple zones of flat-lying artifacts; (3) the vertical distribution of Folsom diagnostics does not the mimic verical distribution of the assemblage as a whole; and (4) artifact refits do not link artifacts from the occupation surface to levels above and below it.

To perform these analyses, it was first necessary to standardize artifact elevations by excavation unit to take into account stratigraphic dip. This required the identification of a reliable stratigraphic marker common to all excavation units. Stratigraphic contacts in the site are typically irregular, gradational, and bioturbated, making them very difficult to define precisely in excavations, particularly when viewed from above. We identify an arbitrary occupation surface for use as a stratigraphic marker using major peaks in vertical artifact density profiles. For each excavation unit, the elevation of this surface was identified in vertical space first by tallying artifact counts for each 5-cm excavation level. Next, the three contiguous levels containing the greatest numbers of artifacts were identified. Using the mean elevations and the number of artifacts recovered from each of those levels, a weighted average elevation was calculated. For each artifact, a "relative elevation" is calculated as the difference between the artifact elevation (measured from the bottom of the artifact) and the inferred elevation of the occupation surface for each excavation unit.

All tests support the single-component hypothesis. Figure 3 shows artifact mass versus relative elevation for 2390 piece-plotted artifacts. A somewhat noisy but clear

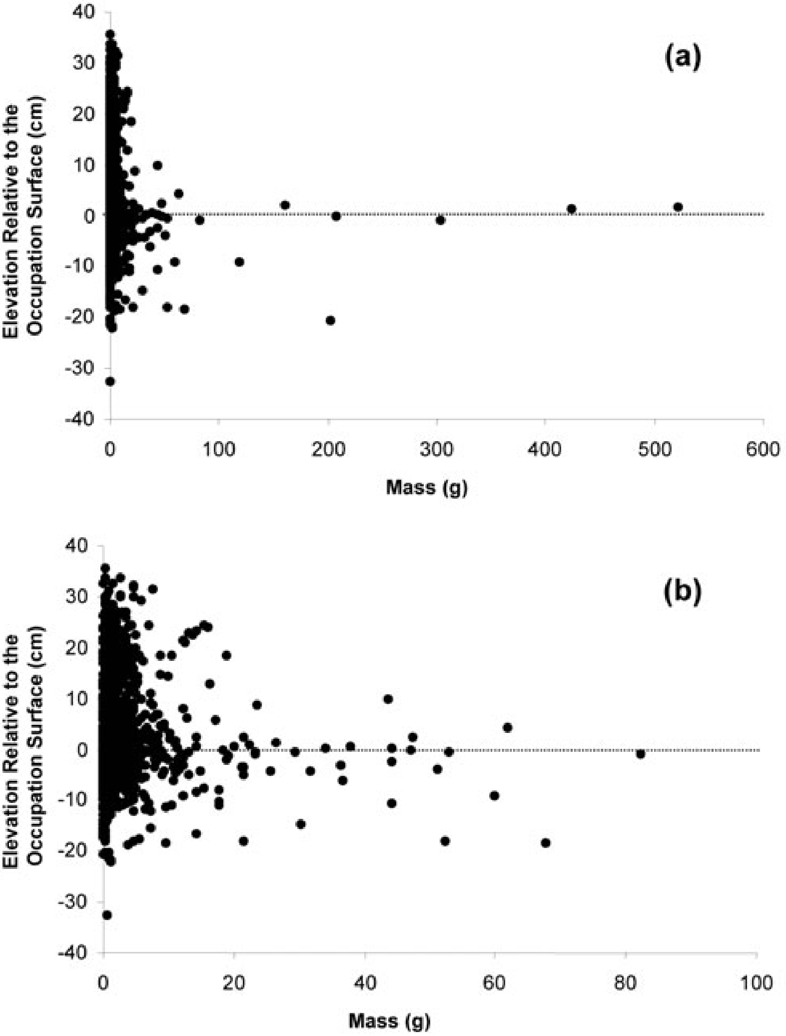

Figure 3. (a) Artifact mass versus the elevation relative to the interred Folsom occupation surface for 2390-piece-plotted artifacts. (b) Same, with the x-axis truncated, showing only artifacts ⩽ 100 g.

trend can be seen in the distribution of artifact mass by relative elevation with the largest artifacts consistently being located near the inferred occupation surface (Figure 3). Median artifact inclinations[2] from the site show little variation throughout the deposits, ranging from 17° to 26°, but these differences are statistically significant (Kruskal-Wallis test, $p = 0.001$). Importantly, the lowest artifact inclinations correspond precisely to our inferred occupation surface (Figure 4). Inclinations

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[2] Median values were used because the distributions tend to be heavily right skewed.

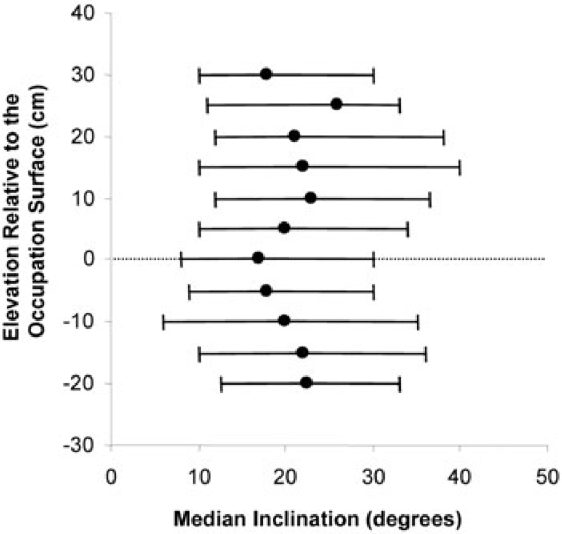

Figure 4. Median and quartile artifact long axis inclinations (dips) for 5-cm levels above and below the inferred Folsom occupation surface. A zero value indicates a flat-lying artifact, and a 90 value indicates an artifact on edge. The analysis excludes levels with fewer than 10 artifacts.

gradually increase with greater vertical distance from that surface. However, artifacts in the uppermost level, 30 cm above our inferred occupation surface, have inclinations (median = 18°) statistically indistinguishable from those at the occupation surface (Mann-Whitney U-test, p = 0.727). This finding could support the multiple-component hypothesis, but we suspect that these artifacts, which are very near the surface, tend to be more flat lying because they have been ejected from the surface, only to be reburied by recent eolian deposition. The distribution of Folsom diagnostics (n = 46) and nondiagnostic artifacts are statistically indistinguishable (Kolmogorov-Smirnov test, p = 0.587) (Figure 5). Finally, artifact refit pairs link virtually the entire vertical sequence, and they show no clear breaks or clusters that might indicate multiple components (Figure 6).

STRATIGRAPHY AND VERTICAL ARTIFACT DISTRIBUTIONS

Using stratigraphic descriptions and radiocarbon dating of natural and excavated exposures from valley and upland settings, Mayer et al. (2005) have developed a model of geologic events that have affected the Barger Gulch drainage system during the late Pleistocene and early Holocene and readers are referred to that paper for detailed descriptions and maps of the profiles discussed herein. Exactly what occurred during the latest Pleistocene (~11,000–10,000 ^{14}C yr B.P.) remains unclear because we have discovered very few *in situ* deposits dating to this time period. Possible landscape stability is indicated by a soil (Soil I) present in multi-

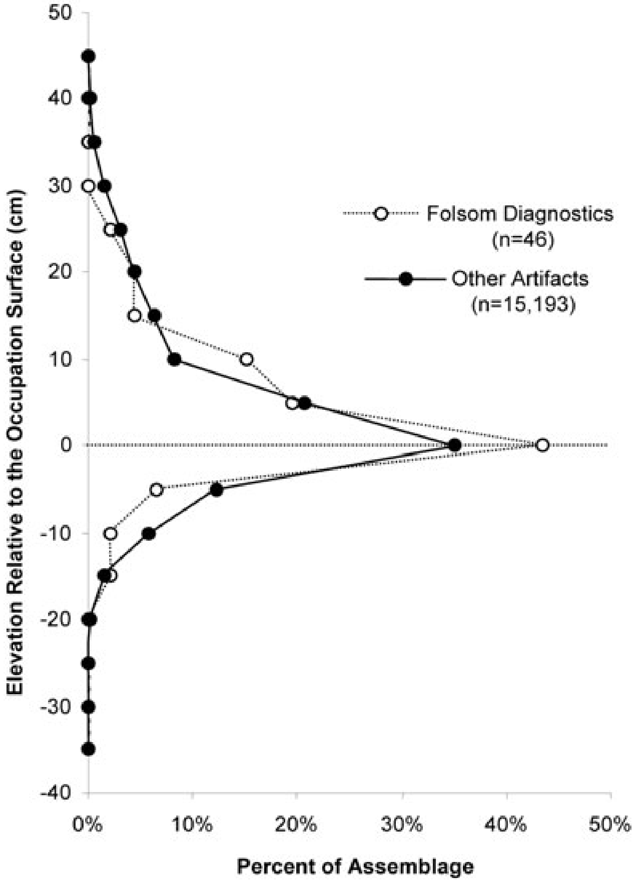

Figure 5. The percentage of Folsom diagnostics (n = 46) and all other artifacts (n = 15,193) from the site versus elevation in 5 cm levels relative to the inferred occupation surface. The analysis includes items recovered from screens.

ple exposures, usually appearing as a truncated Btb horizon. An erosional interval, evident in a 2-m section adjacent to a tributary gully of Barger Gulch approximately 55 m northwest of the excavation area (Profile 02-3), is constrained in time between ~10,700 and 9700 ^{14}C yr B.P. and possibly ~10,200 and 9700 ^{14}C yr B.P. Mayer et al. (2005) suggest that late Pleistocene/early Holocene landscape instability may be related to rapid climate change at the close of the Younger Dryas climatic interval. Radiocarbon dates from a 5.5+ m high terrace (Qt3) adjacent to the modern stream (Profiles 02-2 and 03-1) indicate that the main axis of Barger Gulch began aggrading by 10,000 ^{14}C yr B.P. and continued until at least 8000 ^{14}C yr B.P. Near the site area at Profile 02-3, deposition slowed to permit formation of two Holocene soils, Soil

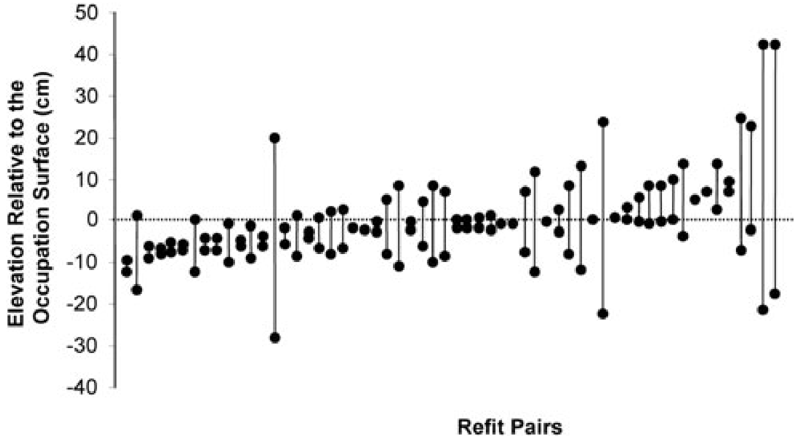

Figure 6. Elevations relative to the inferred Folsom occupation surface for 58 pairs of refitted and conjoined artifacts.

II and III (Mayer et al., 2005). Radiocarbon dates from Soil II suggest an age of roughly 9600 to 8800 ^{14}C yr B.P. The younger Soil III in this profile remains to be dated.

In the excavation area, more than 12,000 cal yr are represented by only 35–80 cm of deposits. Therefore, correlating Locality B excavation stratigraphy to the stratigraphy present in 2–3-m deep exposures is by no means straightforward. In our excavations, all stratigraphic units dip to the north. Sediments appear to be comprised primarily of reworked Troublesome Formation and are dominated by silts and very fine sands, no doubt due to the topographic position of the site on a ridge top, which limits deposition to mainly windblown material (Leigh, 2001). Occasional small clasts (<1 cm) are present throughout the deposits, possibly indicating some sheetwash input from the south. These clasts may also, or instead be derived from, the underlying Troublesome Formation, dispersed vertically with artifacts. At least three depositional units unconformably overlie the Miocene Troublesome Formation (Figure 7). Stratum 1 is a dark brown (7.5YR 3/2 to 3/4) silt loam, 5–10 cm in thickness with a truncated Bt/Btk soil profile (Soil I) developed in it. Overlying Stratum 1, Stratum 3 is a very dark grayish-brown (10YR 3/2) silt loam that is pedogenically modified by the formation of a mollic epipedon 10–30 cm thick. This buried soil (Soil II) is rich in organic matter, and is easily identified in excavation units by a dramatic color change and a very fine weak subangular blocky structure. The variation in thickness suggests that its upper contact is erosional. Stratum 4 is a brown (7.5YR 4/2 to 4/4) silt loam with an A/Bw soil profile (the modern surface soil) formed in it. It ranges from over 30 cm to less than 5 cm in thickness.

From the start of our excavations, we were plagued by questions of whether the 1/3 and 3/4 stratigraphic contacts were conformable, or whether erosional episodes interrupted deposition. Initially, we suspected that the A and B horizons of Strata 3

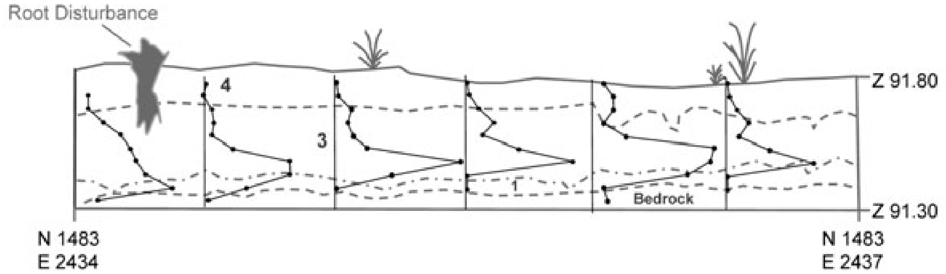

Figure 7. North profile of the 2001 excavation block showing site stratigraphy and vertical artifact density profiles using 5-cm level counts for 50 × 50 cm excavation quad. The scale of the x-axis varies for each plot. Artifact counts within each vertical density profile are relative, and counts between profiles are not directly comparable.

and 1, respectively, were genetically related (Surovell et al., 2001). The association of Folsom artifacts with what was believed to be a soil-organic-matter radiocarbon date of 9420 ± 50 (Beta-109464) from the base of Stratum 3 suggested to us that the buried A and B horizons represented a Younger Dryas soil commonly found at Paleoindian sites across the western Plains and Rocky Mountains (e.g., Irwin-Williams et al., 1973; Reider, 1980, 1990; Haynes, 1993). In his initial study of the site, however, Reider (1998), like Mayer et al. (2005) felt that the A horizon formed in Stratum 3 was welded to a truncated late-Pleistocene B horizon developed in Stratum 1. The question has important implications for the Folsom archaeology at the site because the occupation surface, as we define it, correlates with this contact in vertical space. If the 1/3 contact is disconformable, it suggests that the Folsom materials represent a deflated lag. If it is conformable, the occupation surface remains in its original stratigraphic position. Futhermore, multimodality in vertical artifact profiles in the absence of multiple occupations could be explained by a disconformity at the contact of Strata 3 and 4 if secondary modes represent lags.

We use two lines of evidence to address these questions—correlations between vertical artifact profiles and site stratigraphy, and particle-size analysis. In Figure 7, we present the profile of the northern wall of the excavation block following the 2001 field season. Superimposed on the profile are vertical artifact density profiles for the 50 × 50 cm excavation quads immediately south of that wall. The artifact density data have only 5-cm precision in elevation, since they are grouped by excavation level. On the profile, moving from east to west, the high density level appears to be coincident with the 1/3 contact between E 2436 and E 2437, but between E 2435 and E 2436, the high density level is well within Stratum 3. Even farther west, the level of greatest artifact density drops to the contact again from E 2434 to E 2435. In places, therefore, the Folsom occupation surface is well within Stratum 3, and in other places it falls on the mapped 1/3 contact. This pattern conforms to our observations in the field where, in some excavation units, large flat-lying artifacts appeared to be within Stratum 3, while, in other units, they were on its lower contact. This suggests that the 1/3 contact is erosional. Where the peak falls above the mapped 1/3 contact, erosion may have removed more of Stratum 1. Where it falls on the mapped contact, erosion may have been less severe. Furthermore, it suggests that the 1/3 contact identified in the field may not be a geologic contact but instead a pedogenic contact, and that identifying the geologic contact in the field will be difficult because it has been overprinted by pedogenesis.

A second pattern is also evident in Figure 7. In all but one vertical density profile, a secondary peak or shoulder of high artifact density is present 15–20 cm above the level of highest density. This peak is often coincident with the contact between Strata 3 and 4, and we suggest it represents the vertical concentration of artifacts resulting from an erosional event occurring sometime after the deposition of Stratum 3. In other words, the Folsom component was buried within a latest-Pleistocene soil. Shortly thereafter, erosion brought the artifacts to rest on a deflation surface. That surface was buried as Stratum 3 was deposited. As deposition slowed, soil formation became the dominant process. During deposition and pedogenesis, artifacts continued to disperse upward (into Stratum 3) and downward. A later erosional event created a second deflation surface on which artifacts, that had previously migrated upwards, came to rest; this second deflation surface was buried by Stratum 4 and vertical dispersal of artifacts continued.

If we are correct that both the 1/3 and 3/4 contacts are disconformable, then particle size analysis of excavation-block sediments should be congruent with artifact distributions, indicating concentrations of relatively coarse-grained sediments at these contacts (Glennie, 1970; Mayer, 2002). Samples were collected in 2.5-cm increments from Profile 02-4 (see Mayer et al., 2005, for a detailed stratigraphic description) on the eastern side of the excavation block. Each sample underwent particle size analysis using the pipette method (Singer and Janitsky, 1986) and sonic sifting for sand fractions, percent carbonate using a Chittick apparatus, and percent organic carbon content using the Walkley-Black method. Laboratory data are presented in Table I.

The relative scarcity of coarse-grained sediments in the silt-loam deposit somewhat limits the potential of particle size-analysis for identifying stratigraphic breaks. Nonetheless, the particle-size data provide some support for the hypotheses that both the 1/3 and 3/4 contacts are erosional. Three peaks in medium to very coarse sands are evident in the sample column. These peaks represent very small differences in quantities of coarser sands (<1%), and may not exceed the standard error of the sonic sifting method. While the reality of such small textural differences may reasonably be questioned, their concordance with field observations and artifact distributions provides supporting evidence that they are, in fact, real. Two of these peaks correspond precisely to the 1/3 and 3/4 contacts. Furthermore, both peaks are stratigraphically congruent with the peaks in artifact density discussed above (Figure 7), further supporting the hypothesis that these contacts are disconformable. The third peak is only 5 cm beneath the modern ground surface. Across the site area, the upper 2 to 5 cm of Stratum 4 are loose and disturbed from trampling by animals and excavators. This uppermost concentration of coarse sediments, therefore, could be a product of recent disturbance, or alternatively it could indicate a recent erosional episode. Recent surface deflation could explain the predominance of relatively flat-lying artifacts high in the stratigraphic sequence (Figure 4).

Table I. Laboratory data for sediment samples collected from Barger Gulch Locality B Profile 02-4.

Depth		Soil	Sand Fractions										
(cm)	Stratum	Horizon	%VCOS	%COS	%MS	%FS	%VFS	%Sand	%Silt	%Clay	Texture	%OC	$\%CaCO_3$
1.25	4	A	0.00	0.12	0.25	1.58	20.34	22.28	67.22	10.50	Silt Loam	1.70	0.21
3.73	4	A	0.09	0.27	0.48	1.89	27.62	30.35	59.82	9.83	Silt Loam	1.68	0.20
6.22	4	Bw	0.03	0.15	0.26	1.40	28.49	30.32	59.37	10.31	Silt Loam	1.48	0.16
8.70	4	Bw	0.00	0.05	0.21	1.88	30.28	32.42	57.77	9.81	Silt Loam	1.47	0.21
11.19	4	Bw	0.00	0.04	0.25	1.68	30.08	32.06	58.21	9.74	Silt Loam	1.70	0.12
13.67	4	Bw	0.00	0.14	0.41	2.21	34.07	36.83	54.75	8.42	Silt Loam	1.28	0.16
16.15	4	Bw	0.00	0.18	0.48	1.88	28.94	31.49	59.41	9.11	Silt Loam	0.91	0.21
18.64	3/4	Bw	0.00	0.11	0.41	1.92	26.05	28.48	63.29	8.22	Silt Loam	1.09	0.21
21.12	3	Ab	0.04	0.17	0.37	2.16	31.10	33.83	58.03	8.14	Silt Loam	0.90	0.16
23.61	3	Ab	0.00	0.07	0.30	2.06	26.75	29.18	62.29	8.52	Silt Loam	0.72	0.21
26.09	3	Ab	0.00	0.06	0.34	1.58	36.90	38.88	53.93	7.19	Silt Loam	0.71	0.16
28.58	3	Ab	0.04	0.09	0.34	1.60	33.00	35.06	57.78	7.17	Silt Loam	1.18	0.16
31.06	3	Ab	0.01	0.11	0.30	1.51	31.29	33.22	57.36	9.42	Silt Loam	1.01	0.16
33.54	3	Ab	0.01	0.07	0.33	1.79	30.34	32.54	57.41	10.05	Silt Loam	1.68	0.12
36.03	3	Ab	0.01	0.05	0.33	1.64	27.89	29.92	60.22	9.86	Silt Loam	1.47	0.25
38.51	3	Ab	0.04	0.12	0.42	1.65	32.83	35.05	56.82	8.13	Silt Loam	1.67	0.16
41.00	3	Ab	0.00	0.18	0.45	1.70	33.70	36.02	55.65	8.33	Silt Loam	1.47	0.21
43.48	1/3	ABtb	0.01	0.21	0.61	1.85	30.30	32.99	58.81	8.20	Silt Loam	1.48	0.25
45.96	1/3	ABtb	0.00	0.17	0.43	1.85	29.58	32.04	59.73	8.24	Silt Loam	1.09	0.29
48.45	1	ABtb	0.08	0.20	0.48	2.13	33.75	36.64	54.66	8.70	Silt Loam	1.09	0.37
50.93	1	Btkb	0.04	0.10	0.37	1.89	31.68	34.08	55.96	9.96	Silt Loam	0.72	0.25
53.42	Tr Fm	2Btkb	0.02	0.09	0.39	1.80	24.88	27.17	60.84	11.98	Silt Loam	0.72	0.21
55.90	Tr Fm	2Btkb2	0.00	0.04	0.27	1.36	29.09	30.77	59.28	9.95	Silt Loam	0.72	0.25

Note. Abbreviations: VCOS = very coarse sand, COS = coarse sand, MS = medium sand, FS = fine sand, VFS = very fine sand, OC = organic carbon, Tr Fm = Troublesome Formation.

RADIOCARBON DATING AND VERTICAL ARTIFACT DISTRIBUTIONS

The Radiocarbon Database

The most reliable radiocarbon dates from other archaeological localities place the Folsom complex just prior to the Pleistocene-Holocene transition.[3] Haynes suggests the Folsom period dates between 10,950 and 10,250 ^{14}C yr B.P. (Haynes, 1992, 1993; Haynes et al., 1992; Taylor et al., 1996), and Holliday (1997, 2000) proposes a similar but slightly younger and shorter time span of 10,800–10,200 ^{14}C yr B.P. From our excavations at Locality B, we have obtained a total of 17 radiocarbon dates on charcoal and soil organic matter[4] (Table II) ranging in age from 10,770 ± 70 (Beta-173385) to 5178 ± 49 (AA-45657). Soil organic matter dates at the site are almost certainly complicated by additions of younger organic matter from the early Holocene to the present, and locating cultural charcoal has been especially difficult, since the charcoal assemblage appears to be a composite of natural and cultural burning events. In this section, we present a brief account of our efforts to date the site and explain how vertical artifact density profiles have aided in sorting out these problems.

Following the first season at the site in 1997, a single radiocarbon date (Beta-109464) was obtained from what was believed to be charcoal taken from the base of Stratum 3 in a test excavation unit. This sample was dated by Beta Analytic, and produced an age of 9420 ± 50 ^{14}C yr B.P. Because the sample lacked woody structure, Beta referred to it as "organic material," rather than charcoal. Nonetheless, the sample did produce a base-insoluble residue (humin) fraction (the fraction dated). We have variously referred to this sample as charcoal or soil organic matter in our writings on the site (e.g., Surovell et al., 2001; Waguespack et al., 2002; Surovell et al., 2003). Herein, we treat it as a charcoal sample, but we are not confident that it actually was a fragment of burned wood. The early Holocene age was encouraging because it suggested that the Folsom materials were buried in primary context. If the sample was actually soil organic matter, then some contamination by younger carbon would be expected, and in that respect, the date was not out of the range of expected ages for a Folsom occupation.

Six additional radiocarbon dates were produced following the 2000 field season. Paired soil humin and humate dates were obtained from the top and bottom of Stratum 3 (AA45655–45658). Two charcoal dates (Beta 155403 and 155404) were also produced from the same stratigraphic contexts. We hoped that the charcoal sample collected from the base of Stratum 3 was cultural and that it would date the occupation, but all of the dates were early to middle Holocene in age. Following the 2001 season, we decided to employ two strategies for locating charcoal that might have a high probability of association with the Folsom occupation. First, we selected a number of large samples (>10 mm) to be identified to taxon (performed by Owen Davis of the Department of Geosciences at the University of Arizona), thinking that samples dating to the late Pleistocene may not be indicative of modern vegetation grow-

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[3] Following Hopkins (1975), we define the Pleistocene/Holocene boundary as 10,000 ^{14}C yr B.P.

[4] C. Vance Haynes has produced an additional seven radiocarbon dates on various fractions of soil organic matter from the base of Stratum 3. These dates are not reported herein, but they are all Holocene in age.

Table II. Radiocarbon dates from Barger Gulch Locality B excavations.

Sample No.	Stratum	Soil Horizon	Material	Fraction	Uncal. ^{14}C Age ± σ	δ^{13}C	Taxonomic ID	Calibrated 14C Age ± σ*	Comments
Beta-173385	1	Btkb	Charcoal	Residue	10,770 ± 70	–24.3		12,650–12,960 yr B.P.	Assoc. w/probable hearth
Beta-173381	1/3	ABtb	Charcoal	Residue	10,470 ± 40	–24.5		12,150–12,800 yr B.P.	Assoc. w/probable hearth
Beta-173387	1/3	ABtb	Charcoal	Residue	9450 ± 40	–23.9	Conifer *Pinus* cf. *ponderosa*	10,580–10,750 yr B.P.	
Beta-109464	Lower 3	Ab1	Charcoal?	Residue	9420 ± 50	–23.8		10,560–10,740 yr B.P.	
Beta-173379	1/3	ABtb	Charcoal	Residue	9390 ± 40	–21.7	Conifer cf. *Pinus*	10,550–10,660 yr B.P.	Probable burned root
Beta-173388	1	Btkb	Charcoal	Residue	8790 ± 40	–22.9		9700–10,110 yr B.P.	
Beta-173384	Tr Fm	2Btkb	Charcoal	Residue	7980 ± 50	–23.3		8660–9010 yr B.P.	
Beta-173383	Tr Fm	2Btkb	Charcoal	Residue	7930 ± 40	–22.9	Conifer, cf. *Pinus*	8640–8990 yr B.P.	Intrusive, mapped just beneath a krotovina
Beta-155403	1/3	ABtb	Charcoal	Residue	7880 ± 60	–23.2		8590–8930 yr B.P.	
Beta-173382	1/3	ABtb	Charcoal	Residue	7850 ± 40	–22.3	Conifer *Pinus ponderosa*	8590–8645 yr B.P.	
Beta-173386	1/3	ABtb	Charcoal	Residue	7590 ± 40	–22.7	Conifer, *Pinus* cf. *ponderosa*	8370–8410 yr B.P.	
Beta-173389	1/3	ABtb	Charcoal	Residue	7510 ± 60	–23.8		8200–8390 yr B.P.	
Beta-155404	3/4	Bw	Charcoal	Residue	6880 ± 60	–23.9		7660–7790 yr B.P.	
AA45656	Lower 3	Ab	Soil	Humates	6003 ± 64	–25.0		6740–6900 yr B.P.	
AA45655	Lower 3	Ab	Soil	Residue	5890 ± 65	–24.6		6640–6790 yr B.P.	
AA45658	Upper 3	Ab	Soil	Humates	5437 ± 45	–24.6		6195–6290 yr B.P.	
AA45657	Upper 3	Ab	Soil	Residue	5178 ± 49	–25.7		5905–5990 yr B.P.	
Beta-173380	Pit Fill	C	Charcoal	—	—	—		—	From pit feature; insufficient carbon for AMS dating

Notes. Abbreviations: Tr Fm = Troublesome Formation; * Calibration performed using OxCal, v. 3.9 (Ramsey, 2003).

ing in the site area. The second strategy was to select deeply buried samples from contexts likely to contain cultural charcoal. Three samples were selected for this purpose. Two (Beta 173381 and 173385) were recovered in the vicinity of a possible hearth, identified on the basis of high frequencies of burned artifacts and bone (see Surovell and Waguespack, 2004). A third sample (Beta-173380) was taken from a pit feature buried roughly 5–10 cm beneath the occupation surface.

Taxonomic identification of twelve charcoal samples suggested the presence of conifers at the site (Davis, 2003). All of the samples that could be identified to genus were identified as *Pinus*, and a single sample (Beta-173382) was identified as *Pinus ponderosa*. Although Ponderosa pine is present in Middle Park today, it is not found, as far as we know, within the Barger Gulch area, which has occassional stands of Douglas fir and juniper on north-facing slopes and willow and narrow-leaf cottonwood along the stream course. Of these 12 samples, five were selected for ^{14}C dating and were found to range in age from 7590 ± 40 (Beta-173386) to 9450 ± 40 ^{14}C yr B.P. (Beta-173387). None of these samples produced dates falling within the Folsom age range, but they did suggest the presence of trees in the early Holocene at Locality B, which is entirely treeless today.

Using the second strategy, selecting samples from contexts likely to retain cultural charcoal, we had more success. The two samples taken from the vicinity of a probable hearth did produce Folsom-aged dates: 10,470 ± 40 (Beta-173381) and 10,770 ± 70 (Beta-173385). The third sample (Beta-173380), taken from a pit feature, contained insufficient carbon for AMS dating. The dates on the two hearth charcoal samples do not overlap at two standard deviations, but we suggest that they do date the occupation. The 300-radiocarbon-year discrepancy could be accounted for by the use of old wood. Also, once calibrated, they overlap at one standard deviation (Table II), but the low precision of the calibration curve beyond 10,000 ^{14}C yr B.P. makes the calibrated age ranges less reliable (Ramsey, 2003). The presence of post-Folsom charcoal radiocarbon dates and the absence of post-Folsom artifacts suggests that Holocene charcoal ages are the product of natural fires that burned across or near the site area. Using clustering in the Holocene charcoal radiocarbon dates, we were able to identify at least five burn events dating between 9420 ± 25 and 6880 ± 60 ^{14}C yr B.P. (Surovell et al., 2003), and a single date produced on what we believed to be a burned root supports this idea (7980 ± 50, Beta-173384).

Refining the Chronology

To further refine the dating of the stratigraphic sequence in the excavation area, two additional analyses were performed. First, radiocarbon dates were plotted by stratigraphic unit as recorded by excavators (Figure 8). Samples of soil organic matter taken for dating were all removed from excavation profiles, and we consider their stratigraphic assignments to be accurate. This may not be true of charcoal samples recovered from excavation. As stated above, we consider excavator assignment of stratigraphic level somewhat unreliable. Furthermore, as we have shown above, the 1/3 contact identified in the field is likely not a geologic contact, rendering it a dubious divider of depositional units. When the radiocarbon dates are viewed in this

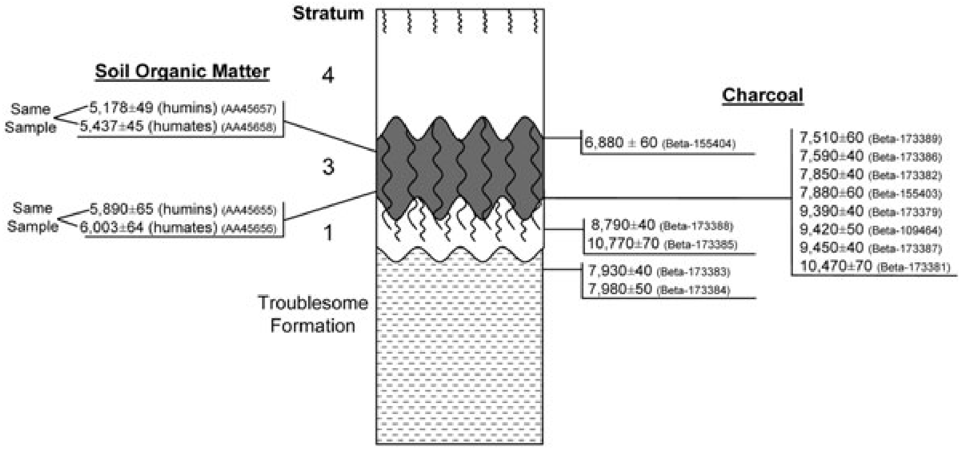

Figure 8. Generalized stratigraphic column of the excavation area showing the position of charcoal and soil organic matter radiocarbon dates by stratigraphic unit as recorded by excavator.

manner, a number of stratigraphic inversions are evident. The two stratigraphically deepest charcoal samples are believed to be intrusive, and their recovery from weathered Miocene sediments leaves little doubt. Beta-173384 is the burned root previously mentioned, and a krotovina was mapped directly above Beta-173833. Disregarding these dates, two patterns are evident. First, dates on soil organic matter are considerably younger than those on charcoal, possibly due to contamination by younger carbon. Alternatively, the Stratum 3 buried soil may have formed in early Holcene sediments during the middle Holocene. Second, the 1/3 contact is associated with a large range of ages (10,470 ± 70 to 7510 ± 70 ^{14}C yr B.P.).

To refine our chronological control, instead of relying on necessarily coarse-grained stratigraphic designations, the elevation of charcoal radiocarbon ages were plotted in relation to the elevation of the Folsom occupation surface for each respective excavation unit (Figures 9 and 10) because this is arguably our most reliable stratigraphic marker. From Figure 10a, an age trend with depth relative to the occupation surface is apparent, with the two samples known to be intrusive clearly breaking from that trend. A third sample (Beta-173388) was recovered from an excavation unit with an atypical vertical density profile showing a peak of high artifact density near the surface and a second peak 10 cm deeper. The deeper peak most likely represents the occupation surface, and if the relative elevation for this sample is corrected to take this into account,[5] it falls in line with the remaining samples (Figure 10b). Samples recovered below the occupation surface date between 10,770 ± 70 and 9340 ± 40 ^{14}C yr B.P., and samples recovered above the occupation surface date between 9450 ± 40 and 6880 ± 60 ^{14}C yr B.P. Because the 1/3 contact is most likely

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[5] The relative elevation for this sample was corrected using the middle elevation for the excavation level marking the deeper mode ($z = 91.625$ m) as the elevation for the Folsom occupation surface.

erosional, we suspect that the 9390 ± 40 ^{14}C yr B.P. date, which post-dates the Folsom occupation, is slightly out of place. It is only 1.7 cm beneath our inferred occupation surface, a distance that is comparable to the precision with which we can identify that surface using a weighted average of artifact counts from 5-cm levels. If we are correct, we can bracket erosion in the excavation area between roughly ~10,400 and

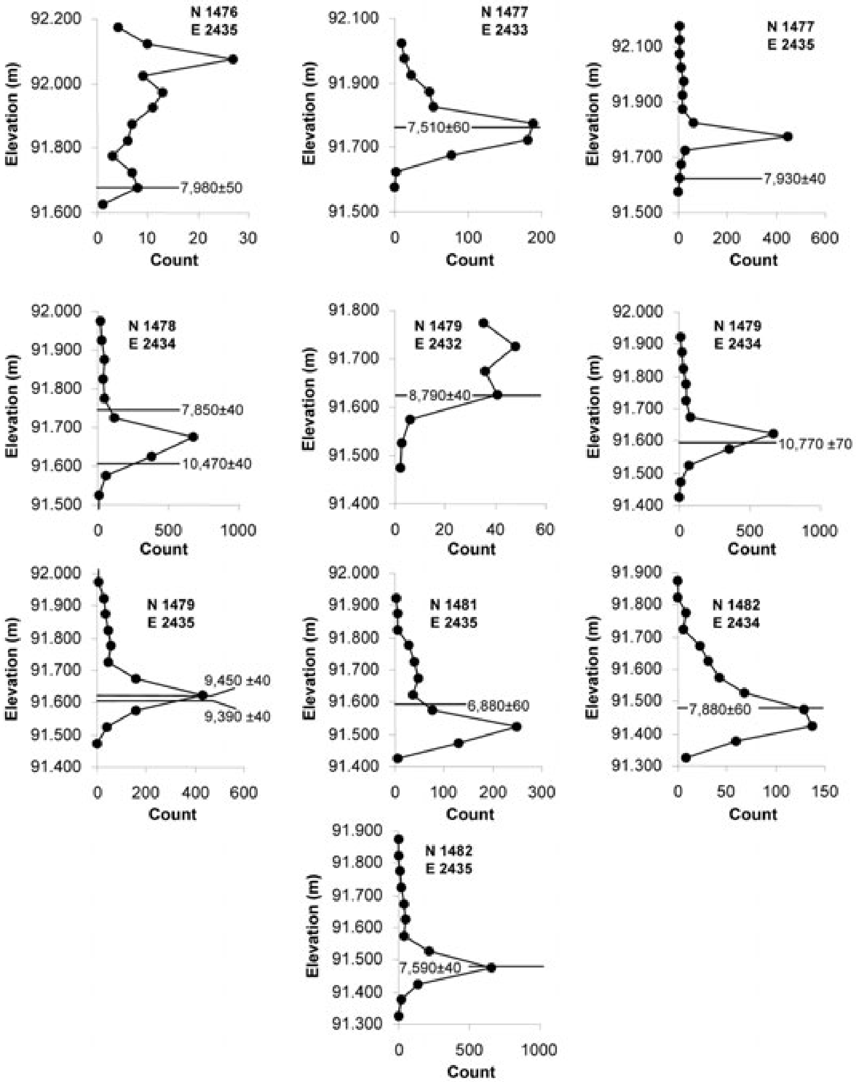

Figure 9. Charcoal radiocarbon ages plotted by elevation relative to vertical artifact densities for ten excavation units.

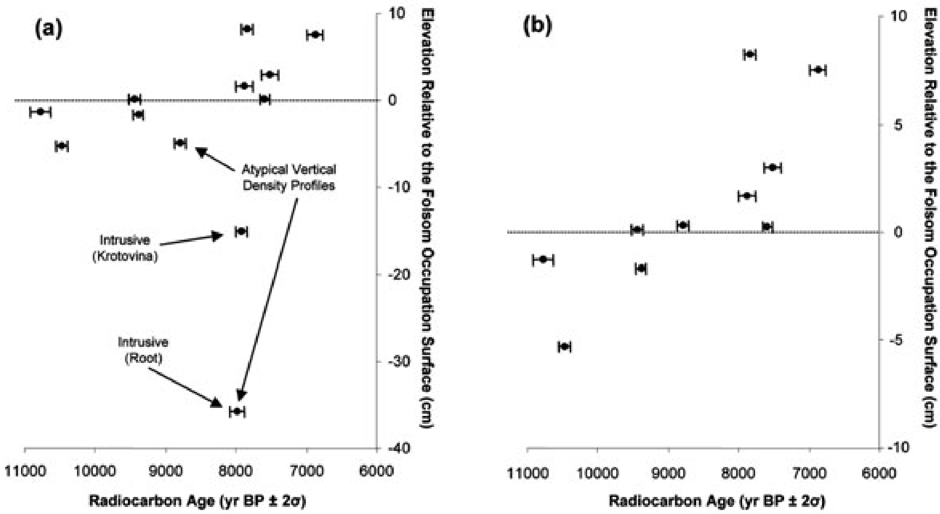

Figure 10. (a) Charcoal radiocarbon ages plotted by elevation relative to the inferred Folsom occupation surface. Two samples believed to be intrusive are labeled as are two samples from units with atypical vertical artifact density profiles. (b) Same, with two intrusive samples removed and with elevation corrected for one sample from an excavation unit with an atypical density profile.

9400 ^{14}C yr B.P., an age estimate roughly comparable to that identified by Mayer et al. (2005) using independent lines of evidence from other stratigraphic sections.

CONCLUSIONS

Using peaks in vertical artifact density profiles, we were able to take what at first appeared to be an impossibly jumbled set of radiocarbon dates and refine the chronology of events that have impacted the site. Above the Miocene Troublesome Formation, landscape stability is indicated by a remnant of a late-Pleistocene soil (Soil I). At approximately 10,450 ^{14}C yr B.P., the Folsom occupation occurred. At some time between 10,400 and 9400 ^{14}C yr B.P., erosion partially removed Soil I, leaving a lag of artifacts on the surface. It should be noted that depending on the precise timing of erosion and the deposition that followed, it is possible that we have later Paleoindian components mixed with the Folsom occupation, but, in the absence of diagnostics, we remain skeptical of this possibility. Deposition likely resumed by 9400 ^{14}C yr B.P., but slowed during the early to middle Holocene and soil formation became the dominant process in the site area. Sometime after 7000 ^{14}C yr B.P. (possibly after ~5200 ^{14}C yr B.P. if the soil organic matter dates are accurate), erosion removed the upper portion of Stratum 3 and created a secondary lag of artifacts. Although at least one final episode of deposition eventually buried the truncated soil, we have yet to produce any radiocarbon dates from Stratum 4, such that we are unable to reconstruct the chronology of events beyond this time.

This sequence of events was by no means immediately apparent during site excavations, since artifacts were dispersed through the entire late Quaternary depositional sequence. In some excavation units, bimodal or multimodal artifact density profiles were present, and radiocarbon dates spanned thousands of years. Stratigraphic contacts were difficult to define, and a very different interpretation of site formation could have evolved in the absence of these analyses, as is clearly demonstrated by our initial and slightly erroneous description of site stratigraphy (Surovell et al., 2001). However, using a number of lines of evidence stemming primarily from the vertical distribution of artifacts in the deposits, we were able to clarify what was at first a somewhat opaque set of events. The temporally constrained nature of cultural deposition, as compared to the slow and gradual buildup of sediments at the site, permitted a number of inferences that are further refined by the incorporation of geological data from multiple scales (Mayer et al., 2005).

Although vertical artifact dispersal is the focus of this paper, we have not discussed the mechanisms responsible for moving buried artifacts. This is simply because we do not know exactly what they were. We know that casts of insect and fossorial mammal burrows are common, but we also know that we find artifacts dispersed vertically in the absence of such features at Barger Gulch, as has been observed in other contexts (Villa, 1982). We know that roots and rootlets are present in the deposits today, and we suspect that they always have been. We know that trees likely grew at the site during the early Holocene, and that at least five fires burned across the site during this time. Furthermore, artifacts buried in fine-grained silt loam should be especially prone to frost heave (Johnson and Hansen, 1974; Wood and Johnson, 1978), and Middle Park, sitting above 2000 m asl is known for exceptionally cold winters. So, there are a number of contributory factors, such as rodents and small carnivores, insects and other invertebrates, roots, shrinking and expansion, freezing and thawing, fire, tree throws, and probably many more. Although we cannot identify the precise disturbance agents at this time, we can establish that their effects were deterministic and predictable. It is also worth briefly mentioning that although vertical displacement of artifacts is common at Barger Gulch, horizontal spatial patterning at the the site appears to have remained intact, suggesting that vertical movement of artifacts was associated with relatively little horizontal displacement (Surovell et al., 2003; Surovell and Waguespack, 2004). Finally, if the methods we have used for refining occupation history, stratigraphy, and radiocarbon chronology can be used with success at a site containing cultural materials that have remained near or on the surface for more than 12 millennia, then they should be broadly applicable to other contexts as well.

This work was supported by funding from the Colorado State Historical Fund, the George C. Frison Institute (University of Wyoming), the Emil Haury Fund for Archaeology (University of Arizona), and the Kremmling office of the Bureau of Land Management. Many thanks are owed to Frank Rupp of the Kremmling office of the Bureau of Land Management for all he has done to facilitate our research. Art and Roberta Bruchez and their family kindly granted us access to the site. The early geoarchaeological work of Dr. Richard Reider at Barger Gulch formed the foundation for our later research and deserves acknowledgment. Thanks to two anonymous reviewers and the editor, Art Bettis. The text was improved considerably through the review process. This research would not have been possible without the hard work, dedication, and careful excavation of all of the individuals who have worked at the site over our five seasons at Barger Gulch.

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Received February 24, 2004
Accepted for publication September 13, 2004