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Latest Pleistocene–early Holocene human occupation and paleoenvironmental change in the Bonneville Basin, Utah–Nevada

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ABSTRACT

On this field trip, you will visit two important archaeological cave sites that provide the most compelling evidence for latest Pleistocene and earliest Holocene human occupation in the Bonneville Basin. Danger Cave, located near Wendover, Utah/Nevada, is famed for its deeply stratified archaeological deposits dating as old as 10,300 radiocarbon yr B.P., when the remnant of Lake Bonneville stood at the Gilbert shoreline. Bonneville Estates Rockshelter, located south of Danger Cave at the Lake Bonneville highstand shoreline, also contains well-preserved stratified deposits, including artifacts and cultural features radiocarbon dated to at least 11,000 radiocarbon yr B.P., making it one of the oldest known archaeological occupations in the Great Basin. We describe results of our recent research at these sites and show the stratigraphic evidence for these earliest human occupations. We also review recent work at the Old River Bed Delta, on

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Dugway Proving Ground, that has documented hundreds of Paleoarchaic occupations sites dating 11,000–8500 radiocarbon yr B.P. Together these localities give us an unparalleled picture of human occupation during the first few thousand years of known human occupation in the region, during a time of dramatic environmental change. Packrat middens, pollen sampling localities, and geomorphic features that illustrate the history of Pleistocene Lake Bonneville and the environmental history of the western Bonneville Basin will also be observed on this trip.

Keywords: archaeology, Late Pleistocene, early Holocene, Bonneville Basin, Bonneville Estates Rockshelter, Danger Cave, Old River Bed, Paleoindian.

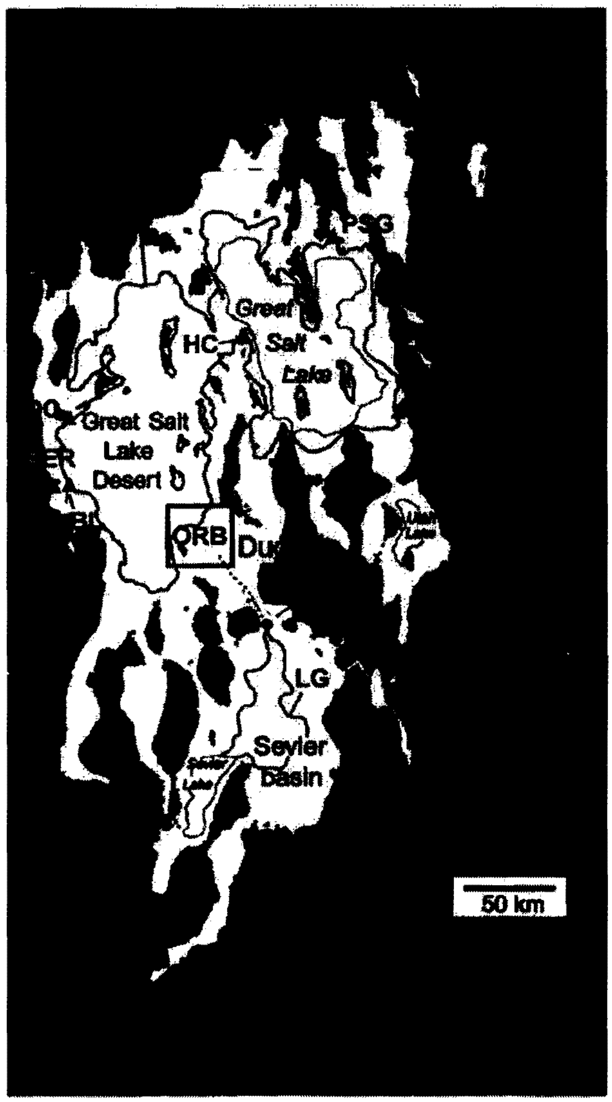

Figure 1. Extent of Bonneville Basin, northwest Utah and adjacent Nevada and Idaho, showing locations of field trip stops and other localities mentioned in the text. BER—Bonneville Estates Rockshelter; BL—Blue Lake; DC—Danger Cave; HC—Homestead Cave; LG—Lake Gunnison; ORB—Old River Bed delta sites; ORBT—Old River Bed Threshold; PSG—Public Shooting Ground; RRP—Red Rock Pass; SLC—Salt Lake City (City Creek locality).

INTRODUCTION

Recent investigations into latest Pleistocene–early Holocene human occupation of the Bonneville basin, northwest Utah and adjacent Nevada, shed considerable new light on the nature of earliest human adaptations in the context of dramatic environmental changes in the region. In this field guide, we present results of recent archaeological work at the Old River Bed paleodelta, Danger Cave, and Bonneville Estates Rockshelter (Fig. 1).

This guide departs from the traditional "road-log" style because the stops described herein are either inaccessible (for government security reasons) or require escorted permission to visit. All historic properties on federal lands, including Bonneville Estates Rockshelter and those in the Old River Bed paleodelta, are protected under the National Historic Preservation Act and the Archaeological Resources Protection Act. Danger Cave is secured under lock and key as a State Park. General directions to the locations of these stops are provided below, but access to them must be arranged in advance with the appropriate land manager.

PALEOENVIRONMENTAL CONTEXT

People first occupied and settled into the Bonneville basin during a time of great transition in the character and operation of geomorphic and hydrologic systems, in the content and distribution of vegetation associations, and in the composition and abundance of faunas. This section briefly introduces the environmental context for initial human occupation from ca. 15,000–7500 radiocarbon yr B.P.

About 15,000 radiocarbon yr B.P., when Pleistocene Lake Bonneville reached its highstand, it covered 51,700 km^2 of northwestern Utah (Fig. 1) to a maximum depth of ~372 m. At this level (1552 m, adjusted for isostatic rebound; Fig. 2), the lake overflowed into the Snake River drainage through a natural alluvial divide at Zenda, Idaho. This huge, cold lake was supported by very low postglacial temperatures relative to today, combined with moderately enhanced precipitation resulting from a southward shift of the mean jet stream (Thompson et al., 1993).

Evidence from packrat middens (Rhode and Madsen, 1995; Rhode, 2000a; Thompson, 1990) indicates that, when Lake Bonneville filled much of the lowlands, the mountains west of the Bonneville basin were covered with a subalpine parkland dominated by sagebrush, with scattered stands of spruce, smaller amounts of limber pine, and shrubs such as currant and snowberry as common associates. The presence of mesophilic shrubs and grasses, along with the apparent dominance of spruce over limber pine, suggests the period was cold and relatively moist. Fossil remains of musk ox, mountain sheep, mammoth, horse, camel, bison, mastodon, short-faced and black bear, ground sloth, peccary, and other large beasts document the presence of a diverse megafaunal community.

Around 14,500 radiocarbon yr B.P., the unconsolidated alluvial dam at Zenda collapsed catastrophically (Fig. 2), producing a massive flood of 4750 km^3 of water into the Snake River drainage, with a calculated peak discharge of ~10^6 m^3/s, roughly equivalent to the mean discharge of all the world's rivers *combined* (Jarrett and Malde, 1987; O'Connor, 1993). Within a year, the spill reached resistant bedrock at Red Rock Pass, Idaho, and the lake stabilized at the Provo shoreline, ~1444 m, where it remained for at least several centuries.

Lake Bonneville began to recede from the Provo level sometime after 14,000 radiocarbon yr B.P. This regressive phase lasted for the next few thousand years with several fluctuations, but its tempo is the subject of much current debate and ongoing research (Fig. 2). Oviatt (1997; Oviatt et al., 1992) proposed that the lake's decline began ca. 14,000 radiocarbon yr B.P. (see also Sack, 1999), gradually at first and then more rapidly after ca. 12,500 radiocarbon yr B.P., reaching the level of modern Great Salt Lake by 12,000 radiocarbon yr B.P. More recently, Oviatt et al. (2005) suggest that the decline from the Provo shoreline began later, ca. 13,000 radiocarbon yr B.P., declining gradually until ~12,000 radiocarbon yr B.P., after which it dropped more rapidly to the level of Great Salt Lake at ca. 11,200 radiocarbon yr B.P. An even later age of regression is proposed by Godsey et al. (2005), who examined a large suite of dates and geomorphic profiles from the Provo shoreline complex. They concluded that the lake fluctuated significantly from 14,000–12,500 radiocarbon yr B.P. but that it existed at the Provo shoreline as late as 12,000 radiocarbon yr B.P., after which it declined precipitously to low levels by ca. 11,500 radiocarbon yr B.P. The reconstruction posited by Godsey and colleagues may conflict with other evidence such as the date of initial overflow of Lake Gunnison into the Great Salt Lake Desert (Fig. 2). The different scenarios have implications for the relationship of Lake Bonneville's decline to global climatic forcing at the end of the Pleistocene, as well as more local considerations such as the antiquity of delta and fluvial channel deposits and the development of wetlands in places such as the Old River Bed (see Stop 1).

Fish remains from Homestead Cave, in the Lakeside Range (Fig. 1), provide constraints on the timing of Lake Bonneville's demise (Broughton, 2000; Broughton et al., 2000). Abundant remains of eleven species of cold- and freshwater adapted fish, including bull and cutthroat trout, whitefish, Bonneville cisco, and sculpin, were found in deposits dating to ca. 11,300–10,400 radiocarbon yr B.P. These remains signal catastrophic die-offs of the native coldwater fishes as the lake receded and became warmer and/or more saline (Broughton et al., 2000). The Homestead record suggests the lake was sufficiently cold and fresh to support these fishes prior to ca. 11,300 radiocarbon yr B.P., but by then had declined. Strontium-isotope ratios of fish bones from Homestead Cave and other sites support the idea of a high freshwater lake prior to ~12,000 radiocarbon yr B.P., but a much lower lake by ca. 11,200 radiocarbon yr B.P. (Broughton et al., 2000; Quade, 2000).

As the lake declined, the mesophilic parkland that characterized the vegetation in the western Bonneville basin was replaced by a limber pine–sagebrush mosaic, at least at lower elevations above the Bonneville shoreline (Rhode, 2000a; Rhode and Madsen, 1995). This transition at ca. 13,200 radiocarbon yr B.P. suggests a significant drying trend within a still-cool temperature regime. Limber pine became the widespread and dominant tree species, while spruce and mesophilic shrubs largely dropped from the midden record. Common juniper and snowberry were frequent associates. The abundance of limber pine at lower elevations implies the climate was substantially cooler than today (6–7 °C during the growing season), with precipitation slightly greater than modern levels (Rhode and Madsen, 1995). This limber pine-sagebrush association persisted until at least 11,800 radiocarbon yr B.P. in the lower elevations around the Bonneville shoreline.

The decline of Lake Bonneville to levels at least as low as 1280 m by 11,200 radiocarbon yr B.P. signals the end of the Bonneville cycle and the beginning of the Great Salt Lake cycle (Fig. 2; Oviatt et al., 1992, 2005). It correlates with a brief period that Haynes (1991) termed the "Clovis drought." This sharp drying episode might have lasted only a few centuries, but it may have been responsible for significant vegetation changes and the extirpation of Pleistocene megafauna in the Bonneville basin (Madsen, 2000, p. 171), as well as the depletion of the Bonneville fish fauna. The limber pine–sagebrush mosaic widespread before 11,800 radiocarbon yr B.P. was replaced by a shrubland dominated by sagebrush and shadscale, lacking conifers, that was in place by at least 11,000 radiocarbon yr B.P. After that time,

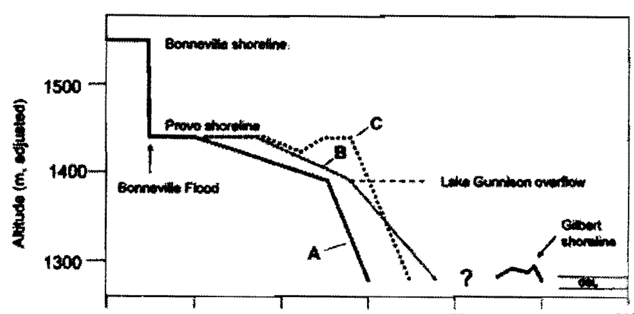

Figure 2. Alternative scenarios for timing of regression of Lake Bonneville from highstand. A—Oviatt et al., 1992, Oviatt, 1997. B—Oviatt et al., 2003, 2005. C—Godsey et al., 2005. GSL—Great Salt Lake.

limber pine retreated to mid-montane settings and may have persisted in small locally protected pockets at lower elevations.

The decline of the lake allowed marshes to develop on the old lakebed in various parts of the Basin (Oviatt et al., 2003). Marshes and wetlands are thought to have developed along the channels of the Old River Bed delta (Stop 1), at Public Shooting Grounds (Oviatt et al., 2005), and at Fish Springs, where peats as old as 11,400 radiocarbon yr B.P. have been found (Godsey et al., 2005). These wetlands may have served as magnets for occupation by some of the first human inhabitants of the region.

While the timing of the regressive phase is still uncertain, a subsequent transgressive phase is somewhat better understood (Oviatt et al., 2005). This transgression resulted in the formation of the Gilbert shoreline (Eardley et al., 1957; Currey, 1982), with an elevation ranging between 1293 and 1311 m. The variation reflects isostatic adjustments to some degree (Currey, 1980), but may be the result of other factors such as wave energy, sediment supply, slope morphology, etc. (cf. Oviatt et al., 2005). Currey (1990) and Benson et al. (1992) thought that the transgression to the Gilbert shoreline began by ca. 12,000 radiocarbon yr B.P., progressing through four successively higher transgressive stages to reach the uppermost Gilbert shoreline ca. 10,300 radiocarbon yr B.P. That timing seems to conflict with the more recent estimates of the Bonneville regression, however. Work by Oviatt et al. (2005) at the Public Shooting Grounds, northeast Great Salt Lake (Fig. 1), indicates the Gilbert shoreline deposits there date between 10,500–10,000 radiocarbon yr B.P. (12,900–11,200 cal B.P.). This transgressive phase roughly coincides with the Younger Dryas cold event. Oviatt et al. (2005) caution that the two events, the Younger Dryas and the lake rise to the Gilbert shoreline, presently appear to be only partially coincident in time; a causal connection needs stronger confirmation. Broughton (2000) suggests that stocks of the Bonneville fish fauna, adapted to cold fresh water, may have rebounded as the lake rose to the Gilbert Shoreline, but by 10,400 radiocarbon yr B.P. most of those fish stocks were apparently decimated as well (except perhaps the more salinity- and warmth-tolerant Utah chub, which can survive in springs and marshes).

Sometime around 10,000 radiocarbon yr B.P., the Gilbert transgression waned and the lake returned to low levels once again. Extensive wetlands expanded in several parts of the Bonneville basin lowlands: for example, along the Old River Bed, where wetlands had covered the lowlands since before the Gilbert transgression (Oviatt et al., 2003); at the Public Shooting Grounds (Oviatt et al., 2005); along the margins of the Silver Island Range, near Danger Cave where peats located at an elevation slightly lower than the Gilbert Shoreline date to 9450 ± 150 radiocarbon yr B.P.; and at Blue Lake near Bonneville Estates Rockshelter (Fig. 1), where basal peat deposits date to 9590 ± 50 radiocarbon yr B.P. (Beta-197282). Elsewhere, an exposure of the City Creek fan east of Great Salt Lake (Fig. 1) revealed a series of at least 12 streamside, gallery-forest deposits interbedded with alluvial sand and gravel. Wood from two of these forest-floor mats produced radiocarbon dates of 9670 ± 80 radiocarbon yr B.P. (Beta-145038) and 9360 ± 60 radiocarbon yr B.P. (Beta-142291), respectively. These ages indicate that gallery forests grew here at an altitude only slightly higher than the long-term modern average altitude of Great Salt Lake (GSL) (1280 m), at a time when isostatic rebound was still under way.

The Holocene Great Salt Lake probably oscillated significantly in elevation and surface area. Between 10,000 and 9000 radiocarbon yr B.P., the geographic center of the lake was located west of its current center, and its surface area was much larger than at present (Bills et al., 2002). A presumed early Holocene shoreline at ca. 1290 m (Murchison, 1989) may date ca. 9700 radiocarbon yr B.P. (Murchison and Mulvey, 2000), but this lake rise and its age are both uncertain.

Early Holocene vegetation in lowlands of the western Bonneville basin was dominated by xerophilic shrubs such as sagebrush, shadscale, greasewood, and horsebrush, but also included hackberry in rocky settings. Hackberry prefers more summer precipitation than is typically available today, so summers were likely to have been somewhat moister than now (Rhode, 2000b). Upland woodlands were dominated by Rocky Mountain juniper. These shrublands and woodlands probably reflect a somewhat cooler and more mesic environment than exists today, with greater sagebrush abundance than now (Rhode, 2000b). Well-dated faunal sequences from Homestead Cave and Camelsback Cave (near the Old River Bed delta; Fig. 1) indicate more mesic and cooler temperatures as well (Grayson, 1998; Madsen, 2000; Schmitt et al., 2002).

Under these slightly more mesic conditions, a larger early Holocene Great Salt Lake was probably supported, even though it might not have greatly exceeded the elevation of the lake today. This is because the basin configuration differed from today. The Eardley threshold north of the Lakeside Mountains had not yet formed as a result of isostatic rebound, and the Great Salt Lake occupied a much larger area in the western Great Salt Lake Desert. The existence of this large but shallow lake would have been possible only under conditions of less evapotranspiration than today, hence slightly cooler or moister conditions as reflected in the vegetation, fauna, and well-watered marshlands.

By ca. 8500 radiocarbon yr B.P., increased aridification had resulted in a more open shrubland increasingly dominated by shadscale and other more drought-tolerant plants (Bright, 1966; Beiswenger, 1991; Thompson, 1992). The extraordinarily rich faunal record from Homestead Cave clearly demonstrates how increasing aridity and vegetation changes during the early Holocene dramatically affected the relative abundance of a wide range of small mammals, including cottontails, pygmy rabbits, kangaroo rats, voles, pocket and harvest mice, pocket gophers, woodrats, and marmots (Grayson, 1998, 2000; Madsen, 2000). By 8000 radiocarbon yr B.P., lowlands in the Bonneville basin had reached a character much more like that of today (Grayson, 2000; Rhode, 2000b; Schmitt et al., 2002). Warmth-tolerant conifers such as singleleaf piñon and Utah juniper migrated into the region and established montane woodlands by ca. 6500 radiocarbon yr B.P., and the transition to a modern regional ecosystem was essentially complete.

The first people to inhabit the Bonneville basin saw the region when it was still very different from the modern. Present evidence demonstrates that humans began to occupy the region by ca. 11,000 radiocarbon yr B.P. and possibly somewhat before. The record of these initial occupations, and how people subsequently adjusted to latest Pleistocene and early Holocene environmental shifts, is best illustrated by the three archaeological sites or site complexes discussed or visited on this field trip: the Old River Bed sites, Danger Cave, and Bonneville Estates Rockshelter.

STOP 1. OLD RIVER BED PALEODELTA OPEN SITES

The Old River Bed paleodelta and wetlands are located on the southeast side of the Great Salt Lake Desert (Fig. 1), south of Interstate 80 (I-80) between mile posts 10 and 40, and north of the Simpson Springs–Callao road. The area is generally inaccessible as it is almost wholly contained within lands under the control of the U.S. Air Force Utah Test and Training Range and the U.S. Army Dugway Proving Ground, which lies at the north end of the Old River Bed. We will not visit this stop on the field trip, but we will observe the area from a distance and discuss the sites and setting while we are at Stop 3, Bonneville Estates Rockshelter. For those who wish to visit the Old River Bed and the extreme southern portion of the paleodelta on public lands, take the Tooele exit on I-80 and travel southbound on State Highway 36 for 42 miles (68 km) to Vernon, then turn west on the Simpson Springs–Callao Road (the old Pony Express Route) and drive ~35 mi to the Old River Bed.

The Old River Bed is an abandoned river valley eroded into deposits of Lake Bonneville in western Utah (Fig. 1). During the regressive phase of Lake Bonneville, a shallow lake in the Sevier basin overflowed to the north. The river created by this overflow eroded a meandering, narrow valley in the fine-grained lake sediments on the basin floor (Oviatt et al., 2003). Sometime after ca. radiocarbon yr B.P., water ceased to flow in the Old River Bed and environmental conditions along the channel began to approach those found at present. During the roughly 3000 yr of its existence, however, the water in the river fed a large marsh–wetland system at the Old River Bed delta and supported a riverine environment along its length. This 3000 yr interval corresponds almost exactly to the earliest Paleoarchaic phase of human occupation in the Bonneville basin (Beck and Jones, 1997). Foragers have been drawn to these rich marsh–wetland ecosystems throughout the human history of the Great Basin (Madsen, 2002), but sites of the Paleoarchaic period are particularly associated with Great Basin wetlands.

Most major wetlands in the Great Basin lie at the end of major river systems, such as the Humboldt, Bear, and Carson Rivers, and have been in existence for at least the period of human occupation in the region. As a result of both continuous use of these marshes by foragers and erosional-depositional cycles associated with Holocene climatic changes, intact Paleoarchaic sites are relatively rare. The Old River Bed delta differs in that it was forming for only a limited time during the Paleoarchaic period, and, while erosion has taken place since that time, there has been no subsequent lateral migration of streams that would result in the disturbance of early sites. After ca. 8500 radiocarbon yr B.P., when the wetlands dried up, the area became unattractive to hunter-gatherers, so subsequent human disturbance has been minimal.

Primary Geomorphic Features of the Old River Bed

This section briefly summarizes the geomorphic features of the Old River Bed wetland, described elsewhere in greater detail (Oviatt et al., 2003). The wetlands of the Old River Bed delta once covered ~700 km^2 in the Great Salt Lake Desert. An abrupt boundary in the delta separates the present-day groundwater-discharge mudflats from well-drained, fine-grained sheetflow and eolian deposits (Fig. 3). We informally use "gravel channel" and "sand channel" for fluvial landforms and deposits on the mudflats (Oviatt et al., 2003, their Figures 3 and 4). Gravel channels are deposits of coarse sand and gravel that in planview are straight to curved and digitate, and have abrupt bulbous ends. In transverse cross section, gravel channels are topographically inverted, with the crests of the gravel deposits standing one to four meters

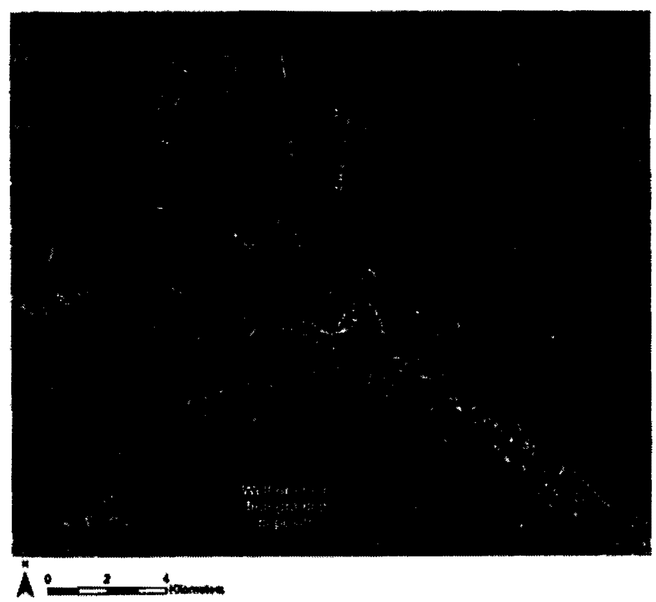

Figure 3. Location of Old River Bed delta sites on Dugway Proving Ground, as shown in Figure 1. Note the gravel channels on the mudflats (dark anastomosing features on the mudflats), sand channels (lighter sinuous features around gravel channels), and the abrupt boundary between the mudflats and the well-drained, fine-grained deposits on the flat desert floor. Gravel and sand channel locations that have been surveyed for archaeological sites are outlined in white, and the locations of known Paleoarchaic sites are marked with black dots. Given the site density in the surveyed areas, there may be as many as 500 Paleoarchaic sites in the delta.

higher than the surrounding mudflats. They can be traced down to an altitude of 1299 m, where they end abruptly.

Gravel channel characteristics indicate the Old River Bed river emptied into a shallow Lake Bonneville (Fig. 4). Lake Bonneville had dropped to approximately the level of the Old River Bed threshold (~1390 m) by ca. 12,500 radiocarbon yr B.P. (Oviatt, 1988), and the gravel channels were produced by river discharge from the Sevier basin across the threshold after this time (Fig. 4). They ceased to form after the lake declined to below 1299 m, probably about the time of the massive fish die-off around 11,200 radiocarbon yr B.P. (Broughton et al., 2000).

Sand channels are found in the same general area of the mudflats as the gravel channels (Fig. 3). They are less topographically inverted and are truncated by the mudflat surface. Where they have been protected, they may stand as much as 1.2 m above the surrounding mudflats, and in other areas they typically stand ~0.5 m above the mudflats. Sand channels are not easy to identify on the ground due to deflation of the mudflats, but from the air the preserved sand channel roots exhibit well-developed meander-scroll patterns. Sediments in sand channels consist of fine to coarse cross-bedded sand, and locally include mud containing organic mats, mollusks and bones of Utah chub, a fish adapted to warm and slightly saline waters. Most sand channels end at an altitude between 1301 and 1303 m. Intermediate channel forms, which are straighter and smaller in width than sand channels and locally contain some gravel, can be traced to altitudes as low as 1285 m in the west-central Great Salt Lake Desert.

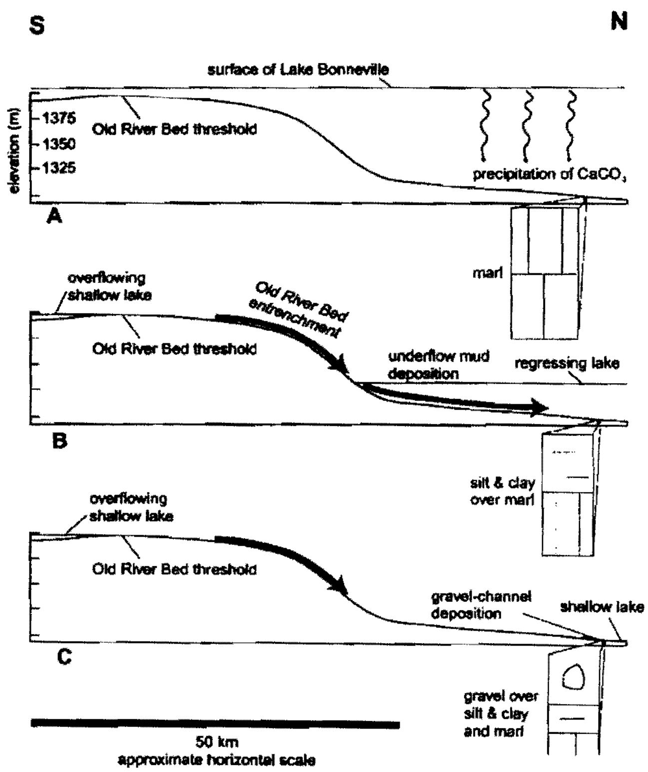

Figure 4. Schematic diagrams showing changing lake level during the regression of Lake Bonneville and its effect on river flow in the Old River Bed valley and on the deposition of gravel channels at Dugway Proving Ground. (A) Early regressive phase of Lake Bonneville. Lake surface is above the Old River Bed threshold, and endogenic calcium carbonate (marl) is being deposited. (B) Lake has dropped below threshold and river flow has begun in the Old River Bed valley; suspended-load sediments are spread to the north by underflow currents in the regressing lake, and silt and clay are deposited over the marl. (C) Lake level continues to drop, and bedload sediments are deposited over the underflow muds; gravel channels prograde into the shallow lake.

Sand channels are younger than gravel channels. The scoured bottoms of sand channels are topographically lower than the bottoms of gravel channels, and sand-channel deposits are inset into gravel-channel deposits. Sand channels were produced by perennial rivers that were active during the period from at least 11,000–8800 radiocarbon yr B.P. (see Oviatt et al., 2003, their Table 1). Sometime prior to 11,000 radiocarbon yr B.P. the Sevier basin stopped overflowing, and stream flow in the river was reduced, though still substantial enough to carry coarse sands in channels. Water in these sand channels fed a large wetland-marsh ecosystem over much of what is now the Great Salt Lake Desert. During this episode, exposed underflow fan and lacustrine deposits began to deflate in what are now mudflats, partially exhuming the gravel channels.

Human Occupation of the Old River Bed Wetlands

Archaeological sites in the Old River Bed delta are associated with the exposed sand and gravel channels (Fig. 3). The sand channel streams meandered extensively through the delta, creating a vast wetland system with relatively few areas suitable for habitation or for activities not directly associated with foraging in the marsh itself. The only dry areas were probably the partially exposed gravel channels and natural levees along the sand channel margins, and it is these areas where sites appear to be concentrated.

We have conducted archaeological inventories of 52 km of the more than 200 linear km of exposed channels within Dugway Proving Ground and located 51 Paleoarchaic archaeological sites directly associated with channels or immediately adjacent wetlands (Fig. 3). An additional five sites not directly associated with channel features have also been identified. This density, together with archaeological investigations at the extreme northwestern toe of the delta (Arkush and Pitblado, 2000; Carter and Young, 2001), suggests as many as 500 or more Paleoarchaic sites may be present within the delta area. These sites consist of surface arrays of a few dozen to hundreds of basalt and obsidian flakes and tools.

None of these sites has yet been excavated, and they are not directly dated. But their ages can be estimated by their relationship to channel features and by typological dating of associated diagnostic artifacts. All the sites postdate formation of the gravel channels, and, hence, date to the period between 11,000 and 9000 radiocarbon yr B.P. (Oviatt et al., 2003).

Site Types and Tool Forms

The Paleoarchaic sites in the Old River Bed delta area take one of two principal forms. The majority are linear features along the margins of topographically inverted gravel channels or adjacent to sand channels. These linear sites have a high ratio of finished tools to flaking debris and most of the tools consist of stemmed, hafted bifaces. Debitage and some tools feather out onto adjacent mudflats that were probably wetlands when the sites were occupied. The other, less common, site type consists of diffuse scatters of lithic debitage and stone tools on mudflat surfaces. These are often hundreds of meters in diameter, and in places merge into a background scatter of cultural materials covering much of the mudflats within the delta area. Tool to debitage ratios in these sites are reduced and they appear to represent resource procurement activities within the wetlands themselves.

The sites are characterized by a variety of Great Basin Stemmed bifaces and crescents dating to 11,500–8500 radiocarbon yr B.P. (Fig. 5) (Beck and Jones, 1997). Many tools appear to have been scavenged and reworked from earlier deposits and were repeatedly resharpened to such an extent that the amount of cutting edge above the hafting element is minimal. This is particularly true for a unique form of Great Basin Stemmed biface we term Dugway Stubbies. Large basalt flakes and cores, which appear to have been used as tools, are also common. These cores are usually in the form of large thin bifaces (Fig. 6), but include platform cores used to produce short blades. Although we have no direct dates for any of these tool forms, the sample size is sufficiently large at 23 sites to determine a relative chronology based on seriation of stemmed bifaces and crescents (Fig. 7). Stone used for making these tools consists primarily of local basalts and Topaz obsidian from sources less than 50 km from the Old River Bed delta. Minor amounts of Browns Bench obsidian, from a source near the junction of the Utah-Nevada-Idaho borders, are also present.

Foraging Adaptations

We have little direct evidence of the foraging activities of the Paleoarchaic people who occupied the sand channel sites, other than that they likely focused on the marsh-wetland resources that dominated the Old River Bed delta landscape at the time. What is most remarkable about the artifact complex we have identified is that it lacks groundstone, suggesting that seed collecting and processing was not part of the subsistence focus. Whether foraging was limited to large and small game animals or included other plant resources such as marsh rhizomes is presently unknown. In the western Great Basin, Paleoarchaic foragers around the Stillwater marsh area were eating small fish at the time the Old River Bed sand channel sites were occupied (Napton, 1997), and it is possible that the fish in the Old River Bed streams were also being exploited. It now appears that seed grinding was not a significant part of foraging strategies in the Bonneville basin until after ca. 8600 radiocarbon yr B.P., about when the Old River Bed wetlands were finally eliminated (Rhode et al., 2006).

Paleoarchaic Mobility

Paleoarchaic sites in the Old River Bed delta fit easily within the Western Stemmed Tradition characterized by an adaptation to wetland ecosystems around the many shallow lakes on valley floors in the Great Basin during the Pleistocene-Holocene transition (Willig et al., 1988). The kind of mobility pattern characteristic of foragers on the Old River Bed delta, while generally similar to that found among Paleoarchaic foragers elsewhere in the Great Basin, appears to have differed in the Old River Bed delta due to the size of the marsh ecosystem. In most of the small, isolated Great Basin valleys, wetland ecosystems were small relative to the Old River Bed delta, and both theoretical models and limited empirical data suggest foragers employed a high mobility pattern characterized by the use of a variety of widely-spaced toolstone sources, large flake and biface tools, high percentages of scrapers, and a diet narrowly focused on wetland resources (Graf, 2001; Elston and Zeanah, 2002; Huckleberry et al., 2001; Beck et al., 2002; Jones et al., 2003). In the Old River Bed delta area, on the other hand, biface tools are extremely small and often extensively reworked, toolstone sources are local and limited in number (much like later Archaic and Fremont toolstone use in the region) (Schmitt and Madsen, 2005), and scrapers are relatively uncommon (cf. Arkush and Pitblado, 2000), suggesting a more restricted pattern of movement between sites. Much of this difference may be due to resource patch size. Elsewhere in the Great Basin, wetland ecosystem patches are small and resources were quickly depleted, necessitating frequent moves of relatively large distances between foraging patches (Madsen, 2002; Elston and Zeanah, 2002; Jones et al., 2003). The wetland ecosystem on the Old River Bed delta was enormous relative to these other small Paleoarchaic wetland foraging localities, and, while movement within the wetland may have been almost as frequent, the distances involved were much shorter. As a result, movement outside the Old River Bed delta area to other foraging locations only occurred after extended periods of stay within the marsh. In turn, the ability to refurbish tool kits frequently at a variety of widely separated toolstone sources was limited and is reflected in the extensive reworking of tools and the few toolstone types found at Old River Bed delta sites.

STOP 2. DANGER CAVE

Danger Cave is located in the Silver Island Range on the edge of the Great Salt Lake Desert, just northeast of the town of Wendover, Utah, where I-80 crosses the Nevada-Utah line (Fig. 1). Now the centerpiece of a small State Park, it is accessible via dirt road from the Bonneville Speedway exit off I-80. Take Exit 4 northward past the truck stop, then turn left onto a westbound paved road and proceed 2.4 km to a dirt road angling northwest. Proceed on this road 1.3 km to a road heading southwest along flank of Silver Island Range. Head southwest along this dirt road 1.0 km (watch for gullies!) until

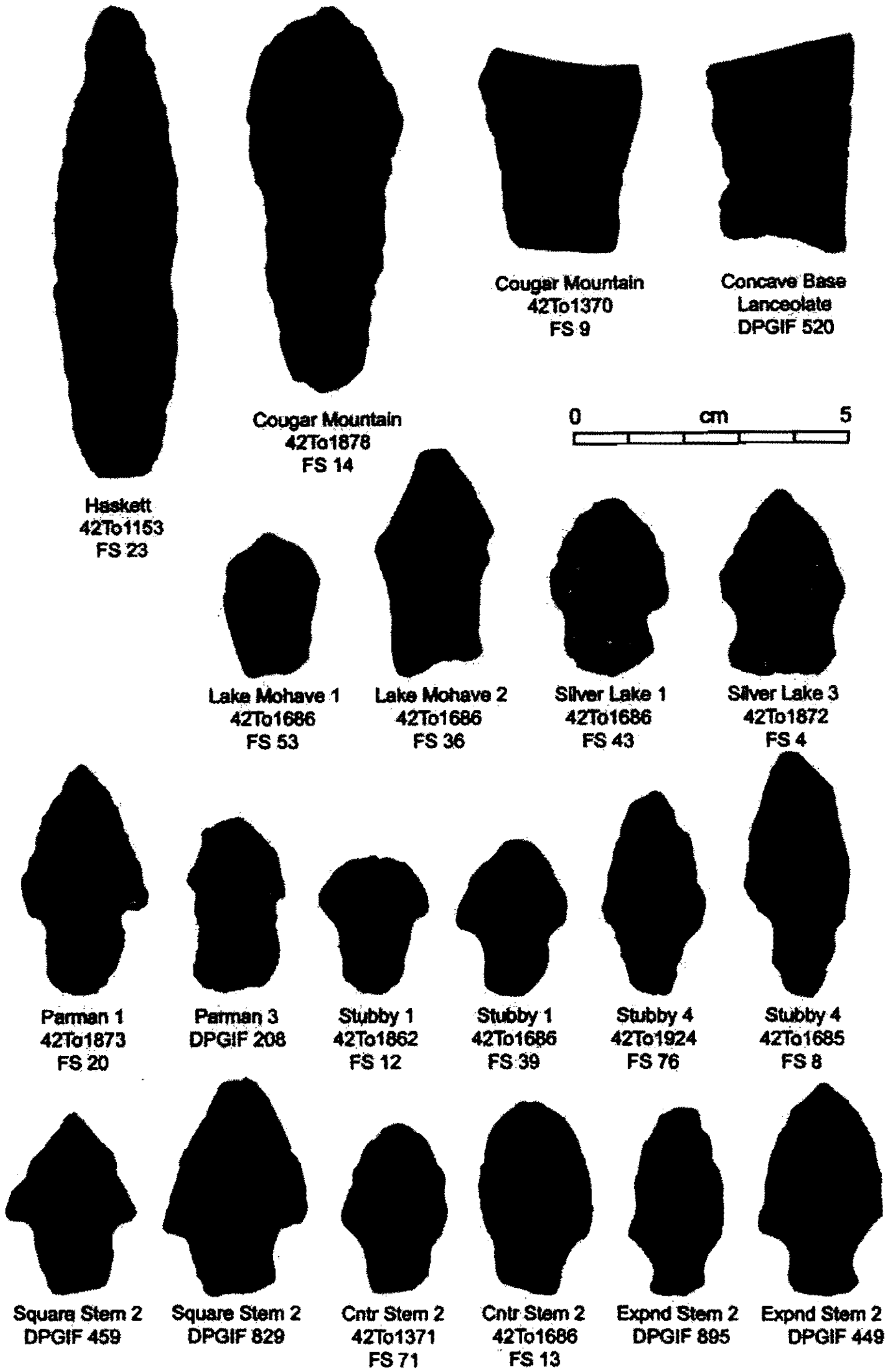

Figure 5. View of typical Great Basin Stemmed bifaces found on Old River Bed delta sites. Note the generally irregular forms, extensive reworking, and weathering on all these tool types.

you reach a widened parking area, with the fenced-in cave ~50 m away to the west. The cave entrance is fenced to prevent unauthorized visits. To obtain entry into the cave, contact Utah State Parks or the state archaeologist, Antiquities Section, Utah Division of State History.

Danger Cave is justly regarded as one of the most important archaeological sites in the Great Basin. The cave attracted human habitation in an otherwise hostile environment throughout the Holocene. A small spring-fed wetland on the playa margin nearby provided water and wetland resources, and the cave itself gave ample shelter from summer heat and winter cold. Excavated by archaeologists several times since the 1940s, its deep multi-millennial stacks of well-preserved cultural strata are the fount of some of the most influential concepts in the human prehistory of western North America. Equally amazing, after all the digging by archaeologists (and generations of looters), Danger Cave still has much to offer Great Basin prehistory. We recently assayed its research potential as it relates to early Holocene occupation, and here we describe our results to date.

Danger Cave is a large oval chamber ~20 m wide by 40 m long (Fig. 8), formed in Paleozoic limestone by solution weathering in fractures and subsequently enlarged by spalling of the walls and possibly wave action by Lake Bonneville. Situated at an altitude of 1315 m, it is ~311 m below the Bonneville shoreline, 189 m below the Provo, 18 m above the Gilbert shoreline, and ~20 m above the current playa. A date of 13,250 ± 160 radiocarbon yr B.P. was obtained on outermost tufa within the cave, giving a minimum limiting age of its submergence beneath Lake Bonneville's waters. Lake Bonneville exited Danger Cave sometime prior to ~11,500 radiocarbon yr B.P., as indicated by dates on uncharred wood and sheep dung (Jennings, 1957).

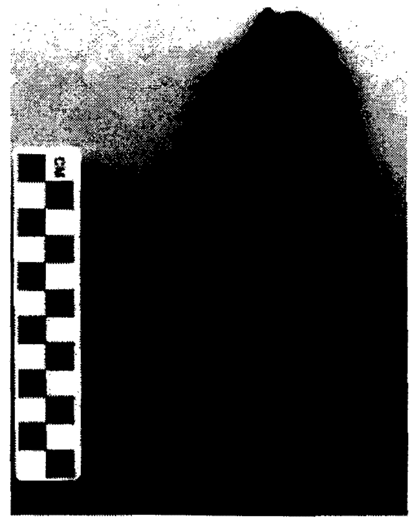

Figure 6. Large basalt bifaces from the Old River Bed delta. Thinning flakes from these large bifaces appear to have been a principal tool used by Paleoarchaic foragers in the delta. Overshot flakes similar to that seen on this surface are characteristic of Clovis biface forms (M. Collins, 2005, personal commun.).

History of Investigations

The site was first archaeologically sampled in the early 1940s by Elmer Smith, who limited his testing to the very front of the cave, beneath the drip line. Its real claim to fame, however, came with the excavation campaigns led by Jesse Jennings

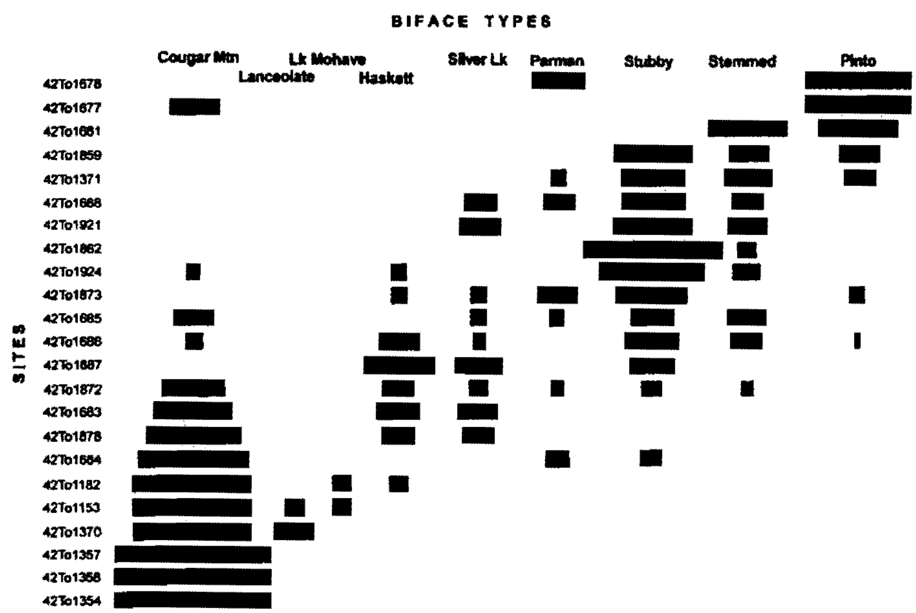

Figure 7. Seriation of Great Basin Stemmed bifaces from 23 Old River Bed delta sites. Biface types are arrayed left to right, sites are arrayed bottom (oldest) to top (youngest) according to the best fit of the "battleship curves" of the seriation. Width of the bars represents proportion of biface types at each site. Pinto points are generally thought to date after ~9000 radiocarbon yr B.P. The age of the other types is unknown, but the time span represented by this seriation is ~11,000–8800 radiocarbon yr B.P.

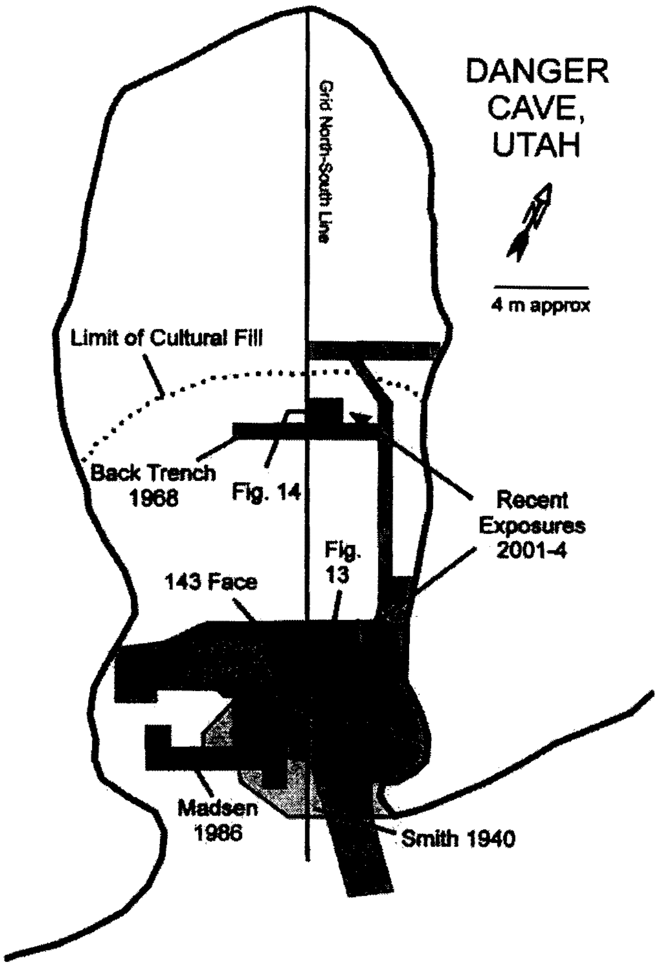

Figure 8. Plan map of Danger Cave, showing excavation areas of various investigators discussed in text. Note position of stratigraphic profiles depicted in other figures.

in 1949–1953. Jennings and his University of Utah field crews removed an impressive block in the front half of the cave, exposing an extraordinary stack of well-preserved primarily culturally-derived sediments (Fig. 9). Jennings used the then-new radiocarbon dating method to determine that these deposits span more than 10,000 yr (Jennings, 1957).

That experience led Jennings to devise his Desert Culture concept, which proposed that hunter-gatherer lifeways, similar to those of the historically known Shoshonean peoples (Steward, 1938), had stretched back essentially unchanged for over ten millennia. The Desert Culture concept influenced archaeological thought about hunter-gatherer adaptations continent-wide, and stimulated much regional research that refined and ultimately refuted some of its conclusions. Although the Great Basin archaeological record now demonstrates significant variability in foraging lifeways through time and across space, the concept still underlies much current regional thought, in the form of the "Desert Archaic" concept and derivatives such as "Paleoarchaic."

In 1968, a new generation of Jennings's students, including Gary Fry, David Madsen, and others, returned to Danger Cave to obtain sediments that might allow them to learn more about changing subsistence practices and paleoenvironmental change. They excavated a trench ~8 m farther back in the cave, beyond the back wall of Jennings's block excavation (Fig. 8), and collected samples of the strata and other materials including human paleofecal material (coprolites). Partial results of these investigations were later published by Harper and Alder (1972) and Fry (1976).

In 1986, a block of well-exposed intact deposits was excavated by David Madsen and associates to address new questions about the occupation history of the cave and use of key dietary plants (Madsen and Rhode, 1990; Rhode and Madsen, 1998). These excavations (Fig. 10) provided fine-grained detail about the occupational sequence not afforded by Jennings's broader treatment. However, the excavation was necessarily more restricted in spatial scope, and the block's location near the front of the cave (Fig. 8) limited preservation of vegetal remains and other perishable artifacts to the past 8000 yr. Preserved materials dating earlier than that were buried elsewhere in the cave, but these were not obtained in the 1986 excavation.

To find earlier well-preserved deposits in other parts of the cave, the Utah Division of State History and the Division of State Parks authorized a reconnaissance of areas previously excavated by Jennings and Fry, allowing the removal of backfill to assess the extent and research potential of remaining intact deposits. The re-exposure of intact deposits serves to enhance the educational value of the site as a historical component of the State Parks system. It is these efforts, conducted since 2001, that we now describe.

The 143 Face and Back Trench

Jennings and his students terminated their excavations in 1953 at what they called the 143 face; that is, an east-west side-wall running perpendicular to the 143-ft point on the main grid north-south line (Fig. 8). In our investigations, we were able to expose the original 143 face (at least, the lower third of it) and discovered intact deposits undisturbed by decades of looters. These deposits lay protected beneath large rocks and an impenetrable plate of calcium-cemented ash that had formed from water seepage and cementation. These lower strata contain a remarkably well-preserved set of cultural deposits dating from ca. 8000 to over 10,000 radiocarbon yr B.P. Figure 11 shows a profile drawing of the wall as it appears today, together with an inset of the original profile of the 143 face as depicted by Jennings (1957; Figure 54 therein).

The back trench, excavated in 1968, exposed layers of pure to nearly pure pickleweed chaff, the byproduct of processing pickleweed for its edible seeds, in a context that was thought to date to ca. 9000–10,000 radiocarbon yr B.P. (Harper and Alder, 1972). To verify the antiquity of pickleweed processing at Danger

Cave, we re-exposed this trench area, revealing a very well-stratified set of deposits (Fig. 12). The age of the lowest pickleweed processing layer, found at the base of Stratum 04-11 in Figure 12, is 8570 ± 40 radiocarbon yr B.P. (Beta-193123).

The two profiles (Figs. 11 and 12) show the lowermost of the main stratigraphic divisions given by Jennings in his original report (1957). Jennings divided the 10,000 yr occupation of Danger Cave into five levels, DI through DV, separated by layers of roof spall that implied long hiatuses of occupation. The upper three (DIII–DV) were composed of thick layers of well-preserved vegetal debris, dust, ash, and artifacts, dating from ca. 8000 radiocarbon yr B.P. to historic times. They are largely destroyed in the vicinity of the 143 face, but a remnant still exists at the top of the back trench. Of greatest significance here are the lowest two of Jennings's levels, which he called DI and DII.

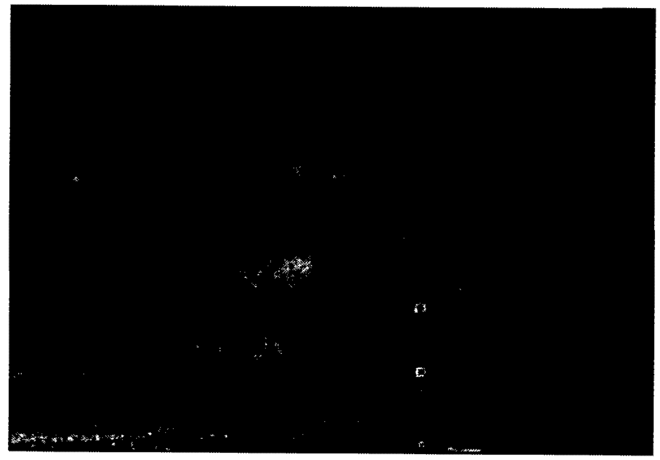

Figure 9. The back wall (143 face) of excavations in Danger Cave led by Jesse Jennings in 1949–1953. The deposits consist of extensive beds of vegetal material, mostly pickleweed processing residue, some of it burned, resulting in white ash beds. The area recently exposed is to the right of the photographer.

Figure 10. David Madsen (with shovel) and crew member exposing an intact block of sediments in 1986. Over 106 individual strata were mapped in this block (note tags in wall) and were carefully removed in 36 separate excavatable units for subsequent lab analysis.

The DI Occupation: 10,300 Radiocarbon yr B.P.

The DI level holds evidence of the earliest human occupation at the site (Fig. 11). Several small firehearths accompanied by a sparse scatter of artifacts and ecofacts lay on a bed of beach sand ("Sand 1"), capped by a variably thick layer of wind-deposited sand containing abundant artiodactyl pellets ("Sand 2"). Jennings's original radiocarbon dating together with recent radiocarbon dates we obtained from ash lenses exposed in the 143 face, confirm that this earliest occupation took place at 10,300 radiocarbon yr B.P. (Fig. 11). This occupation was likely coeval with the existence of a large shallow lake that covered the Great Salt Lake Desert at the level of the Gilbert Shoreline, just below the mouth of the cave.

A small but interesting collection of artifacts was obtained from the DI level. These include one lanceolate projectile point of the Agate Basin style, several unifacial scrapers, a few pieces of possible groundstone artifacts (including stones for grinding ochre), numerous chert and obsidian flakes, several knotted pieces of twine of unknown function, modified bone, and assorted fragments of "food bones," as Jennings called them. Six human coprolites had been found on this level (Fry, 1976), but they date to later times (Rhode et al., 2006). We took several small samples of sediments from the 143 face, and these contained an abundance of chipped stone waste flakes, though no tools, as well as knotted string fragments and small wood whittling curls. Given the small size of our samples, it is likely that the remaining DI occupation deposit still contains an abundance of artifacts.

The DII Occupations: 10,100–7500 Radiocarbon yr B.P.

The overlying DII level is a thick deposit of organic debris, cemented ash, rockspall, bat guano, and artifacts that combines three distinct stratigraphic layers (Figs. 11 and 12). The DII level was initially thought to date between ca. 10,000–9000 radiocarbon yr B.P. (Grayson, 1988, 1993; Jennings 1957, 1978), but our excavation and radiocarbon dating of the 143 face and back trench, together with a reanalysis of Jennings's original field notes and radiocarbon dates, now show that the three main layers of DII span a longer duration: an upper layer (called F30 in Jennings's field notes) dating 8200–7500 radiocarbon yr B.P.; a middle layer (F16) estimated to date ca. 8600–8400 radiocarbon yr B.P.; and a lower layer (F31) resting on DI sands dated ca. 10,100–9800 radiocarbon yr B.P.

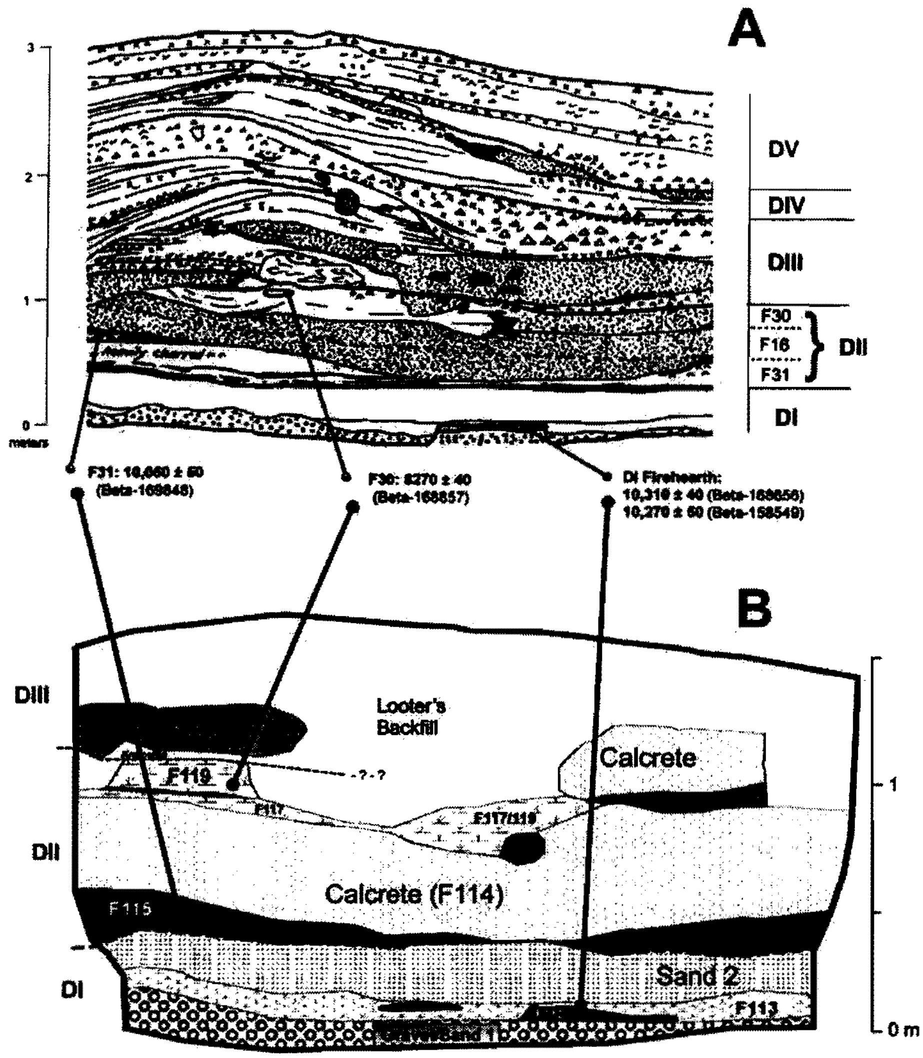

Figure 11. Danger Cave 143 face stratigraphic profile as mapped by Jennings in 1953 (A), and as it appears today (B). Radiocarbon dates were obtained from charcoal-ash stains (F111 and F112), charred vegetation from the lowest part of D2 (F115), and pickleweed chaff from the uppermost part of D2 (F119).

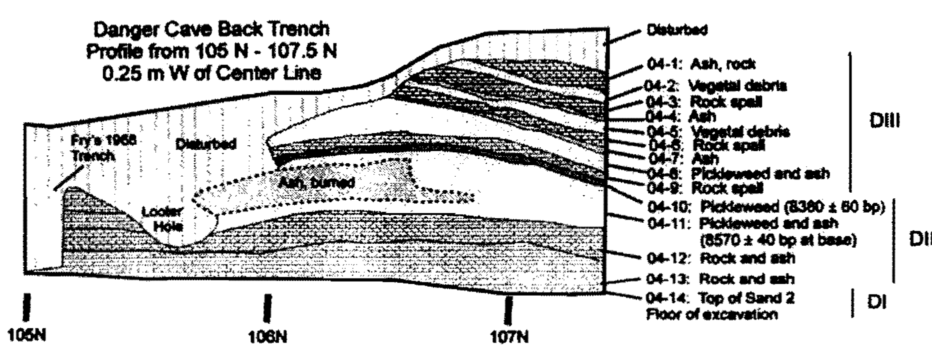

Figure 12. Stratigraphic profile of intact sediments exposed in the Back Trench area seen on field trip. Strata 04-1 through 04-9 correspond to Jennings's DIII cultural level, strata 04-10 through 04-13 correspond to the DII level, and stratum 04-14 (base of profile) is the DI level. Height of profile at 107.5 N is 115 cm. Radiocarbon dates were obtained from stratum 04-10 and stratum 04-11.

The DII layer contained a much richer and more abundant collection of artifacts than the DI occupation. Jennings (1957) reported the following artifact categories: projectile points, bifaces of various stages, end scrapers and flake scrapers, drills and gravers, choppers and scraper planes, shale knives, utilized flakes and blades, abundant millingstones, fragments of cordage, leather, and basketry, and pieces of ochre and mica. Direct evidence of diet included 11 paleofecal specimens (analyzed by Fry, 1976), numerous chewed-up tule wads ("quids"), and hundreds of "food bones."

Although it is difficult to reconstruct artifact counts from available notes, it is clear that most of the artifacts in the DII level came from the two upper layers (F16 and F30) and postdate 8600 radiocarbon yr B.P. Projectile point types commonly found in the DII level generally postdate 8500 radiocarbon yr B.P. (Aikens, 1970; Beck and Jones, 1997). The DII level contained over 160 millingstone and handstone artifacts, almost all coming from layers postdating 8500 radiocarbon yr B.P. (Rhode et al., 2006). Eleven paleofecal samples from DII all contained pickleweed seeds (Fry, 1976), while numerous thin layers of nearly pure pickleweed chaff in DII clearly demonstrate that pickleweed seed winnowing and processing took place in the cave during DII times. Dating of the coprolites and the earliest pickleweed processing layer from the Back Trench shows that pickleweed processing and consumption began ca. 8600 radiocarbon yr B.P. (Rhode et al., 2006). The artifact inventory and character of occupation pre-dating 8600 radiocarbon yr B.P., the lowermost part of DII, is unfortunately poorly known at present, and there may have been a substantial hiatus of occupation between ~10,000 and 8600 yr ago.

The advent of pickleweed processing occurred while extensive wetlands like those at the Old River Bed delta were drying up, as the Bonneville basin underwent a period of significant environmental change under increasing Holocene aridification (Madsen et al., 2001). The timing of small-seed use at Danger Cave suggests that people adopted small seeds in their diets in response to broad-scale aridification in the Bonneville basin. In this regard it is of interest to note that other cave sites in the Bonneville basin began to be occupied at about this time or somewhat later, including Hogup Cave (Aikens, 1970) and Camelsback Cave (Schmitt and Madsen, 2005), which provide evidence for a broad-scale adaptation to desert resources.

STOP 3. BONNEVILLE ESTATES ROCKSHELTER

This site is located ~30 km south of Wendover, off Hwy 93. To visit the site, obtain permission from the Elko Field Office, Bureau of Land Management, Elko, Nevada. To access the site, take Nevada State Highway 93 south from Wendover 17.7 mi to the gravel road to Blue Lake, then follow a dirt road from the Blue Lake road southward to the site.

Bonneville Estates Rockshelter is located in the Lead Mine Hills of the Goshute Mountains, Elko County, Nevada, ~30 km south of Danger Cave (Fig. 1). The rockshelter is situated along the high Bonneville shoreline complex of Pleistocene Lake Bonneville, at an elevation of ~1580 m. It is a large, "open-mouthed" rockshelter, ~25 m wide and 10 m high at its mouth and as much as 15 m deep, from front to back (Fig. 13). Within the confines of the rockshelter is more than 250 m^2 of excavatable surface area (Fig. 14).

Although only 30 km apart, the environmental settings of the Bonneville Estates Rockshelter and Danger Cave are significantly different. Given its position on the Lake Bonneville highstand shoreline, the Bonneville Estates Rockshelter would have become open and available for human occupation as much as 3000 yr earlier than Danger Cave. Bonneville Estates Rockshelter is situated 6 km from the nearest source of fresh water (Blue Lake), whereas Danger Cave is only a few hundred meters from a freshwater spring. Today, vegetation in the vicinity of Bonneville Estates Rockshelter is dominated by shadscale, rabbitbrush, and Indian ricegrass, whereas at Danger Cave vegetation is dominated by shadscale, greasewood, pickleweed, and saltbush (Madsen and Rhode, 1990). Vegetation communities at the two sites likely would have been different during the late Pleistocene and early Holocene as well, with limber pine and sagebrush communities persisting longer in the vicinity of the Bonneville Estates Rockshelter (Rhode, 2000a). As a result of these environmental differences, the two sites contain remains of significantly different human activities, and together they have the potential to provide a detailed portrayal of human adaptive change in the western Bonneville basin since initial colonization more than 10,000 radiocarbon yr B.P.

Background

The Bonneville Estates Rockshelter is one of 13 rockshelters and caves known to exist in the Permian-aged limestones and dolomites of the Lead Mine Hills. Nearly all of these are associated with prominent wave-cut features that correlate with Lake Bonneville's various shorelines. Bonneville Estates was

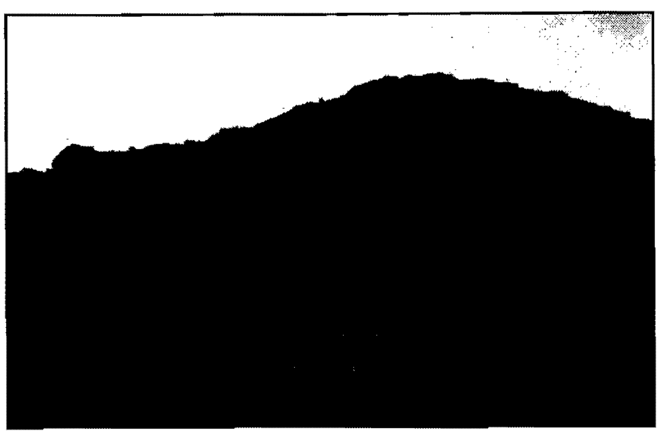

Figure 13. View of Bonneville Estates Rockshelter, 2004.

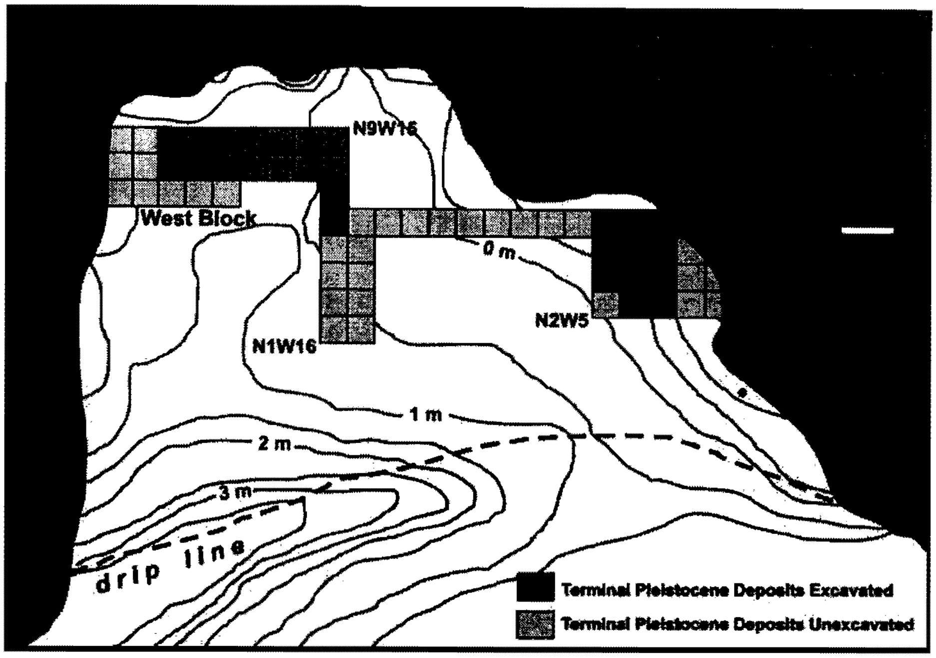

Figure 14. Map of Bonneville Estates Rockshelter, showing extent of excavations through 2004.

discovered in 1986 by T. Murphy and S. Dondero of the U.S. Department of the Interior Bureau of Land Management (BLM). At the time, the rockshelter was being actively looted. In 1988, P-III Associates, Inc., under the direction of A. Schroedl, conducted test excavations for the BLM in order to discern whether intact cultural deposits still existed in the rockshelter. They found a well-preserved sequence of cultural components that spanned the past 6000 yr of prehistory (Schroedl and Coulam, 1989). At the time, however, they were not able to penetrate deeper into the rockshelter's deposits due to budgetary constraints.

In 2000, our team resumed test excavations in the rockshelter, to learn whether pre-6000 radiocarbon yr B.P. deposits existed, and to determine the rockshelter's potential for investigating human paleoecology and adaptive change during the late Pleistocene and early Holocene. By the end of 2001, excavations had opened an area of 20 m^2, and in two deep tests we exposed cultural components dating to 10,100, 7400, and 7200 radiocarbon yr B.P. (Goebel et al., 2003). In 2003–2005, we further investigated these early components, and so far have opened an area of nearly 60 m^2, focusing on two areas referred to as the West and East blocks (Fig. 14). In the West Block, four components spanning from 10,800–9400 radiocarbon yr B.P. have been identified, and below them is even an older stratum with hearth-like features and lithic artifacts that may date to 12,300 radiocarbon yr B.P. In the East Block, two stratigraphically separate components with hearths have been recognized and ^{14}C dated to between 10,600 and 9400 radiocarbon yr B.P. Descriptions of the stratigraphy and cultural remains thus far recovered from the pre-9000 radiocarbon yr B.P. deposits in the two excavations are presented below, to augment our examinations of the exposures on the field trip.

West Block

In the western area of Bonneville Estates Rockshelter, we have identified 21 stratigraphic layers in a profile that reaches 280 cm in thickness and spans from ~15,500 radiocarbon yr B.P. to the present (Figs. 15 and 16). The lower 130 cm of this profile are so far culturally sterile. They consist of a thin band of pebble-sized gravels (at the base of the profile) thought to represent the 15,500 radiocarbon yr B.P. highstand beach of Lake Bonneville (stratum A21), and an overlying massive silt and rubble deposit (A20) thought to date to between 15,000 and 12,500 radiocarbon yr B.P. (Fig. 15). Among stratum A20 faunal specimens are the only remains of extinct fauna yet found in the rockshelter: a central phalanx of a medium-sized felid (either extinct North American cheetah or cougar) and a large canid patella possibly of dire wolf.

The upper 150 cm of the profile consists of a series of 19 discernible strata rich in perishable artifacts and ecofacts as well as hearths, pits, and other cultural features. The early part of this record, spanning from ca. 12,300 to 9400 radiocarbon yr B.P., can be provisionally grouped into three time-stratigraphic zones: (1) late Pleistocene (12,300 radiocarbon yr B.P.), (2) latest Pleistocene (10,800–10,400 and 10,000 radiocarbon yr B.P.), and (3) earliest Holocene (9440 radiocarbon yr B.P.).

Late Pleistocene

Possibly the oldest cultural remains thus far exposed in Bonneville Estates Rockshelter occur within stratum A19 (Fig. 16). In an area of ~4 m^2, we have unearthed an organic-rich layer of silt that contains unequivocal lithic artifacts (20 flakes),

Bonneville Estates Rockshelter
N7, W16-18 South Wall Profile

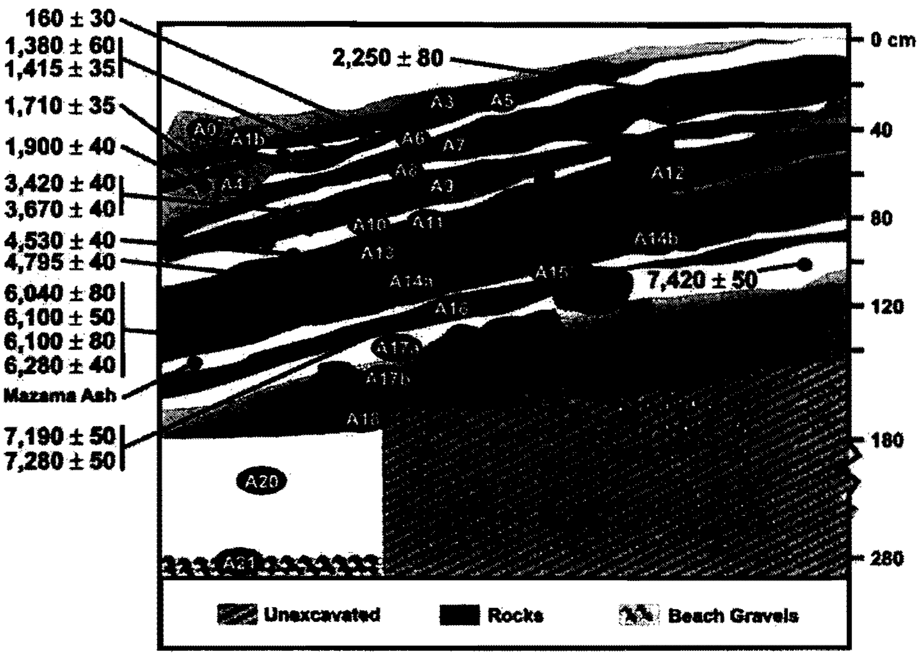

Figure 15. Stratigraphic profile of the West Block excavation of Bonneville Estates Rockshelter, exposed in 2000–2003.

Bonneville Estates Rockshelter
Late Pleistocene-Early Holocene Profile

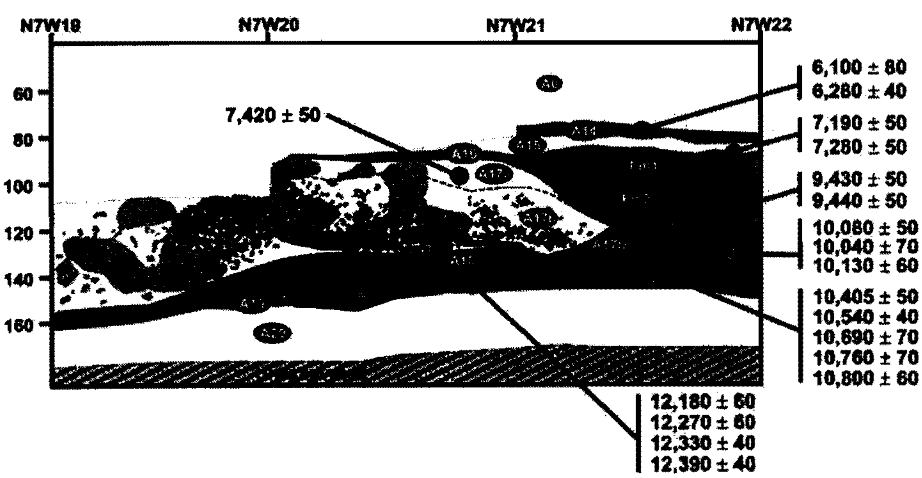

Figure 16. Stratigraphic profile of the lower strata preserved in the West Block of Bonneville Estates Rockshelter, exposed in 2004. The left side of the profile shown here lies 1 m west of the profile shown in Figure 15.

floral and faunal remains (including cottontail rabbit, pygmy rabbit, hare, woodrat, pocket gopher, and marmot), and two hearth-like features have been unearthed. One of these (Feature 03.17) has two associated ages of 12,180 ± 60 and 10,640 ± 60 ^{14}C yr B.P., while the other (Feature 04.13b) has four associated ages of 12,270 ± 60, 12,330 ± 40, 12,390 ± 40, and 10,970 ± 60 radiocarbon yr B.P. The 12,400–12,200 ^{14}C assays (Fig. 16) were obtained from charred samples having a resinous and mostly non-woody structure, unidentified at the time but now identified as conifer, possibly limber pine. After receiving the four early ages, we dated a sample of unequivocal sagebrush charcoal from each feature; these have yielded the ^{14}C ages of 10,640 and 10,970 radiocarbon yr B.P. The discrepancy between these two sets of ages for stratum A19 is a problem that will be solved with more excavation, detailed macrobotanical analysis, and ^{14}C dating of multiple materials recovered from the features.

Latest Pleistocene

Two stratigraphically separate cultural components, strata A18b and A18a, have been delineated that date to the very end of the Pleistocene. The lower of the two (A18b) is a 3- to 5-cm-thick organic-rich, ashy stratum. Five hearth features have been excavated from stratum 18b; four of these have produced ages (on charcoal) of 10,405 ± 50, 10,760 ± 70, 10,800 ± 60, 10,690 ± 70, and 10,540 ± 40 radiocarbon yr B.P. (Fig. 16). Faunal remains identified include not only the same leporids and rodents identified in stratum A19, but also numerous specimens of sage grouse, several medium-sized ungulate (including pronghorn) long bone fragments (some with cut marks and others that are burned), and one charred central phalanx of a black bear. Lithic artifacts include 172 flakes and four tools (a finished but unhafted biface [Fig. 17A], two biface fragments, and a retouched flake).

Stratum A18a, which lies immediately above A18b, occurs across nearly the entire West Block (Figs. 15 and 16). It is a 5- to 10-cm-thick band of silt with minimal organics that grades from east to west into a richly preserved stratum of organics. Wood charcoal from the single hearth so far excavated in this component yielded three ^{14}C ages averaging 10,090 ± 30 radiocarbon yr B.P. (Goebel et al., 2003). Among faunal remains, sage grouse bones continue to be rather abundant, as are cut and burned ungulate shaft fragments. Additional species include a shaft fragment of pronghorn, an ungulate shaft fragment that is either deer or mountain sheep, and a complete mandible of an ermine, as well as remains of short-eared owl, screech owl, and pintail. Lithic artifacts include 157 flakes and seven tools (three stemmed-point fragments, two side scrapers [Fig. 17E and 17H], one retouched flake, and one possible hammerstone). Perishable materials include six cordage pieces, one small textile fragment, a worked piece of wood, and several knotted feather quills.

Earliest Holocene

An early Holocene cultural component occurs in Stratum A17b′, a 5–10-cm thick band of organics that is sealed by a massive rock-fall feature (stratum A17b) and a 30-cm thick set of woodrat midden deposits (PM1 and PM2) (Figs. 15 and 16). So far, we have excavated an area of <6 m^2 of this component, exposing one unlined hearth feature, charcoal from which has yielded ^{14}C ages of 9440 ± 50 and 9430 ± 50 radiocarbon yr B.P. (Fig. 16). Associated faunal remains continue to include leporids, rodents, sage grouse, short-eared owl, pronghorn, and cut and burned ungulate long bone fragments. In particular, one complete sage grouse humerus displays numerous stone tool cut marks near its proximal end. Other species identified include bat, horned lizard, and screech owl. Recovered artifacts include a Haskett stemmed-point midsection fragment (Fig. 17G), a Windust stemmed-point basal fragment (Fig. 17C), a retouched flake, 93 waste flakes, and three pieces of cordage.

East Block

Our study of the eastern area of Bonneville Estates Rockshelter began with the cleaning of a large looters' pit against the back wall of the rockshelter, and continued with excavation of a 10-m^2 area adjacent to this pit in order to expose fresh stratigraphic profiles and to investigate early deposits stratigraphically beneath the looters' fill (Fig. 15). This excavation is still in progress; however, since 2002 we have unearthed two stratigraphically distinct cultural components spanning from the latest Pleistocene through the earliest Holocene (10,500–9400 radiocarbon yr B.P.), as well as nine middle and late Holocene cultural components spanning from 7250 to 80 radiocarbon yr B.P. (Fig. 18). The upper deposits postdating 7250 radiocarbon yr B.P. consist of rich organics and well-preserved features, but the lower deposits are less well-preserved and occur in loose silt and rubble with little internal structure. In one 1-m^2 test pit, we have further excavated to the base of the rockshelter's Quaternary-aged deposits, unearthing beach gravels lying unconformably upon bedrock at a depth of ~300 cm below the modern surface. Each of the three early cultural components is described briefly below.

Latest Pleistocene

The basal cultural component in the east block is stratum 11/12, a deposit of loose and massive silt and rubble (Fig. 18). In an area of ~4 m^2, we have unearthed five oval-shaped stains of charcoal and ash that range from 1 to 5 cm in thickness and are underlain by fire-reddened silt. Each of these hearth features has been ^{14}C dated: the first to 10,380 ± 40 radiocarbon yr B.P., the second to 10,030 ± 50 radiocarbon yr B.P., the third to 10,380 ± 55 radiocarbon yr B.P., the fourth to 10,560 ± 50 and 10,050 ± 50 radiocarbon yr B.P., and the fifth to 9990 ± 50 radiocarbon yr B.P. Associated faunal remains include sage grouse and a variety of leporids, as well as one specimen of deer and numerous ungulate long-bone fragments. Lithic artifacts include one midsection fragment of a stemmed point (Fig. 17B) and seven flakes.

Earliest Holocene

Near the top of stratum 10, ~10–15 cm above the latest Pleistocene component described above, we have exposed two hearth features (Fig. 18). One hearth yielded ^{14}C ages of 9520 ± 60 and 9440 ± 75 radiocarbon yr B.P., and the other hearth yielded ^{14}C ages of 9580 ± 40 and 9570 ± 40 radiocarbon yr B.P. Associated faunal remains include sage grouse, deer, at least one cut ungulate long bone fragment, leporids, rodents, and bats. Lithic artifacts include a finished but unhafted stemmed point, an end scraper on a blade (Fig. 17F), and nine flakes.

Stratigraphic Trench—First Clovis Find at Bonneville Estates Rockshelter

In 2003 we began excavating an 8-m-long stratigraphic trench connecting the two block excavations. Through 2004, excavation of the trench penetrated to the top of the early-middle Holocene components discussed above. Besides well-preserved Fremont- and Elko-aged cultural remains, our excavation of the trench has also yielded the first Clovis-aged artifact in the rockshelter. This is a Clovis fluted point base (38 mm wide and edge-ground) manufactured on green chert (Fig. 17D). It was found in the historic sheep dung deposit at the very top of the stratigraphic profile. Although undoubtedly redeposited, the primary context of the point may have been the rockshelter's deeper sediments. Perhaps late prehistoric or even historic digging in Bonneville Estates Rockshelter led to its removal from that original place of deposition.

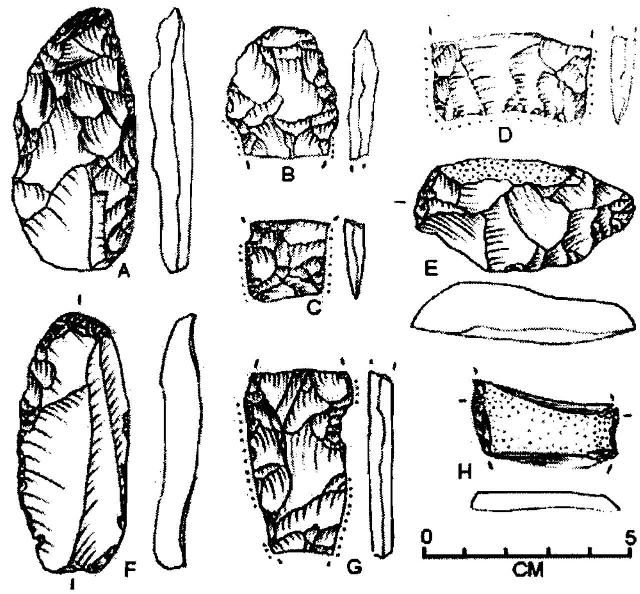

Figure 17. Lithic artifacts from Bonneville Estates Rockshelter. (A) Unhafted bifaces. (B–C and G) Stemmed point fragments. (D) Clovis fluted point fragment. (E–F and H) Unifacial scrapers.

Discussion

Our excavations at Bonneville Estates Rockshelter will continue for several more years, and analyses of materials recovered from the excavations are in progress. Nonetheless, several preliminary conclusions can be made concerning early human activities in the rockshelter, based on initial observations of data recovered through 2004.

Chronology

The earliest unequivocal evidence for humans in Bonneville Estates Rockshelter is found in stratum 18b, dating to between 10,800 and 10,400 radiocarbon yr B.P. (Fig. 16). Possibly an earlier occupation is represented by stratum A19; however, additional excavations are needed to better define the age of this stratum as well as to unequivocally demonstrate whether lithic artifacts are primarily associated with faunal remains and features. Strata A18a and A17b in the West Block (Figs. 15 and 16) and strata 11/12 and 10 in the East Block (Fig. 18) are clearly related to the Great Basin's stemmed point complex, but no diagnostic bifacial points have been encountered in stratum A18b. Nonetheless, the numerous hearths (n = 14) so far encountered in these strata indicate that Paleoindians frequently visited Bonneville Estates Rockshelter between ~10,800 and 9400 radiocarbon yr B.P. Shortly after 9400 radiocarbon yr B.P., however, these visits appear to have ceased, and Bonneville Estates Rockshelter was not occupied again until after 7500 radiocarbon yr B.P. The Danger Cave record has a similar hiatus in its ^{14}C chronology (9800–8700 radiocarbon yr B.P.; see above), and along the Old River Bed, water appears to have ceased flowing by 8500 radiocarbon yr B.P. These data suggest that human population densities declined dramatically in the western Bonneville basin during the increasingly arid early Holocene. When humans returned to Bonneville Estates Rockshelter after 8000 radiocarbon yr B.P., they had adopted seeds into their diets, as shown by the presence of groundstone artifacts as well as pine-nut hulls and ricegrass seeds in the rockshelter's early Archaic components.

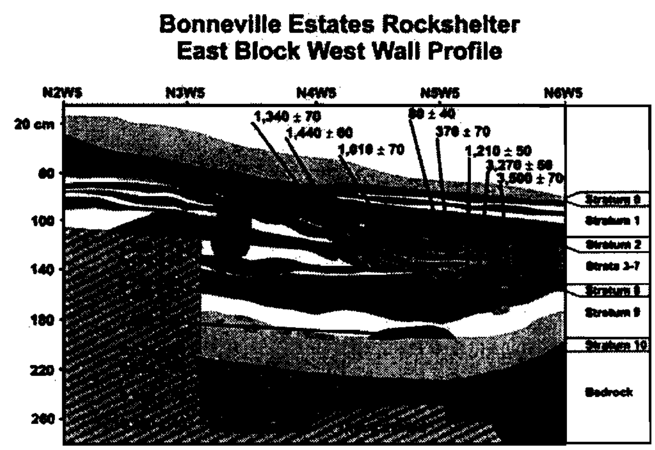

Figure 18. Stratigraphic profile of the East Block excavation of Bonneville Estates Rockshelter, exposed in 2001–2004.

Technological Activities

All of the pre-9400 radiocarbon yr B.P. debitage assemblages from Bonneville Estates Rockshelter are dominated by biface thinning flakes and retouch chips as well as complex platforms, indicating that the chief technological activities carried out in the rockshelter related to reduction and rejuvenation of tools, primarily bifaces. Nearly all debitage pieces are either tiny (<1 cm^2) or small (1–3 cm^2), further indicating that the bifaces being worked were far along in their reduction streams. Virtually none of the debitage pieces appear to relate to primary reduction activities, indicating that Bonneville Estates Rockshelter's early inhabitants typically transported complete or nearly complete bifaces and unifaces to the rockshelter. In terms of lithic raw materials, Bonneville Estates Rockshelter's early assemblages have about equal amounts of chert (41.7%) and fine-grained volcanics (e.g., basalt) (38.3%), while obsidian is less common (19.8%). Among 29 obsidian artifacts thus far subjected to X-ray fluorescence analysis, the majority originated from the Browns Bench (69.0%) and Malad (10.3%) sources, located 180 km north-northwest and 240 km northeast of Bonneville Estates Rockshelter, respectively. Other obsidians include Topaz Mountain, Utah, 105 km southeast (6.9%), Ferguson Wash, 6 km southeast (3.4%), and an unknown source (10.3%). These data indicate that the early inhabitants of Bonneville Estates Rockshelter were highly mobile, far-ranging foragers who made short but frequent stops at the rockshelter.

Taphonomy and Subsistence Activities

We have not recovered any remains of extinct fauna from the cultural components at Bonneville Estates Rockshelter. Nonetheless, faunal remains are abundant and well-preserved in Bonneville Estates Rockshelter's lower cultural components. Taphonomic and zooarchaeological analyses of these materials are still incomplete, but some of the remains are clearly the product of human activity (e.g., sage grouse, artiodactyls, hare, bear), while others are more likely the product of nonhuman agents (e.g., cottontail, pygmy rabbit, rodent, waterfowl). The sage grouse remains are especially interesting. More than 250 grouse bones have been recovered that represent at least 20 sage grouse individuals. Four percent of the bones are charred and 12% display stone tool cut marks, leaving no doubt that the carcasses were systematically butchered and then discarded directly around the hearths of the early components. The artiodactyl bones identified belong primarily to pronghorn, but also include mountain sheep and deer. These bones were extensively broken and appear to be the result of marrow extraction. About one-third of these artiodactyl fragments were burned, and one displays stone tool cut marks. Regarding the hares, 24 tibiae, femora, and humeri cylinders have been identified, and 33% of these display stone tool cut marks. The faunal assemblages from Bonneville Estates Rockshelter are especially significant, in that they represent one of the first clear cases of butchered animal remains in association with archaeological artifacts pre-dating 10,000 radiocarbon yr B.P. in the Great Basin.

Paleobotanical analyses of hearth contents and other uncharred vegetal remains recovered from the early deposits of Bonneville Estates Rockshelter are still under way. However, preliminary results suggest that the rockshelter's early human inhabitants did not regularly include seeds in their diets. Instead, virtually all of the plant macrofossils thus far identified in the pre-9000 radiocarbon yr B.P. components appear to have been the result of either humans collecting materials to burn in their fires, or nonhuman agents like woodrats. Plants do not appear to have become an important component of human diets at Bonneville Estates Rockshelter until the early Archaic, after 8000 radiocarbon yr B.P.

SUMMARY

The research discussed here, all conducted within the past five years, affords considerable new information about the nature and timing of earliest human occupation in the Bonneville basin, during an interval of substantial environmental change from the latest Pleistocene to the Holocene. In particular, this research demonstrates human occupation of the basin by at least 11,000 radiocarbon yr B.P., and perhaps by 12,300 radiocarbon yr B.P. The hundreds of occupation sites in the Old River Bed delta attest to an important subsistence focus in the basin's wetland ecosystems, while faunal evidence from Bonneville Estates Rockshelter indicates a fairly broad array of prey species including large ungulates, hares, and sage grouse. Importantly, significant evidence for consumption of plant foods in these earliest occupation sites is presently lacking. The use of grinding stone technology for processing small seeds (a hallmark of the so-called Desert Archaic; Jennings, 1957) does not appear to have begun until after 8600 radiocarbon yr B.P., when the Old River Bed wetlands had dried up and the basin's environment reached its modern desert character. Research planned for the next few years in the region will clarify the pattern of environmental change during the crucial latest Pleistocene-Holocene transition, confirm the dating of key occupations at Bonneville Estates Rockshelter and Old River Bed, and extend our analyses of the archaeological assemblages obtained from all of these sites.

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