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Archeological Investigations at Three Prehistoric Lithic Sites along U.S. 380 and Chupadera Arroyo, Socorro County, New Mexico

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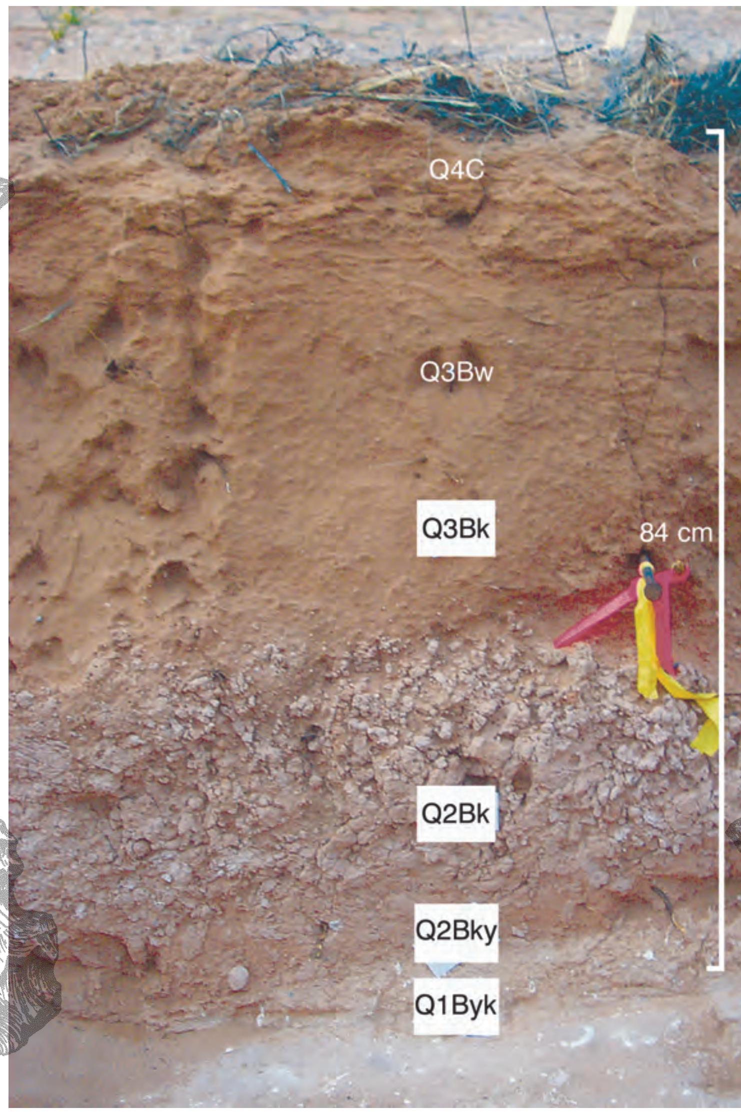

New Mexico State Highway and Transportation Department

Archeological Investigations at Three Prehistoric Lithic Sites Along US 380 and Chupadera Arroyo, Socorro County, New Mexico

by

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ABSTRACT

Between 6 March and 12 May 2000, the Office of Contract Archeology, University of New Mexico completed data recovery excavations and geomorphological at three sites within the proposed construction zone along highway US 380, east of San Antonio, Socorro County, New Mexico (UNM Proposal No. 185-655D, Contract No. CO3859, Project No. TPM-380-1(23)12, Control No. CN1665). LA 67451, LA 126619, and LA 126620 consist of multiple component lithic scatters with suspected Archaic affiliations and possible Paleoindian components. Janette Elyea was the project director, John Mark Sheppard was crew chief, and Byrd Bargman, Tod Dikeman, Stephen Pezetti, Stanley Brown, and Tim McEnany were crew members. William Doleman, with assistance from Scott Worman, directed the geomorphological studies and Richard Chapman was the principal investigator.

The New Mexico State Highway and Transportation Department (NMSHTD) is engaging in a project to widen and improve highway US 380 within Socorro County, New Mexico. This project began at mile mark 12.1 (about 20 km east of San Antonio, New Mexico) and ends at mile mark 24.1. This multiphase project was surveyed for archeological remains in March 1999 by Ecosystem Management, Inc. (Wells and Kramer 1999). Between 12 October and 3 November 1999, the University of New Mexico Office of Contract Archeology (OCA) tested eight sites for evidence of subsurface cultural deposits. Three of the tested sites contained intact cultural materials within the proposed construction zone and further work was recommended. The three sites are on New Mexico State Trust lands and work was conducted under New Mexico State Land Office Archaeological Excavation Permit No. 87.

The excavations recovered artifact assemblages with distinctive projectile point forms ranging from the early through late Archaic Period (5500 BC–AD 400). Sparse materials from the Paleoindian period (12,000 BP to 7000 BP) were also recovered at one of the sites (LA 126619). Early Archaic Jay phase materials were located at LA 67451, and materials from unknown periods were recovered from LA 126620. Although the diagnostic lithic assemblages all appear to date to the Paleoindian and Archaic periods, nine radiocarbon assays from the two sites all date within the Formative period from AD 650 to AD 1660.

ACKNOWLEDGEMENTS

The successful completion of excavations on US 380 required the contributions and help of several individuals. First, we want to thank the field crew, Byrd Bargman, Stan Brown, Tod Dikeman, Tim McEnany, Steve Pezzetti, and John Mark Sheppard (crew chief), who always maintained a positive and cheerful attitude even through cold and hot winds, snow storms, dust storms, and searing heat. Second, many thanks to Dick Chapman, principal investigator, who also maintained a great supportive attitude. Scott Worman also assisted Bill Doleman with the geomorphology studies and his help and good cheer is greatly appreciated. Dr. Bruce Huckell, the University of New Mexico Anthropology Department, also visited the project and his imput on the geoarcheology studies was invaluable. Eligio Aragon did his usual excellent work, including the excavation of stratigraphic trenches and overburden stripping. His excellent skills with power equipment saved many back breaking hours of overburden removal.

Blake Roxlau of the New Mexico State Highway Transportation Department supported the research throughout the project and his efforts to facilitate the project are greatly appreciated.

The preliminary processing of the field samples was completed by Kathy Pierce. The analysis of macrobotanical materials was conducted by Lisa Huckell. Peter Eschman coordinated all computer work and designed the lithic input program. Ron Stauber produced all of the graphics, while Dave Kilby did the artifact illustrations.

We give a special thanks Dr. Robert Weber who visited often and shared valuable information about the geomorphology, lithic source areas, lithic reduction techniques, and general archeology of the area.

To all of these people we offer our thanks. Their interests and contributions greatly aided in the success of this project.

Janette M. Elyea

William H. Doleman

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1 INTRODUCTION

by Janette M. Elyea

Between 6 March and 12 May 2000, the Office of Contract Archeology, University of New Mexico completed data recovery excavations for the New Mexico State Highway and Transportation Department (NMSHTD) at three sites (Figure 1) within the proposed construction zone along US 380, east of San Antonio, Socorro County, New Mexico (UNM Proposal No. 185-655D, Contract No. CO3859, Project No. TPM-380-1(23)12, Control No. CN1665). LA 67451, LA 126619, and LA 126620 consist of multiple component lithic scatters with suspected Archaic affiliations and possible Paleoindian components. All these sites are located on New Mexico State Trust lands and were excavated under New Mexico State Land Office Archaeological Excavation Permit No. 87. Janette Elyea was the project director, John Mark Sheppard was crew chief, and Byrd Bargman, Tod Dikeman, Stephen Pezzetti, Stanley Brown, and Tim McEnany were crew members. William Doleman with assistance from Scott Worman directed the geomorphological studies and Richard Chapman was the principal investigator.

One primary objective of our data recovery plan was to recover materials that would allow chronological assessments of the occupations. Charcoal samples from hearth features, bulk soil samples, or charcoal flecks were the ideal samples that we hoped to recover. In the absence of charcoal, we planned to collect subsurface fire-cracked-rock for thermo-luminescence dating. Since charcoal was collected we did not collect fire-cracked rock. Finally, an assessment of the soil stratigraphic sequences would evaluate the relative age of the archeological deposits at the sites.

Several interrelated research domains served as guidelines for site specific data recovery plans. These include lithic technology and site activities, lithic raw material acquisition and regional mobility, and intrasite spatial patterning. In order to acquire data that would address these research domains, we placed an emphasis on contiguous excavation units. At the large site (LA 126619) several excavation areas (Study Units) were placed along the length of the proposed construction zone to increase the probability of encountering potentially differing occupational episodes.

Our data recovery plan also included a geoarcheological component. This study was to acquire data necessary to address intrasite variation in soil characteristics, intersite variation in soil characteristics, the relationship between soil units and archeological deposits, paleoenvironments, and evidence for bioturbation.

Previous Research

Ecosystem Management, Inc. conducted a cultural resources pedestrian survey along a 18.7 km (11.7 mi) stretch of US 380 from March 16 to March 24, 1999. During this survey, nine new archeological sites, three previously recorded archeological sites, and 30 isolated occurrences were documented.

Between 12 October and 3 November 1999, OCA tested eight of those sites (Elyea and Doleman 2000). The sites had been previously determined to be eligible for inclusion into the National Register of Historic Places and the testing was to determine the extent and integrity of the cultural deposits. The testing consisted of shovel test pits, 1 m by 1 m grid units, and mechanically excavated soil trenches.

Eight mechanically excavated stratigraphic trenches were placed at four of the sites (LA 126616, LA 126619, LA 126620, and LA 67451) during the course of this testing, and stratigraphic profiles and detailed soil descriptions were recorded (Doleman 2000).

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of confidential site location data.

Table 1. Legal Descriptions

Site	Section*	Description			Land Status
LA 67451	16	SE ¼ NE ¼ NW ¼			State
LA 126619	16	S ½ NW ¼ NW ¼			State
LA 126620	16	NW ¼ NE ¼			State

* Township 5S, Range 4E, UTM Zone 13, Cerro de la Campana SE, NM, 1982, 7.5' USGS Quadrangle

The testing determined that five sites (LA 126615, LA 126616, LA 126617, LA 126618, and LA 126622) did not have intact cultural materials within the proposed construction area.

LA 67451, LA 126619, and LA 126620 were determined to have intact cultural materials within the slope limits of the proposed construction (Table 1).

Other research adjacent to the project area includes excavations at the Mockingbird Gap site by Robert Weber. This extensive site area is about 800 m south of the project area. It contains extensive Paleoindian Clovis, Folsom, and Cody Complex remains; as well as evidence of Archaic occupations and Formative Period features (Weber 1997, Weber and Agogino 1997).

2 RESEARCH DESIGN AND IMPLEMENTATION

by Janette M. Elyea and William H. Doleman

As reported in test excavation results, LA 67451 and LA 126619, and LA 126620 were suspected to possibly contain both Paleoindian and Archaic materials. The Paleoindian affiliation at LA 126620 was based on the presence of a possible Paleoindian projectile point located during the survey. At LA 126619 a projectile point fragment, parallel flakes, and a Chuska chert sharpening flake suggested multiple Paleoindian occupations at this large site. The postulation of Paleoindian materials at LA 67451 was based primarily on the stratigraphic context of the recovered artifacts. Evidence for Archaic occupations at LA 126619 consisted of bifacial reduction debris, fire-cracked rock, one-hand manos and slab metates. Evidence for an Archaic occupation at LA 126620 consisted of a San Rafael style projectile point located during the survey and evidence at LA 67451 was based on stratigraphic context.

Four general interrelated research domains served as the fundamental guidelines for site-specific data recovery and analysis methods. They are lithic technology and site activities, lithic raw material acquisition and regional mobility, spatial patterning, and geoarcheological research issues and relative chronology.

Lithic Technology and Site Activities

An extensive relationship exists between lithic technology and other major components of hunter-gatherer adaptations, which focuses upon the mobility and the organization of resource procurement activities. The study of lithic assemblages is usually divided into three closely related areas of investigation: *raw material selection*, *tool manufacture*, and *tool use*. These aspects of prehistoric lithic technology reflect organizational aspects of mobility and subsistence because the tool-using subsystem is necessarily integrated with other economic subsystems as well as the distribution of lithic resources themselves. The kinds of tools used reflect not only the kinds of subsistence activities pursued, but the kinds of tool kits which their users deemed suitable to those activities, given the constraints imposed by mobility patterns. The mobility patterns constraining tool manufacture and use are in turn conditioned by overall territory size and resource structure.

Paleoindian tool kits are generally highly curated, resource-specific, and owing to the short time frames of usage, must be extremely reliable. Consequently, these tools are often more complex, and less flexible (for use at other tasks than those for which they are designed). In contrast, Archaic foragers move to, and acquire resources on a seasonal and opportunistic basis. They require tool kits that are not resource-specific, and the tools are thus generally simple, and more flexible in their usage for a variety of tasks. Analysis of the lithic assemblages recovered from the three U.S. 380 sites attempted to identify tool kits from their manufacturing, refurbishing, and discard byproducts.

An important component of this analysis was the identification of the kinds of tool manufacture and maintenance that took place at the sites. In conjunction evidence for tool use, including wear pattern analysis, data on tool manufacture and rejuvenation shed some light on site-specific tool-use, and in turn on the sites' functions and roles within the overall settlement and subsistence system.

Lithic Raw Material Acquisition and Regional Mobility

The presence of non-local raw materials in hunter-gatherer lithic assemblages has been interpreted as evidence for the overall scale of

mobility engaged in by site occupants. In keeping with this model, the presence of Chuska chert, and possibly other non-local raw materials at the sites, is taken as evidence that the sites have one or more early components.

The Paleoindian settlement pattern dictates the need for a highly portable tool kit. The settlement pattern suggested by Kelly and Todd (1988) indicates that the Paleoindian hunters may not know where their next move will take them. Furthermore, they may be moving into unfamiliar areas and they may not know the availability or quality of local tool stone sources. Consequently, high quality local resources will be exploited so that the cores, tools and tool blanks carried into to new regions will consist of high quality materials.

Amick's (1994) study of Folsom assemblages from New Mexico emphasized analysis of material sources, and manufacturing treatment of those materials from the perspective of territorial ranges and site specific use of the materials *vis-a-vis* the source locations of those materials. His study has postulated different regional patterns of territorial size and transhumance between the Southern Plains, Tularosa Basin, Rio Grande Basin, and San Augustine Plains/North Plains/San Juan Basin Folsom adaptations. The present study has built upon Amick's model, which suggests that the intermontane southwestern PaleoIndian populations were engaged in relatively restricted territorial ranges. Given the importance of lithic artifact source materials in this analysis, attempts have been made to identify the raw materials present at the US 380 sites as accurately as possible.

Spatial Patterning

Given the areal extent at LA 126619, it is likely that the site was used for different purposes over a long time span. The presence of ground stone in the later Archaic occupations indicates that seed resources may have been the impetus for occupation at that time. In contrast, we suspect that any Paleoindian occupations were related to hunting. Since we suspect that numerous occupations occurred during both the Paleoindian and Archaic times, there may be overlapping occupations.

The functional analysis of artifacts has provided some of the information needed to assess the range of activities conducted at the three US 380 sites. Other information needed to operationally define site types, including the duration of the occupation and the possible size and composition of the residential group, has been examined through an analysis of the spatial distribution of artifacts and features.

We approached site structure analysis as a fairly straight forward process. Initially, the distribution of artifacts and facilities were displayed graphically in a series of plots, and mathematically through tables showing the number and classes of artifacts from each excavation unit. Patterning observed in these data was then evaluated using various statistical measures, such as nearest neighbor analysis.

Traditionally, archeologists have interpreted intrasite patterning in terms of activity areas and tool kits, the underlying assumption being that artifacts in close proximity were associated with a particular task. Although this is often true, a number of natural and cultural factors have tended to obscure such clear-cut relationships. The natural factors include a number of post depositional processes, while the cultural factors include refuse disposal, clean-up, curation, scavenging, and recycling. Our field observations noted extensive bioturbation, mainly from pocket gophers and ants that have had a major impact on artifact location. Obvious cultural factors affecting artifact distribution were the reuse and recycling of ground stone and fire-cracked rock.

Data Recovery Procedures

The data requirements of the research design dictate an extensive excavation strategy toward the discovery of additional archeological deposits including any extant features, dateable materials and archeobiological remains. This strategy is also consistent with the management objectives of the project —to recover relevant data from the sites and obtain clearance for construction in this segment of Highway US 380 right-of-way.

Topographic maps of the sites had been prepared during the 1999 testing program and all excavations were oriented along a datum system

established during the testing phase, which was oriented parallel to the road. Excavations proceeded in stratigraphic units and the matrix was screened in 1/8" hardware cloth. Artifacts and samples were collected and provenienced in units no coarser than 1 by 1 m squares and stratums were excavated in 10 cm units. Artifacts were collected by level and stratum and assigned field specimen numbers.

The upper Q4 stratum, which contains recently redeposited materials, was removed without screening for cultural materials and mechanical stripping was employed at a portion of LA 126619. Mechanically excavated stratigraphic trenches were placed at the three sites and the southern portion of the proposed construction zone at LA 126619 was mechanically stripped to look for additional features after our excavations were complete.

Our testing program indicated that the Q3 stratum contained the intact deposits that we were targeting during our excavations. Below this, is a Q2 and Q1 caliche-gypsum stratum. While the Q2 stratum is generally believed to predate human occupation, the Q1 stratum definitely predates human occupation in North America. All of our excavation units were excavated to either the Q2 or the Q1 stratum. In some cases, we excavated up to 20 cm into the Q2 stratum and we never recovered any materials from the stratum.

Forms used to document the excavations included a field specimen catalog, photo log, study unit log, feature log, study unit definition form, feature record, grid excavation record, and a stratigraphy form. Forms included comment fields for narrative description, in addition to standardized nominal and metric attribute recording. The field specimen catalog was computerized to facilitate linkage of the results of laboratory analyses to field provenience data.

Any encountered features were photographed, excavated, and resultant plans and profiles were drawn. All matrix from these small hearth features were collected and processed in the OCA lab with standard water-flotation. The heavy fraction of each sample was scanned to extract any remaining botanical, microfaunal, or microlithic materials.

Geoarcheological Studies

During the course of the US 380 testing project a geoarcheologist from the Office of Contract Archeology (William Doleman) visited all three archeological sites chosen for excavation: LA 126619, LA 67451, and LA 126620. The overall goals of the geoarcheological study were to better understand the depositional context of excavated cultural materials as well as to elucidate evidence for past environmental conditions. Excavation-related geoarcheological investigations were conducted at the sites in order to acquire data necessary to addressing several specific issues posed in the data recovery plan. These issues fall under five headings:

1. Intrasite variation in soil characteristics.
2. Intersite variation in soil characteristics.
3. Correlation with Mockingbird Gap stratigraphic sequence.
4. Relationship between archeological deposits and soil/stratigraphic units.
5. Evidence for project area paleo-environments.
6. Evidence for bioturbation of otherwise intact cultural deposits.

The geoarcheological component of the data recovery plan for the US 380 excavation project proposed a simple Quaternary stratigraphic sequence for the tested sites, based upon pedological characteristics of deposits documented in one or more small trenches excavated at each site. The testing study also noted significant differences in soil stratigraphy on the west and east sides of the arroyo, as well as apparent variations within some sites' deposits. Data acquired during the present study offer the potential for addressing all of these questions.

Methods

Soils/stratigraphic data and samples were collected from mechanically excavated trenches at the three sites as well as from a series of five mechanically excavated trenches along the margins and in the bottom of Chupadera Arroyo.

All trenches were oriented parallel to the highway right-of-way. Three contiguous trenches were excavated at LA 126619 along the south margin of the excavated area, totaling approximately 120 m in length. One 15-20 m trench each was also excavated at LA 67451 and LA 126620. These long trenches allowed assessment and reconciliation of the intra-site stratigraphic variations observed during the testing phase.

Mechanically excavated trenches in Chupadera Arroyo were also oriented parallel to the highway right-of-way. Two long trenches were mechanically excavated at the arroyo margins for the purposes of documenting the interface of basin-floor and arroyo deposits, while a series of three deep trenches was excavated into the arroyo floor to ascertain the nature and variation of alluvial arroyo deposits.

On-site trenches were studied until a soil stratigraphic model was developed, and then representative points were chosen for detailed profile descriptions. Model development was aided by consultation with the excavating archeologists, and excavated units. All detailed profiles were documented according to standard soil description techniques similar to those employed in the testing phase. All profiles were photographed, and samples of all identified soil stratigraphic units were taken for laboratory analysis. In addition, where relevant, other exposures were photographed and/or sampled.

Arroyo trenches were sufficiently deep (3–4 m), that one side of each was stepped back to facilitate inspection and photography without requiring direct entry into the trench. Detailed profile documentation was not conducted, but photographs and notes were taken for the purposes of identifying terrestrial and alluvial deposits and their relationships. More detailed recording of the arroyo profiles would require a trained sedimentologist and lies outside the scope of the present project. Sediment samples were taken from the arroyo profiles wherever they could be safely acquired.

Prior to profile documentation, two days were spent in reconnaissance of the project area landscape within an approximate 5 km radius. This activity included visiting various related landforms and documenting the relationship between landform and mapped soil units. As a result, a model of soil-landscape relationships is being developed that will help explain intersite variations in soil stratigraphic characteristics.

3 THE ENVIRONMENT

by Janette M. Elyea

This portion of US 380 is in the northern Jornada del Muerto Basin, which is within the Mexican Highland Section of the Basin and Range Province. Formed from uplifting mountain ranges these grabens have been filling since their formation in the late Pliocene-early Pleistocene. The northern Jornada del Muerto region is notable because it lies at an interface between several basins. The Albuquerque basin is to the west, the Estancia Basin is to the northeast, the San Agustin Basin is to the west, the Tularosa Basin is to the south-southeast, and the Southern Jornada del Muerto is to the south. Only a constriction in the width of the Rio Grande Valley distinguishes the northern Jornada del Muerto from the Rio Grande Valley.

Broad alluvial fan piedmonts, alluvial fans, and fan deltas with playa lake plains and dune fields, typical of internally drained basins, characterize the basin. Several small arroyos dissect the northern portion of the Jornada del Muerto and Chupadera Arroyo is the major north south drainage. It terminates into an ephemeral playa area 12.6 km (8 mi) south of the study area. Elevations within the study area average 1533 m (4980 ft) while Oscura Peak rises to 2633 m (8553 ft) 30 km (19 mi) to the southeast.

The region is within the semi-arid environment of the upper Sonoran life zone. Most of the rain, which averages 200 mm (8 inches), falls during July and August during the summer monsoon season. The average summer temperature is 101.3º and the average number of frost-free days is 170.

The study area is near the juncture of Chihuahua grassland and Plains grassland communities (Martin 1986). This area of the Chihuahua grassland is dominated by Black grama in conjunction with several species of dropseed and an occasional yucca. Sand sage is also common. The Plains grassland has sideoats grama as the dominant grass species with lesser amounts of dropseed, black grama, and galleta. Vegetation observed at the sites includes sand sage (*Artemesia filifolia*), four wing saltbush (*Atriplex canescens*), Mormon tea (*Ephedra torreyana)*, soapweed yucca (*Yucca glauca*), prickly pear (*Opuntia erinacia*), galleta (*Pleuraphis jamesii*), black grama (*Bouteloua eriopoda*), three awn (*Aristida*, sp.), and dropseed (*Sporobolus airoides*). This desert grassland currently supports native antelope (*Antilocapra americana*) and introduced oryx and domestic cattle. Both cottontail (*Sylvilagus audoboni*) and jackrabbits (*Lepus californicus*) were observed as well as numerous bird species.

PALEOENVIRONMENTAL CONDITIONS

The end of the late Wisconsin glacial period was marked by a succession of climatic and biotic changes that eventually transformed the full-glacial pine parklands into the modern Sonoran desert in New Mexico. Late Pleistocene and Holocene climatic reconstructions in the Southwest are based on geologic, palynologic, macrofloral, and faunal data from eastern Arizona, southern New Mexico, northern Mexico, and western Texas. Despite this large body of data, there is little agreement among researchers concerning the causes, timing, and scope of these changes. Furthermore, the timing and severity of changes seems to vary in different areas of the Southwest and southern High Plains. Nevertheless, three major climatic shifts and corresponding changes in the vegetation are apparent between onset of Holocene about 11,000 BP and the present.

During the Wisconsin glacial period, forest and woodland species grew as much as 1000 m lower than today, and conifer forests reached as far south as the Llano Estacado in Texas. As the glaciers retreated, a record of the successive vegetation changes was preserved in the pollen and macrofossils incorporated into ancient packrat middens. The bioclimatic chronology, formulated on the basis of these data (Van

Devender and Spaulding 1979; Van Devender et al. 1987), places the end of the late Wisconsin at about 11,000 BP, and divides the Holocene into three periods: early Holocene (11,000–8900 BP), middle Holocene (8900–4000 BP), and late Holocene (4000 BP to present).

Wendorf's (1961, 1975) paleoenvironmental reconstruction for the Llano Estacado is based mainly on pollen profiles and invertebrate fossils from Lubbock Lake, Texas and Blackwater Draw, New Mexico. His periods consist of moist subpluvials and alternating intervals of drying.

Late Wisconsin plant macrofossils from the Hueco Mountains of Texas and Sacramento Mountains of New Mexico indicate greater winter rainfall and cooler summer temperatures than today. Cooler summers and a shorter growing season are also suggested by the apparent zonation of piñon-juniper-oak forests and higher conifer forests in the Guadalupe Mountains of Texas and San Andreas Mountains of New Mexico. Van Devender maintains that this biotic record is indicative of an equable climate with mild winters and cool summers.

On the plains, Wendorf's Tahoka or Blackwater Subpluvial marks a period of greater effective moisture that lasts from about 12,000 to 11,000 BP. During this period, Wendorf believes that a combination of cooler temperature and higher precipitation created warm steppe conditions with mixed boreal woodland and grasslands.

The Early Holocene (11,000–8900 BP)

During the early Holocene, the packrat midden data suggest that winter precipitation remained higher than at present. In the Guadalupe Mountains, the rapid withdrawal of Colorado piñon to elevations at or above 2000 m elevations by 10,900 BP is also indicative of higher summer temperatures than prevailed during the late Wisconsin. By 10,600 BP, piñon disappeared entirely in the Hueco, Sacramento, and Guadalupe Mountains, leaving a transitional scrub oak-juniper woodland.

As defined here, the Early Holocene encompasses Wendorf's Scharbaurer Interval and Lubbock Subpluvial. The Scharbaurer Interval (11,000–10,500 BP) is marked by zones of low pine and rare spruce pollen in the Lubbock Lake and Blackwater Draw profiles, indicating increased aridity and dramatic changes in the vegetation. The boreal forests were replaced by much reduced juniper-dominated woodlands, prairies replaced the southern plains parklands, and the Llano Estacado became a grassland. Climatic conditions during this period appear to have been characterized by high summer and cooler winter temperatures than those of the preceding Tahoka Subpluvial, and by a winter-dominant precipitation pattern.

The succeeding Lubbock Subpluvial (10,500–9500 BP) is marked by a sharp increase in pine pollen and a lesser increase in spruce pollen in both the Black Water Draw and Lubbock Lake profiles. Wendorf (1975) interprets this evidence as indicating a probable reinvasion of boreal woodlands over much of the southern high plains. Diatoms from Blackwater Draw further suggest that this was a period of oscillating wet and drying episodes, and invertebrates from both localities indicate that summer temperatures remained at least 10^{o} F cooler than today.

In the Lower Pecos region of Texas, the pollen profile from Bonfire Shelter also shows a decrease in piñon pollen below the Midland/Folsom bone bed. This drop may reflect a partial loss of trees, suggesting a shift from a piñon woodland to a grass parkland with isolated stands of piñon prior to 10,000 BP. Between 10,000 and 7000 BP, pollen from Bonfire Shelter and the Devil's Mouth Site suggest that this parkland vegetation remained fairly stable (Bryant 1974).

Middle Holocene (8900–4000 BP)

On the basis of packrat midden data, Van Devender (1990) maintains that the winter-dominant rainfall regime of the early Holocene ended by about 9000 to 8000 BP, and that subsequent dramatic increases in summer temperatures produced maximum summer monsoonal rainfall during the middle Holocene. Under this climatic regime, he suspects that permanent lakes would have formed in most of the now-dry playas of New Mexico. Although

summer temperatures were high, the absence of subtropical desert-scrub species in the Hueco Mountain and Last Chance Canyon middens suggests frequent and severe winter freezes, conditions that would have favored the development of grassland over Chihuahuan desert scrub. Van Devender therefore believes that well-developed grasslands probably reached their maximum extent during the middle Holocene, extending from the Great Plains through the Trans-Pecos region and into Chihuahua, as well as across southern New Mexico and into Arizona.

The cool, moist Lubbock Subpluvial was followed by a period of increasing aridity, the Yellow House Interval, which lasted until about 8500 BP. During this interval, Wendorf contends that the pine woodlands disappeared from the Llano Estacado and were replaced by open grassland. He also feels that all but the largest playa lakes had dried up by the end of the interval. Moist conditions returned briefly during the subsequent Portales Subpluvial (8500–8000 BP), but the trend toward increasing dessication then resumes, possibly indicating the onset of a warm, dry Altithermal. Wendorf and Van Devender therefore seem in agreement concerning middle Holocene vegetation changes, but they differ in their interpretations of the climatic conditions that precipitated those changes.

This interval of high temperatures roughly corresponds to the Altithermal, which was defined by Antev's as a hot-dry period marked by extreme aridity. However, herptofauna and microfauna data from Howell's Ridge Cave in the Little Hatchet Mountains suggest that climatic conditions in southern New Mexico were warm and moist until about 4000 or 5000 years ago (Van Devender and Worthington 1974).

Late Holocene (4000 BP to Present)

By about 4000 BP, the modern climatic regime was established. Winter freezes diminished in frequency, and there was greater variability in the summer monsoonal rainfall and more frequent droughts. Creosote appear in packrat middens in the Hueco and Sacramento mountains between 3700 and 3300 BP, marking the establishment of northern Chihuahuan desert-scrub over extensive areas of New Mexico that had previously been desert grasslands (Van Devender 1990).

Implications for Late Paleoindian Settlement

From the paleoclimatic data summarized above, it is clear that environmental conditions in the Southwest between 10,500 and 8500 BP date range were much different from those prevailing at present. The winter-dominant precipitation pattern of the late Wisconsin persisted through the early Holocene, but there appears to have been a sharp increase in both average global and summer temperatures. Nevertheless, summer temperatures remained well below modern levels, and severe winter freezes were more common than at present. Under these climatic conditions, the boreal forests of the late Wisconsin were replaced by much reduced juniper-dominated woodlands, prairies replaced pine parklands on the southern plains, and the Llano Estacado became a grassland.

The earliest dates for the Plainview Complex fall within the Lubbock Subpluvial, which Wendorf characterizes as a period of oscillating wet and dry conditions. The subpluvial coincides with a slight decrease in average global temperatures on the P-V curve, which may have facilitiated the re-establishment of pine woodlands over much of the southern plains (Wendorf 1975). Although this vegetational change may have somewhat reduced the bison habitat, climatic conditions during the early Holocene generally appear favorable for the persistence of a high technology forager adaptation. The date range for the Plainview Complex also brackets the Yellowhouse Interval. Wendorf contends that this was a period of increasing aridity, during which pine woodlands disappeared from the Llano Estacado and most playa lakes dried up. If this interpretation is accepted, then Paleoindian groups in the Southwest may have found it increasingly difficult to maintain a focal hunting economy between 9500 and 8500 BP.

The succeeding Portales Subpluvial (8500–8000 BP) marked a brief return to cool, moist climatic conditions and, as Irwin-Williams and Haynes (1970) have suggested, it may have fostered the widespread expansion of late Paleoindian hunters represented by the Cody Complex.

After 8000 BP, Wendorf sees a return to the trend toward increasing aridity. Irwin-Williams (1979) speculates that this climatic change may have forced Paleoindian groups to withdraw from the Southwest and to concentrate in areas of the plains that could still support bison herds.

Van Devender, in contrast, believes that increasing summer temperatures between 9000–8000 BP produced maximum summer monsoonal rainfall during the middle Holocene. Under this summer-dominant rainfall pattern, Van Devender believes that there were permanent lakes in most of the now-dry playas in New Mexico, and that grasslands reached their maximum extent. He further maintains that these warm, moist conditions generally persisted in the Southwest until 5000–4000 BP.

If Van Devender is correct, then environmental conditions during the middle Holocene would seem optimal for buffalo, which makes it difficult to explain why the Paleoindian period ended at about 8000 BP. Population packing also seems an unlikely explanation, as early Archaic sites appear no more numerous than late Paleoindian sites. In considering alternative explanations, it should be noted that grass pollen cannot be identified below the family level, and that packrat middens are largely restricted to upland areas. Consequently, it is impossible to tell whether the middle Holocene grasslands on the southern plains were short-grass prairies, which could readily support large bison herds, or tall-grass prairies, which are less favored by large ungulate populations. It is also possible that Wendorf's paleoclimatic reconstruction accurately describes conditions on the southern plains, while Van Devender's reconstruction is primarily applicable to the basin and range areas of the Southwest.

4 CULTURE HISTORY OVERVIEW

by Janette M. Elyea

The northern portion of the Jornada del Muerto has a long, successive cultural history that begins with the earliest, widely accepted occupational period in North America–the Clovis Complex–and continues into modern times. During the modern era, the region hosted an event that would forever change the world, when the first atomic bomb was detonated on July 16, 1945 at the Trinity Site. Every cultural period between this early Paleoindian adaptation and modern times is represented in this area and these occupations vary from small campsites to large multi-roomed pueblos. The following cultural history overview is but a brief synopsis of these occupations with an emphasis on the Paleoindian and Archaic periods, which constitute the cultural occupations investigated along Highway US 380.

THE PALEOINDIAN PERIOD

Settlement and Subsistence

The Paleoindian period constitutes the earliest North American human adaptation. Spanning from about 12,000 to 8,000 BP, this adaptation is usually viewed as a "focal economy" dependent on big game hunting. The initial discoveries were associated with massive bone beds, and these large kill sites suggested to some that these hunters were responsible for the extinction of several large Pleistocene species (Martin 1967, 1973). In areas with poorer preservation, surface find studies also supported the interpretation that this early adaptation was based on a hunting economy. Dawson and Judge (1969) and Judge's (1973) studies in the Albuquerque area noted a correlation of sites with physiographic features that were important to hunting—notably high areas that could be used as game overlooks and sites adjacent to playas that presumably attracted game herds. Although lacking faunal materials, the sites were still interpreted as kill sites, campsites, butchery sites, overlooks, and retooling sites based on the presence, absence or proportion of certain tool types.

Irwin-Williams and Haynes (1970) assert that the Paleoindian economic structure or subsistence relied on a selective exploitation of a narrow spectrum of potential resources—particularly bison. Environmental changes required them to move or retreat from the plains and basin and range in order to maintain this specialized economy.

Researchers agree that plant and lesser game animals probably constituted a portion of the Paleoindian diet, but the magnitude of these resources in the Paleoindian diet and their influence on settlement patterns is greatly disputed. The most prevalent argument against a Paleoindian focal hunting economy is modern ethnographic data (Cordell 1979, Tainter and Gillio 1980). In his ethnographic studies, Lee (1968) found only 11 hunter-gatherer groups that exclusively depended on hunting and only two of these were outside the arctic. Binford (1980) found the degree of dependence on hunting inversely proportional to the length of the growing season and the only modern ethnographic groups subsisting primarily on hunting are in the arctic.

Judge (n.d.) agrees that the modern ethnographic data shows that hunting produces only a small proportion of the modern hunter gatherer diet, but he also states that the climatic regimes and biotic communities that were present during the early Holocene are not analogous to any modern occurrences. Kelly and Todd (1988) also refute the utility of modern hunter-gatherer analogs because of low population densities during the Paleoindian period. Low population densities have crucial implications regarding human responses during periods of stress, and these conditions are not operant in any of the ethnographic models. Usually hunter-gatherers respond to resource stress by emigration. Modern groups, however, move to other regions where they have social ties, and these ties allow them to acquire economic knowledge. Without these social ties, Kelly and Todd (1988) contend that an economy emphasizing hunting is more

suitable for populations moving into unknown regions. Within these economies, a general knowledge of faunal behavior is suitable for emigration, while knowledge about the timing, location, and processing of plant foods could be unavailable.

The earliest Paleoindian adaptation (Clovis) has been viewed as a generalist economic strategy of residential mobility where the entire group moved to areas where a particular resource was abundant. In contrast, the massive bison kills associated with later Paleoindian periods has suggested a logistic strategy (Sebastian 1989a). This strategy relies on specialized task groups that procure certain resources that are then transported to residential areas where they are consumed (Binford 1980). The meat from the large kill sites would provide a storable resource that has been suggested as a critical strategy for overweathering the harsh plains winters (Greiser 1985). Judge (n.d.) also suggests that the increase in the number of bison per kill site from the Folsom period to the later periods indicates an increasing specialization of bison procurement during the later Paleoindian periods.

Taphonomic studies of the breakage and distribution of bones in these large bison beds, however, suggest a different strategy. These large bone beds contain only partially butchered carcass remnants, suggesting a gourmet selection of cuts and the use of only a low proportion of the potential meat products (Frison 1987, 1992; Frison and Todd 1987). Some meat surpluses were stored as impromptu frozen caches, but there is no evidence for meat drying that would suggest the large kills constituted a strategy to acquire long-term surpluses. This short-term strategy contrasts with the later Archaic communal kills that occurred in the fall, and where the meat surpluses were dried for easy transport to possibly distant campsites (Frison 1992).

Todd (1983), Speiss (1984), and Kelly and Todd (1988) call this a "high technology forager" adaptation, and it has characteristics of both forager and collector strategies. It resembles a forager system with high residential mobility that is based on local resource abundance without reliance on stored resources; but it also has a highly curated technology, high logistic mobility, and the use of large territories, which are characteristic of a collector system.

Kelly and Todd (1988) believe that a commitment to the use of stores would result in reduced flexibility for regional positioning and place Paleoindian hunters at high risk. Rather than processing long-term stores and reducing mobility after a kill, the most secure tactic would be to begin the search for further resources. Initially, this would consist of daylong foraging trips near the kill. Once game became scarce within a foraging radius, a logistic move would occur, and a special task force would locate and perhaps kill game. The old foraging campsite would be abandoned for the new kill site or hunting area, and the meat and other resources would be left behind. Binford (1983) corroborates that modern hunter-gatherers may change locations because of the food abundance, not scarcity. This is a low risk strategy, because you can always return to areas with resource abundance. The frozen meat caches at the Paleoindian kill sites appear to be remnants of this strategy.

This highly mobile subsistence system would result in redundant use of the landscape and a transportable technology that was hunting specific but flexible enough to allow movement into areas where lithic resources were scarce or unknown. Landscape redundancy or reuse of site areas would occur mainly because of familiarity, although physiographic locales attractive to game also would act as feedback. Redundancy would also be apparent in the types of sites in the settlement pattern. Mainly the sites would consist of short-term residential camps and associated kill sites, whose size and complexity would depend on the number of times it was reoccupied before being dropped from the settlement system. Logistic campsites and retooling sites, occupied by male hunters, also would occur.

It is also likely that high technology foragers systematically exploited other game. Blood residue samples from Folsom projectile points indicate the use of these weapons on rabbit and bear in addition to bison (Amick 1994). It is also likely that other large game was

systematically taken by high technology foragers, and plant resources were probably also used. Kelly and Todd's model accounts for broad based resources, but the pursuit of large fauna, specifically bison, is what directed the settlement pattern.

In contrast to these "high technology foragers," Paleoindian occupations in the mountain and foothill regions of Wyoming suggest a different settlement pattern (Frison 1992). Caves and rockshelters contain storage features with diverse floral resources that include considerable quantities of sunflower, prickly pear, amaranth, juniper, and limber pine. Bison remains are mostly absent, but the faunal assemblages contain deer and mountain sheep remains.

These sites do not solely appear to reflect the use of different resources in differing physiographic situations, but a separate settlement strategy. Projectile point styles are distinct from those found in the plains and intermontane basins. The point styles are regionally endemic, and demonstrate considerable variance over short distances (Frison 1992). Localization and a less mobile adaptation is also apparent in the use of local lithic materials, contrasting to the basin and plains sites, which can contain materials from vast distances.

Amick (1994) proposes that plains bison behavior includes summer distributions consisting of clumps (his phrase). Increased bison herd size during the fall and early winter is amenable to increased human group size and a communal pattern of hunting. All large kill sites are on the plains, and the communal kills appear to occur during the late fall and early winter when the herds aggregate. In contrast, the small basin sites appear to represent small residentially based hunting groups responding to dispersed prey. Although bison were probably common in the intermontane basins, the herds may have been small and dispersed.

Chronology and Taxonomy

The chronological sequence of North American Paleoindian is based on only a handful of stratified sites and a series of dates from open sites. Since the number of dates are considerably fewer than the later Archaic and Formative period sites, the chronological placement of most open sites in the Southwest is intrinsically linked to the taxonomy of projectile point styles. The radiocarbon determinations and projectile point styles from the earliest Clovis and latest Frederick phases are quite distinct, but the intervening periods have dates that often overlap and the projectile point styles are often distinguished by only minor taxonomic variation.

Divisions within the Paleoindian Period have been subdivided into complexes, cultures, phases, and subphases. Early classification of projectile point styles led to confusing taxons such as Llano, Plano, and Yuma. To clarify and offer consistent criteria to projectile point taxonomies, Judge (n.d.) formulated a taxonomic classification based on hafting attributes. This system is based on basal morphology and is considered a functional classification since it relates to hafting technology. It is based on two criteria—the thinning technique employed to reduce the base to the desired hafting thickness and the manner in which the lateral edges of the point base were abraded as a final manufacturing step. These two criteria resulted in four basic "series", and these were meant to denote similar functional contexts, not developmental or sequential implications. The four series include the Fluted, Laterally Thinned, Constricted Base, and Indented Base Series.

Owing to the small number of radiocarbon dates from the thousands of years constituting the Paleoindian phase, the cultural sequence is by no means incontrovertible. It is conceivable that sequences based on varying projectile styles are inaccurate, and that some styles, thought to be temporal markers, are contemporaneous. Cordell (1979) illustrates the overlapping chronology and the various stages of Paleoindian chronology. She believes that the available data are insufficient for even "minimal interpretation" and that there is no evidence for sequential appearances of specific projectile point styles. Recent excavations at the Hell Gap site confirm the contemporaneity of projectile point styles that were previously thought to be sequential markers. These investigations have suggested that Folsom, Agate Basin, and Hell Gap are all contemporaneous (Marcel Kornfeld, personal communication, 1998).

The Goshen Complex, first found below the Folsom level at the Hell Gap Site, Wyoming was thought to be a Clovis variant. This was based on one projectile point that was subsequently lost, and the concept of the Goshen Complex was seriously questioned. Investigations at the Iron Mill Site, Montana (Frison 1988) recovered radiocarbon that AMS dated with averages over 11,000 BP and recent excavations at the Hell Gap Site suggest the Goshen Complex is contemporaneous with the Clovis Complex. Projectile points from the site retain some characteristics of both Clovis and Folsom technology, and many possess a strong resemblance to Plainview points. Similar points were recovered from the lowest level of the Carter McGee site, and Frison suspects that several Goshen points have been misidentified as points from this later, and possibly more southern based Plainview complex.

Regional Distributions

The similarities of fluted Clovis projectile points across North America suggest that regional projectile point styles did not develop during this period. In contrast to the widespread early fluted series, the subsequent complexes may exhibit some regional distributions. Agate Basin points appear to have a northern plains distribution, while Plainview may have a southern plains distribution. We do not have good data on the distribution of these various types, but they suggest some localization of styles and perhaps decreased mobility.

The Plainview complex contains five or six point styles. In addition to Judge's Meserve and Milnesand styles, it may include Dalton, Barber, and Golondrina. Judge's (1973) Belen style also may be a Plainview variant. These styles are located throughout Texas, New Mexico, southeastern Arizona, and northern Mexico, and they exhibit tremendous style variability. In northern Mexico, Epstein (1967) is uncertain if these styles are Golondrina. In southwest New Mexico, Fitting and Price's (1968) sites are called Plainview, but Judge (n.d.) questions the inclusion of one site in this category, and in southeastern Arizona (Dart 1987) the Plainview styles are Golondrina.

After these possible regional developments, the Cody Complex materials appear to represent a widespread style that occurs throughout the northern and southern plains and adjacent basins. In the New Mexico basins, they do not reach the same proportions as the earlier Folsom materials. At about 8000 BP, the high technology foraging pattern ended. Apparently, the high mobility that reduced risk in this adaptation was no longer tenable, and storage or expansion of the diet breadth accommodated subsistence risks.

Paleoindian Materials in the Project Area

The Mockingbird Gap Site, which is about 0.8 km south of LA 67451, is the most well documented Paleoindian site in the immediate area. This site contains extensive Clovis materials as well as Folsom, Cody Complex, Archaic, and later Formative occupations (Weber 1997). Six other Paleoindian components of unknown cultural association are listed in the New Mexico Cultural Resource Information System (NMCRIS) within a 20 km radius of the study area. Amick (1994) reports 526 Folsom artifacts from 8 localities in the northern portion of the Jornada del Muerto. Most of these are in private collections and most of these are near the Mockingbird Gap site. Lithic material types of these Folsom materials consist of materials from the Rio Grande gravels (41%, *n*=216), northern Jornada sources (27%, *n*=144), and southern Jornada sources (32%, *n*=125). Heavy reliance of the Rio Grande gravel sources suggests continuity with the Albuquerque Basin. No tool stones from Plains sources are recognized in these assemblages.

THE ARCHAIC PERIOD

In New Mexico, there is no apparent *in situ* transitional phase from Paleoindian to Archaic. Early Archaic populations in the New Mexico basins seem to represent the gradual eastern migrations from Lake Mojave adaptations (Irwin-Williams 1973, 1979), and there is no continuity in Paleoindian and early Archaic populations. The Archaic period in New Mexico is generally bracketed between the end of the Paleoindian period and the appearance of pottery (ca 6000 BC to AD 200). In New Mexico, three traditions or regional

adaptations have been defined. These consist of the Oshara (Irwin-Williams 1973) generally situated in northwestern New Mexico, the Cochise (Sayles and Antevs 1941, Sayles 1983), which is centered in southeastern Arizona, and southwestern New Mexico, and the Trans-Pecos defined for the Llano Estacado and adjacent areas in the eastern regions of New Mexico and western regions of Texas. Recent criticisms of both the Oshara and Cochise traditions, however, suggest that both are based on speculative data that is "obfuscated by the insidious concept of *in situ* continuity" that has resulted in pseudo-chronologies or "phase-stacking" (Berry and Berry 1986).

The Southwestern Archaic social and economic organization has been proposed as a foraging adaptation that uses residential mobility to map on to seasonally available resources (Vierra 1980; Elyea and Hogan 1983). In this adaptation families or family groups move every few days or weeks when resources within a days-foraging radius (about a 10-km distance) are depleted. Resources are procured day-to-day and transported to the residential camps for processing, consumption, and possibly storage. The resource procurement sites are usually archeologically invisible except in cases where repeated use results in a sufficient density of artifacts. Small hunting sites may also be identified, but the residential campsite or foraging camp is the primary site type that is visible in the archeological record.

Archaic residential campsites vary in size from a few hundred to several thousand square meters. The very large site areas, which may have been interpreted as base camps in the past, are currently viewed as sites that may have been reoccupied over a long time period (Vierra 1980; Vierra and Doleman 1994). Most of the sites consist of artifact scatters, and depending on preservation the scatters may be associated with hearths and roasting pits. The artifacts are mostly lithic debitage and when preserved, concentrations are often located adjacent to hearths. Chipped stone tools, usually not exceeding 3% of the total assemblage, consist of bifaces, projectile points, and the occasional scraper, drill, and perforator. Ground stone is composed of one-hand manos and slab or shallow basin metates.

As in the preceding Paleoindian period, early investigators of the Southwestern Archaic adaptation attempted to construct a chronological typology that would span the Archaic period. These typologies were for the most part based on varying projectile point styles, and they attempted to show continuity from the earliest to the latest Archaic periods. Undisputed archeological materials that confirm the validity of these early phases, however, are absent.

Although they are centered in different geographical areas, the boundaries between these traditions appear to have been fluid, with more Oshara style points in the north, more Cochise style points in the south, and more Trans-Pecos styles in the east. All three traditions have attempted to show continuity from the Archaic adaptations to the early agricultural adaptations. Recent investigations, however, suggest that immigrating agriculturists from Mexico entered the Southwest with an intact agricultural adaptation (Huckell 1990). This San Pedro adaptation, which was earlier associated with Cochise Archaic, appears to be an intrusive adaptation that supplanted the Cochise adaptation. This intrusive culture also reached the Oshara area near San Luis, New Mexico, but did not transform the regional foraging adaptation (Bargman et al 1999, Elyea 1999).

THE FORMATIVE PERIOD

The Formative period is marked by a change from a mobile hunting and gathering adaptation to a more sedentary lifeway based primarily on agriculture. Throughout much of the Southwest, the adoption of agriculture and the beginning of a sedentary lifestyle begins between about AD 1 and AD 500. During the early portion of this period, groups may have been only partially sedentary, continuing to forage during certain parts of the year. The development of the sedentary cultures in the Rio Abajo and northern Jornada del Muerto followed the general trend established for the plateau Anasazi to the northwest and for the Mogollon to the south. Influences from both groups are noted in the area particularly in the ceramic assemblages that include both northern graywares and southern brownwares (Marshall and Walt 1984:35–38).

Whether these mixtures represent movement of people or tradewares, however, remains unclear.

In the San Antonio region, phases within this Formative development period (Mera 1935:25–26) generally start with the San Marcial phase and the introduction of ceramics. House forms are pitstructures with masonry-jacal surface structures that were probably used for storage. The following Tajo phase corresponds with the Pueblo I and Pueblo II Pecos classification. House forms consist of one to ten surface rooms with cobble-based jacal construction. This phase represents an increase in population, especially along the banks of the Rio Grande and Rio Salado (Marshall and Walt 1984:47–49).

The following Elmendorf phase corresponds to the late Pueblo II and Pueblo III Pecos classification. This phase involved a change from small settlements to larger villages and presumably an even larger increase in population. This phase is defined by the presence of locally made Elmendorf whitewares, and White Mountain redwares are introduced during the later part of this phase. Late Elmendorf Phase sites (ca. AD 1100–1300) are often located in defensible settings with fortified exterior walls (Marshall and Walt 1984:95–99).

The introduction of glazewares marks the ancestral Piro phase, AD 1300–1540. Large adobe villages with enclosed plazas appeared at this time and both the number and size of the sites dramatically increase during this phase. The banks of the Rio Grande continue to be the most heavily occupied regions. To the northeast and along the southwestern edge of the Estancia Basin, the Salinas region Pueblos of Gran Quivira, Quarai and Abo also flourished and constructed large masonry pueblos (Marshall and Walt 1984:135–142).

The colonial Piro phase began with Spanish contact and ended with the abandonment of the Piro pueblos in the 1680's. Contact with the Spanish brought about a dramatic population decrease through disease and social upheaval. Some Piro groups moved west of Socorro into the Magdalena Mountains to avoid contact with the Spanish. By the Pueblo revolt in 1680, the Piro and Salinas provinces were abandoned and some remaining Piros moved to the El Paso area under Spanish protection. A 1700's period pithouse at the Mockingbird Gap Site, however, indicates that small group of Piros or Tompiros from the Salinas region persisted after the large villages were abandoned.

THE NEOARCHAIC PERIOD

The transition from mobile hunting and gathering to sedentary agricultural is a complex process and the timing and extent of this transition varies from geographic area to geographic area. In the southern and eastern portions of New Mexico, the persistence of an Archaic-like adaptation into the protohistoric period has been a long established concept. Within eastern New Mexico the appearance of ceramics generally marks the end of the Archaic period at sometime around AD 600 to 900 (Stuart and Gauthier 1981, Sebastian 1989b). Traditionally, open lithic and ceramic scatters have been assigned to Jornada Mogollon occupations and interpreted as logistic procurement sites. More recent investigations, however, have focused on the possibility of mobile hunter-gatherers incorporating certain material traits, perhaps through trade, of nearby sedentary groups.

Jelinek (1967) postulated a post-McKenzie phase in the middle Pecos valley that marked a major shift in subsistence from agriculture to hunting and gathering at AD 1300. He believes agriculturalists in eastern and southeastern New Mexico may have abandoned a sedentary adaptation and returned to a mobile hunting and gathering lifestyle. Sites consist of open lithic and ceramic scatters that lack structural remains and contain a decreased amount of corn pollen and an increased amount of bison bones from the earlier phases. Speth (1984) argues that the increase in bison bones during this period may indicate a more logistic procurement strategy by sedentary agriculturists rather than a transition phase to nomadic bison hunters. More recent models suggest contemporaneous agriculturalists and mobile hunters and gatherers (Sebastian 1989, Wiseman 1991) where two distinct adaptations that occurr throughout the ceramic period—both using the bow and arrow and ceramic vessels. These archeological sites that appear to be the remains of hunters and gatherers, but contain ceramics and arrow

projectile points have been labeled the Neoarchaic (Prewitt 1981, Lord and Reynolds 1985).

Excavations of these Neoarchaic sites at the WIPP core area (Lord and Reynolds 1985), Los Esteros Dam (Levine and Mobley 1976, and Brantley Reservoir (Bearden and Gallagher 1980), as well as numerous small projects have yielded radiocarbon dates from AD 1050 to 1400. All are non-structural, open lithic and ceramic scatters and Jornada brownware or El Paso brown wares are the most common ceramic type and Chupadero Black-on-white is the most common painted ware.

To date, all of these Neoarchaic sites have been located in the eastern plains or the Pecos Valley and have not been found in the basin and range areas of New Mexico. Although open lithic scatters with a few lithics have been located within the Tularosa, Estancia, and Jornada Basins, they have not been investigated to determine if they are Neoarchaic, Archaic with a Formative visitation, or Formative special use sites. Within the Estancia Basin, one excavated site contained a hunter-gatherer component dating to the protohistoric period around AD 1505 to 1620 (Elyea 1999). This site contained bison bone and arrow points, but no ceramics.

THE HISTORIC PERIOD

For most of the historic period, ranching and mining have been the major economic activities in the area. Cattle and stage line trains traversed this portion of the Jornada del Muerto in the vicinity of US 380. Thousands of cattle were driven along this branch of the Chisum trail between 1870 and 1880, delivering cattle to the railhead at Magdalena from Carrizozo. A short line stage route also passed through the area from San Antonio to Nogal with a stop at Ozanne from 1880 to 1910.

Just east and west of the study area, coal was found and mined at Bingham and Carthage. Carthage was mined as early as 1860 by soldiers from Fort Craig and by 1883 was turned into a railway mining complex with a small narrow-gauge railway. The nearby Tokay Mine operated from 1919 to 1932. By the middle 1930's all of the coal mines were abandoned. Just southeast of the study area, gold and silver were mined at Ozanne from 1906 to 1909 (Williams 1986).

The most infamous historic event in the region occurred on 16 July 1945 when the first atomic bomb was detonated at the northern end of the Jornada del Muerto 22.42 km (14 mi) south of the study area. The test code name for the Manhattan Project's first atomic test was Trinity. Originally there were eight potential test sites and these were narrowed to two in August 1944. The first choice was a military base in southern California. When Major General Leslie B. Groves, the military commander of the Manhattan Project, discovered he would have to talk to General George Patton to use the California base, he quickly decided on the Jornada del Muerto (U.S.D.O.E. 1994).

5 SITE DESCRIPTIONS

by Janette M. Elyea

LA 67451

Introduction

LA 67451 is a 50 by 22 m lithic scatter located mostly north of the right-of-way and extending only ten meters south of the right-of-way fence (Figure 2). The survey reported 15 flakes within the right-of-way, but these were about 17 m north of the proposed construction slope limits. One shovel test pit within the slope limits, however, recovered subsurface materials.

Owing to its proximity to the Mockingbird Gap site, the site was originally designated as a Paleoindian occupation, but there were no diagnostic artifacts within the scatter. The scatter contains about 15 lithic flakes, which represent the full range of lithic reduction processes. Material types include cherts, chalcedonies, and some obsidian.

Our excavations recovered materials from an early Archaic campsite that undoubtedly continues to the north of our excavations and beyond the construction zone buffer. Most of the cultural materials came from one or two 10 cm levels that were 30 to 40 cm below the modern ground surface and 20 to 30 cm below the top of the Q3 stratum.

Location and Setting

LA 67451 is about 150 m east of Chupadera Arroyo on a broad, flat plain (Figure 3). The landscape is stable, anchored by sage, yucca, forbes, and grasses, and there is no obvious erosion.

Site stratigraphy consists of an upper recent blow sand (modern Q4 deposit) that was 10 cm thick. Below this was a hard Buckle-Bar sandy clay loam unit with a 30 cm to 50 cm thickness (Chapter 8).

Strategy and Methods

Our excavations began around the shovel test pit that contained the cultural materials and our excavations expanded to include 16 sq m of excavation. Fourteen of these units were contiguous and two were to the west of this block. The depths of these excavation units ranged from 55 to 75 cm with an average of 60 cm or 9.6 cu m. One stratigraphic trench was excavated after our investigations were complete.

The upper Q4 deposits were removed without screening. All grids were excavated in 10 cm levels and included a basal sterile level. Since the lower Q2 stratum was identified by Robert Weber as the unit containing Clovis materials at the Mockingbird Gap site, four of the excavation units were excavated 10 to 20 cm into the weathered stratum. No cultural materials were recovered in the stratum.

Data Recovery Results

Our excavations recovered 565 lithic artifacts and these included a possible early Archaic Jay Phase projectile point (Figure 4). These materials were concentrated in the northern limits of our excavations and centered on N103/E105. Artifact densities dropped dramatically to the east and west and gradually diminished to the south.

Table 2 lists the artifacts recovered from LA 67451. Like other assemblages in the area, it is dominated by flakes with only a few tools or tool fragments. The projectile point is crude but is basally ground indicating its function as a point and not a biface. The biface is chert and was broken in the final stage of manufacture. One of the scrapers is a side scraper manufactured from chert; the other is a silicified wood end scraper. Brown chert is the predominant material type (Table 3) and there are significant amounts of obsidian, chert, and

Rio Grande chalcedony. On the 66 remnant striking platforms 43 (65.2%) exhibit preparation. Step fracture is the most common evidence of preparation (18.2%).

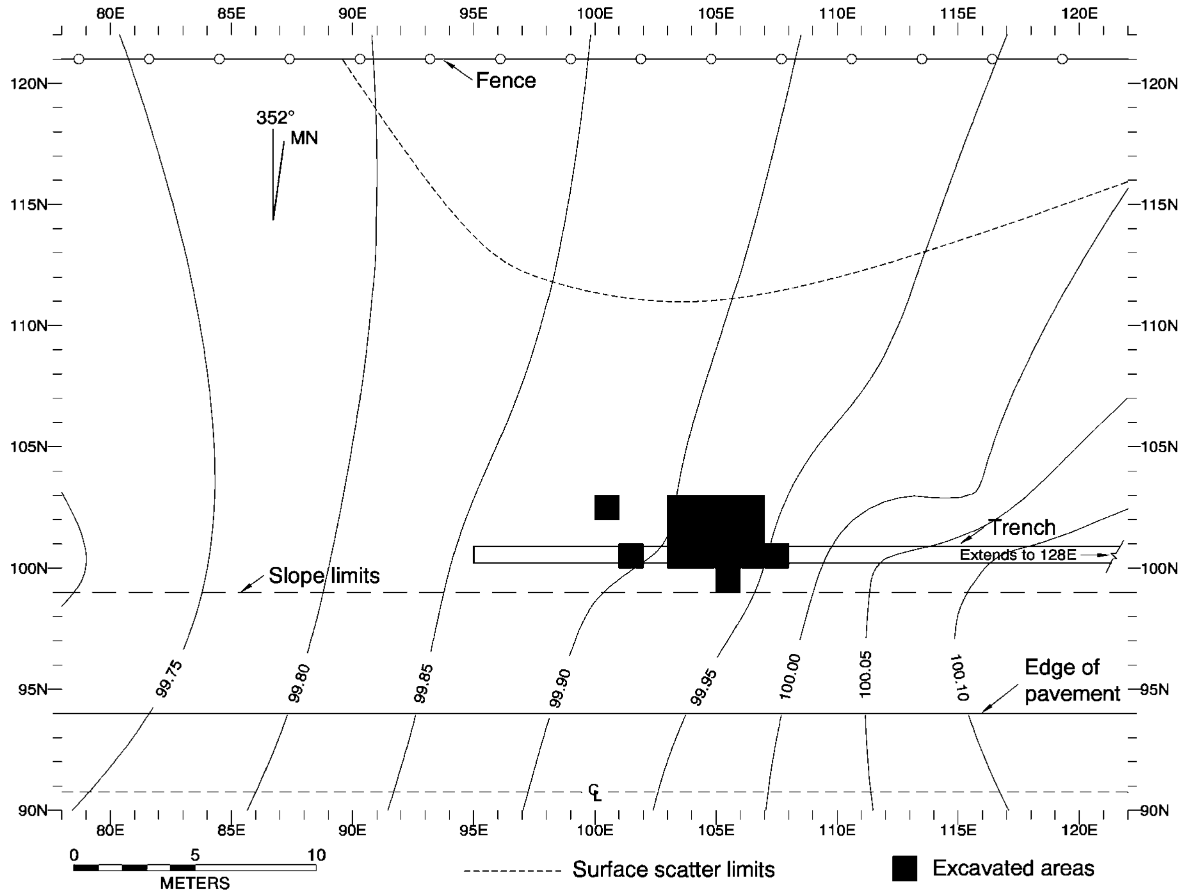

Figure 2. LA 67451 Plan View.

Figure 3. LA 67451 looking east.

Figure 4. LA 67451 Jay projectile point base.

Table 2. LA 67451 Artifact Types.

Artifact Type	Count	Percent
Angular Debris	3	.5
Flake	557	98.6
Projectile Point	1	.2
Biface	1	.2
Scraper	2	.4
Manuport	1	.2
Total	**565**	**100.0**

Table 3. LA 67451 Material Types.

Material	Count	Percent
Chalcedony with black inclusions	58	10.3
Chalcedony with red inclusions	34	6.0
Chalcedony with black and red incl.	4	.7
Silicified Wood	25	4.4
Silicified Wood, red	2	.4
Quartzite, fine grain	12	2.1
Chert, brown	99	17.5
Chert, tan	54	9.6
Chert, gray	5	.9
Chert, black	1	.2
Socorro Peak Jasper	13	2.3
Socorro Peak Jasper, grainy	12	2.1
Chert, pink	2	.4
Chert, yellow	1	.2
Chert, White	1	.2
Chert, fossiliferous white	1	.2
Chert, banded	6	1.1
Chert, banded gray	2	.4
Brown chert with black inclusions	22	3.9
Chert, Brushy Basin	73	12.9
Chert, Jarilla	56	9.9
Jasper, dendritic	5	.9
Moss agate	9	1.6
Obsidian	67	11.9
Limestone	1	.2
Total	**565**	**100.0**

There was neither ground stone nor any fire-cracked rock. We did not find any hearths or oxidized soil, but three small charcoal fragments, from three different grids were recovered and two were submitted for an Accelerated Mass Spectrometry (AMS) date (Appendix 1). One (Beta 149342) was collected 50 cm below the modern ground surface and within the Q3 Bk stratum. It yielded a 2-sigma calibrated date of AD 700 to AD 900. The other (Beta 149343) was collected 38 cm below the modern ground surface, also within the Q3 Bk stratum, and yielded a 2-sigma calibrated date of AD 1470 to AD 1660. Both samples were collected from the field screens and both were within artifact bearing levels.

Summary and Interpretation

The portion of LA 67451 that we investigated appears to be the remains of an early Archaic campsite. The absence of ground stone and fire-cracked rock is common in residential sites of this time-period. The radiocarbon dates do not support this temporal interpretation, however. Nevertheless, material types from the Jarilla Mountains, about 140 mi to the south, and chalcedonies and cherts from the Rio Grande Valley suggest the occupants at this site were highly mobile. The projectile point base and the presence of a high proportion of stepped striking platforms suggest that this site dates to the Jay phase of the early Archaic period around 5500 to 4800 BC. The absence of any materials that would suggest an occupation during either of the Formative periods yielded by the radiocarbon dates suggests that the charcoal is a later contaminant.

LA 126619

Introduction

This extensive site (Figure 5) is located along the western edge of Chupadera Arroyo and extends 240 m to the west. The survey reported 145 flakes, 7 ground stone fragments, 6 biface fragments, a hammerstone, a hammerstone/ chopper, and a uniface. No projectile points, ceramics, or other artifacts suggestive of a temporal or cultural affiliation were reported. This artifact scatter is within the 1988 defined boundaries of LA 26748 (Mockingbird Gap) and the scatter extends to the north and south of the right-of-way. As such, it is considered a portion or sample of the wide prehistoric use along the margins of Chupadera Arroyo. Robert Weber (personal communication, March 2000) also reports a Folsom occupation south of the right-of-way fence. His artifact markers depict a diffuse scatter of Folsom artifacts that extend along the entire east-west margin of our investigated areas.

Initial testing at the site determined that intact prehistoric materials were present within a Q3 stratum. Testing south of the highway indicated extensive intact Q3 deposits, while north of the road recent Q4 deposits overlay a much older Q2 stratum. In all we hand excavated 156 sq m

to depths of 60 to 110 cm and recovered materials from the Paleoindian, early Archaic and middle to late Archaic periods. Radiocarbon assays, however, indicate occupations in the Formative period.

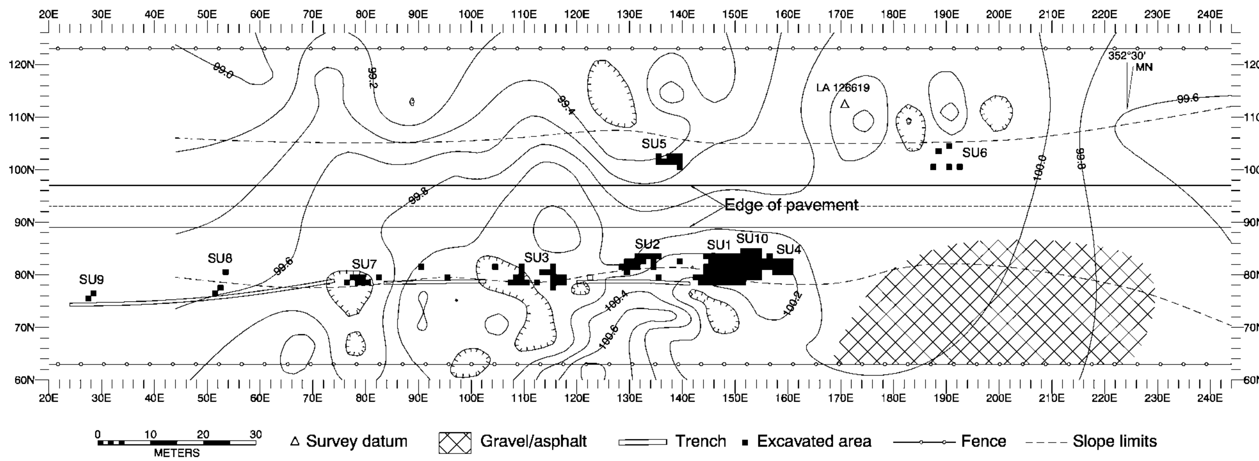

Figure 5. LA 126619.

Location and Setting

Situated immediately west of Chupadera Arroyo, the site sits on a flat, sand mantled plain that rises slightly to the west. Frailly anchored by sagebrush and grasses, the sand deposits contain numerous blowouts and basal gypsum-caliche is exposed in several areas across the site surface. Cultural materials are located in blowouts on both sides of US 380 and consist of chipped and ground stone lithics. Most of the surface artifacts are located in large deflated areas on the north side of US 380 and a diffuse surface scatter of fire-cracked rock is also present at the northeast end of the site.

The site stratigraphy consists of recent blow sands (Q4) overlying Q3 deposits (Chapter 8). Figure 6 shows the strata surfaces from our excavation data. The upper and lower graphics depict the undulating upper surfaces of the Q4 and Q1/Q2 strata. The middle graphic depicts the base of the Q4 stratum. In some areas, this surface represents the top of the intact Q3 stratum, but since this stratum is not uniformly present across the site, the top of the Q1 or Q2 is also represented in the bottom graphic. The relatively planar surface at the top of the Q3 (labeled base of the Q4) in this graphic is interesting, and probably represents a truncated or eroded surface.

Strategy and Methods

The slope limits of the proposed highway construction includes a 170 m span on the north side of the roadway and 121 m on the south side. Slope limits vary from a 6 to 10 m width along the shoulder of the existing pavement. The transition from the Q4 to the Q3 deposits could only be determined by the reaction of the sediments to a 10% hydrochloric acid solution. Owing to varying moisture depths, there is no observed change in hardness between the two strata, and color changes were too subtle to discern during excavation.

Our initial excavations consisted of 12 grids systematically placed along the east-west axis of the proposed construction zone. Placed on the south side of the road, we hoped these units would identify concentrations and direct the placement of large excavation blocks. Eventually ten areas of block excavation or Study Units were placed across the site area. Two were located north of the road and eight were to the south (Figure 5). South of the road, three long stratigraphic trenches spanned the entire length of the site. The Q4 overburden was mechanically removed from three of the Study Units (SU 4, SU 7, and SU 10) and after excavations were completed, the proposed construction area on the south side of the road was mechanically scraped.

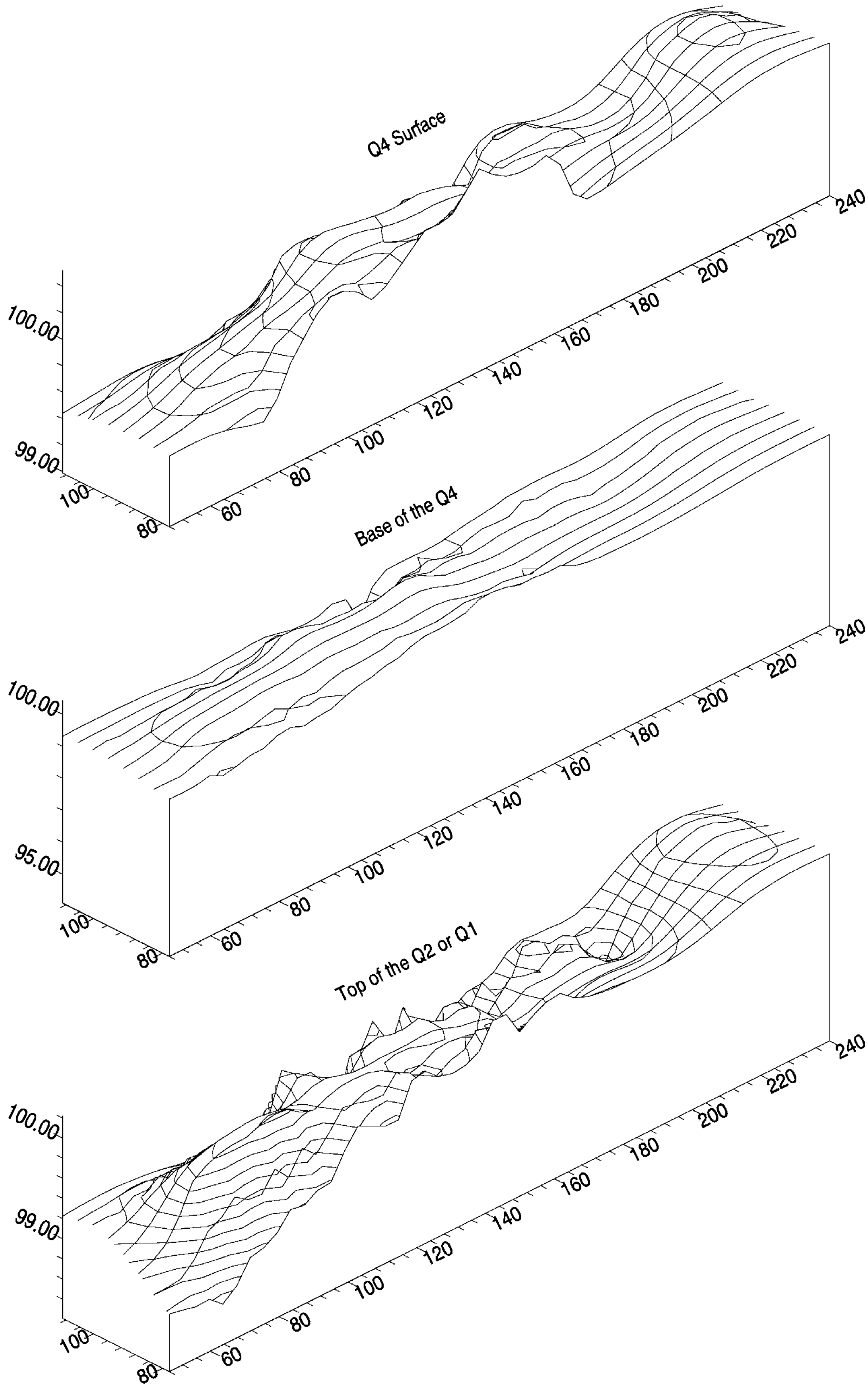

Figure 6. LA 126619 stratigraphic units.

Our initial test units indicated dense and intact materials in the southeast portion of the site (Figure 7). Excavations in this area expanded to include three adjacent Study Units (SU 1, SU 4, and SU 10), which totaled 85 sq m. These excavation units contained 3745 lithic artifacts including 47 pieces of ground stone (Figure 8). Most of the materials were within a 30 cm deposit, and an analysis of the individual and overall grids did not discern any differences in artifact or material type between the various levels. Since this is a large excavation area with abundant materials, we performed a nearest neighbor cluster analysis by material type to discern any patterning in the materials. This resulted in five analytical units (AUs) that contained similar material distributions with no differences between the grids in the analytical units and significant differences in material types between the analytical units (Figure 9).

Figure 7. Southeast portion of LA 126619 during excavation.

Analytical Unit 1

Analytical unit 1 consists of grids that did not cluster with other grids. Tables 4 and 5 list the artifact and material types within these various grids. Included in AU 1 are four grids (N79 E 144, N79 E145, N78 E144, N78 E145) that contained a total of 931 small sharpening flakes. The material types within these grids did not cluster with each other and the artifacts were within a matrix of bb sized gravels. It is likely that this area is a fossil anthill. Other artifacts within this AU also include a corner-notched silicified wood projectile point base fragment that probably dates to the middle to late Archaic period (Figure 10).

One feature was also within these non-clustering grids. Feature 4 is a small possible hearth feature located 2 m west-northwest of Feature 3 that lies within AU 4. Feature 4 was an ovate pit with 18 by 15 cm dimensions and a 6 cm depth. The fill consisted of ash-laden sand with charcoal flecks and there was no oxidation. An AMS assay of the charcoal (Beta 149345) yielded a 2-sigma calibrated and adjusted date of AD 650 to AD 770. The feature was 2 cm from the top of the Q3 Bk horizon and 24 cm above the Q2 horizon. The contents of the feature contained only burned Dicotyledonae (unidentified dicot) fragments that were probably used as fuel.

Analytical Unit 4

Analytical unit 4 includes the grids in the initially designated Study Unit 4. This unit consists of 10 grids and contains 678 lithic artifacts including 7 ground stone fragments and a grooved whetstone (Table 6). The whetstone consists of a flat sandstone fragment with a 1 mm wide, 52 mm long groove. It may have been used to grind the bases of projectile points or the edges of bifaces for platform preparation. The lithic material types in the AU contain significantly high proportions of silicified wood, obsidian, and chert from the Jarilla Mountains, and significantly low proportions of quartzite (Table 7). Diagnostic artifacts include a very well made basalt Jay style projectile point with parallel flaking (Figure 11). If the base of the diamond cross section point were straight instead of convex it would probably be classified within the Cody Complex materials.

One feature was within the AU. Feature 3 (Figure 12) is a probable hearth and is an oblong basin with 50 by 30 cm dimensions and a 4 cm depth. The fill contained charcoal laden sand and there was no oxidation. The contents of the feature contained two fragments of burned Atriplex/Sarcobatus (saltbush/greasewood) and 9 fragments of burned Dicotyledonae (unidentified dicot) that were probably used as fuel. It also yielded five small items, three of which were superficially similar to maize cupule fragments and glumes. An AMS assay (Beta 149346) yielded a 2-sigma calibrated and adjusted date of AD 1050 to AD 1100. The feature was 19 cm below the top of the Q3 Bk horizon and 20 cm above the Q2 horizon.

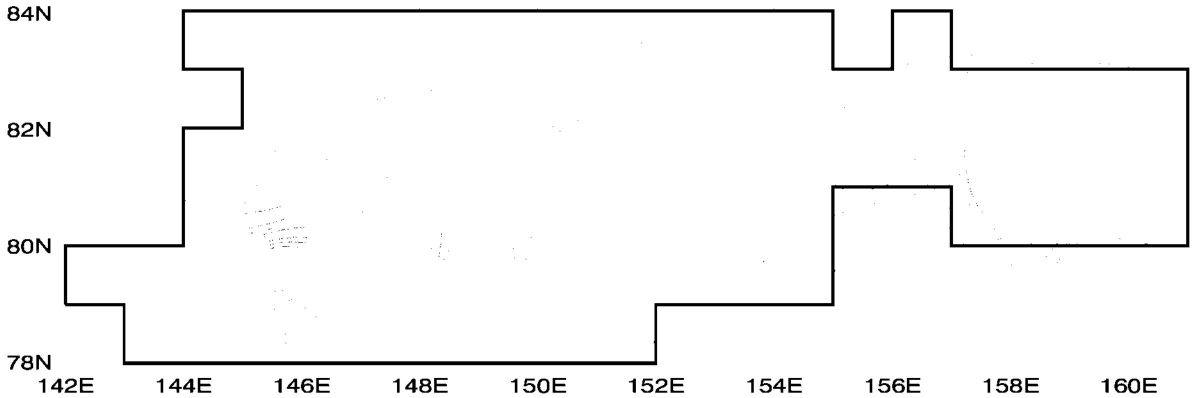

Figure 8. Artifact distributions in Study Units 1, 4, and 10 (contour intervals =20 artifacts).

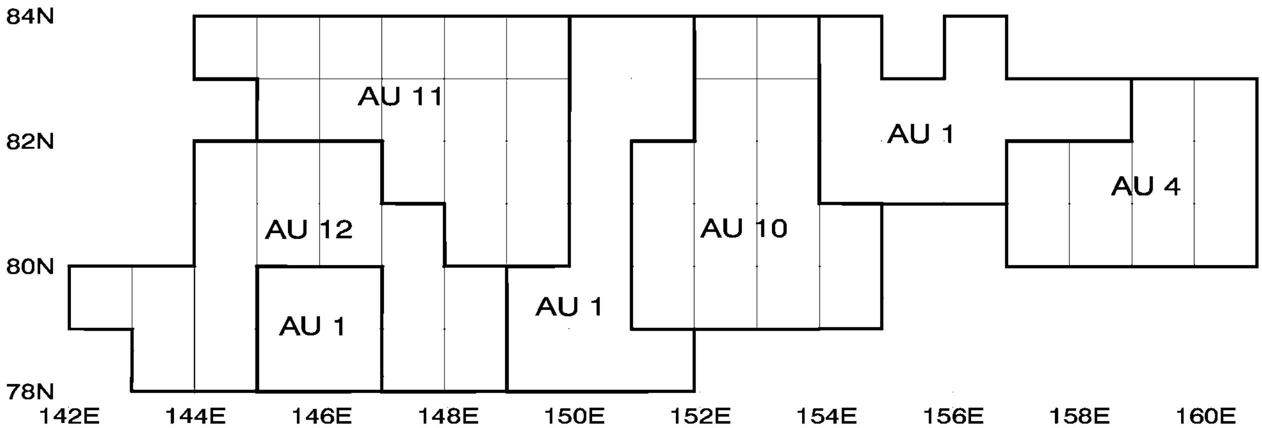

Figure 9. Analytical Units defined in Study Units 1, 4, and 10.

Figure 10. Analytical Unit 1 projectile point.

Figure 11. LA 126619 Jay projectile point base.

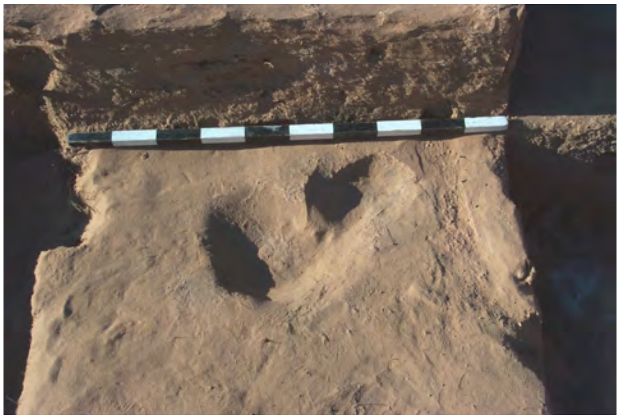

Figure 12. Feature 3 (scale shows 10 cm increments).

Table 4. Analytical Unit 1 Artifact Types.

Artifact Type	Count	Percent
Angular Debris	27	1.6
Flake	1613	97.1
Flake, Utilized	3	.2
Flake, Retouched	2	.1
Projectile Point	1	.1
Biface	1	.1
Unknown Ground Stone	4	.2
Mano, Unknown	1	.1
Metate, Unknown	9	.5
Total	**1661**	**100.0**

Table 5. Analytical Unit 1 Material Types.

Material Type	N	%
Chalcedony with black inclusions	179	10.8
Chalcedony with red inclusions	55	3.3
Chalcedony, with black and red incl.	2	.1
Chalcedony, clear	3	.2
Chalcedony, yellow	7	.4
Chalcedony, opaque	3	.2
Chalcedony, other	29	1.7
Silicified Wood	178	10.7
Silicified Wood, red	4	.2
Quartzite, fine grain	9	.5
Quartzite, medium/coarse	23	1.4
Quartzitic sandstone	11	.7
Chert, brown	116	7.0
Chert, tan	128	7.7
Chert, gray	62	3.7
Chert, black	27	1.6
Socorro Peak Jasper	128	7.7
Socorro Peak Jasper, grainy	339	20.4
Chert, pink	6	.4
Chert, white	1	.1
Chert, fossiliferous white	29	1.7
Chert, banded	2	.1
Chert, Chuska	1	.1
Chert, Jarilla	18	1.1
Chert, other	1	.1
Jasper	2	.1
Jasper, dendritic	20	1.2
Red moss agate	14	.8
Obisidian	246	14.8
Basalt	2	.1
Rhyolite, fine grain	1	.1
Rhyolite, coarse grain	3	.2
Schist	1	.1
Volcanic, other	1	.1
Limestone	2	.1
Limestone, fossiliferous	6	.4
Sandstone	2	.1
Total	**1661**	**100.0**

Table 6. Analytical Unit 4 Artifact Types.

Artifact Type	Count	Percent
Angular Debris	10	1.5
Flake	650	95.9
Core, Irregular	2	.3
Flake, Utilized	3	.4
Projectile Point	1	.1
Biface	1	.1
Scraper	2	.3
Unknown Ground Stone	2	.3
Metate, Unknown	5	.7
Grooved Whetstone	1	.1
Manuport	1	.1
Total	**678**	**100.0**

Table 7. Analytical Unit 4 Material Types.

Material	N	%
Chalcedony with black inclusions	68	10.0
Chalcedony with red inclusions	23	3.4
Chalcedony with black and red incl.	2	.3
Chalcedony, yellow	1	.1
Chalcedony, other	2	.3
Silicified Wood	79	11.7
Silicified Wood, palm	2	.3
Silicified Wood, red	1	.1
Quartzite, fine grain	10	1.5
Quartzite, medium/coarse	8	1.2
Quartzitic sandstone	6	.9
Chert, brown	51	7.5
Chert, tan	38	5.6
Chert, gray	16	2.4
Chert, black	18	2.7
Socorro Peak Jasper	84	12.4
Socorro Peak Jasper, grainy	75	11.1
Chert, pink	3	.4
Chert, fossiliferous white	10	1.5
Chert, Jarilla	17	2.5
Jasper, dendritic	12	1.8
Moss agate	1	.1
Red moss agate	5	.7
Obisidan	134	19.8
Basalt	4	.6
Rhyolite, fine grain	3	.4
Rhyolite, coarse grain	2	.3
Limestone	1	.1
Sandstone	2	.3
Total	**678**	**100.0**

Two additional pieces of charcoal not associated with features, were collected 1 and 2 m east of Feature 3. One (FS 307, Beta 149350) yielded a 2-sigma calibrated and adjusted date of AD 1180 to AD 1280. This piece of charcoal was 25 cm from the top of the Q3 Bk horizon and 6 cm from the top of the Q2 horizon. The other (Beta 149344) yielded a 2-sigma calibrated and adjusted date of AD 1020 to AD 1200.

Analytical Unit 10

Analytical Unit 10 includes 15 adjacent grids and includes portions of Study Unit 10. This AU contained 394 lithic artifacts, including six ground stone fragments, a fragment of yellow ochre, a biface, scraper, and drill (Table 8). The material types are dominated by cherts and a significantly high proportion of obsidian and rhyolites (Igneous) are within this AU (Table 9).

Table 8. Analytical Unit 10 Artifact Types.

Artifact Type	N	%
Angular Debris	2	.5
Flake	379	96.2
Hammerstone	1	.3
Flake, Utilized	1	.3
Flake, Retouched	1	.3
Biface	1	.3
Scraper	1	.3
Drill	1	.3
Unknown Ground Stone	2	.5
Mano, One-Hand	1	.3
Metate, Unknown	3	.8
Pigment	1	.3
Total	**394**	**100.0**

Fire-cracked rock was diffusely scattered throughout the unit with no pattern or concentration and no features were discerned. One piece of charcoal (FS 472, Beta 149348) was collected and an AMS date yielded a 2-sigma calibrated and adjusted date of AD 880 to AD 1010. The charcoal was collected from the screen from a level 15 to 26 cm below the top of the Q3 Bk horizon and 9 to 11 cm above the Q2 stratum.

Analytical Unit 11

Analytical Unit 11 includes 16 adjacent grids and contains 372 lithic artifacts including 13 pieces of ground stone. Artifacts also include one dendritic jasper channel flake and one biface (Table 10). Material types include a high proportion of coarse-grained Socorro Peak jasper (Table 11) and significant amounts of 'other' chalcedonies and low proportions of silicified wood.

Table 9. Analytical Unit 10 Material Types.

Material Type	N	%
Chalcedony with black inclusions	44	11.2
Chalcedony with red inclusions	16	4.1
Chalcedony with black and red inclusions	1	.3
Chalcedony, yellow	2	.5
Silicified Wood	49	12.4
Quartzite, fine grain	4	1.0
Quartzite, medium/coarse	2	.5
Socorro Peak Jasper, grainy	38	9.6
Quartzitic sandstone	4	1.0
Chert, brown	21	5.3
Chert, tan	31	7.9
Chert, gray	5	1.3
Chert, black	4	1.0
Socorro Peak Jasper	63	16.0
Chert, pink	1	.3
Chert, fossilierous white	11	2.8
Chert, Brushy Basin	2	.5
Chert, Jarilla	12	3.0
Jasper, dendritic	5	1.3
Moss agate	1	.3
Red moss agate	2	.5
Obisidian	55	14.0
Rhyolite, fine grain	14	3.6
Rhyolite, coarse grain	2	.5
Limestone	1	.3
Limestone, fossiliferous	1	.3
Sandstone	2	.5
Ochre	1	.3
Total	**394**	**100.0**

Table 10. Analytical Unit 11 Artifact Types.

Artifact Type	Count	Percent
Angular Debris	3	.8
Flake	350	94.1
Channel flake	1	.3
Hammerstone	1	.3
Flake, Utilized	1	.3
Flake, Retouched	2	.5
Biface	1	.3
Unknown Ground Stone	1	.3
Mano, Unknown	2	.5
Metate, Unknown	10	2.7
Total	**372**	**100.0**

Analytical Unit 12

Analytical Unit 12 consists of 16 adjacent grids and contains 745 lithic artifacts including 9 ground stone fragments (Table 12). Coarse grained Socorro Peak jasper is the dominate

material type at 26.5 % (Table 13) and overall the AU has a significantly high proportion of 'other' chalcedony and low proportion of chert.

Table 11. Analytical Unit 11 Material Types.

Material Type	N	%
Chalcedony with black inclusions	28	7.5
Chalcedony with red inclusions	12	3.2
Chalcedony, clear	1	.3
Chalcedony, yellow	7	1.9
Chalcedony, other	4	1.1
Silicified Wood	18	4.8
Quartzite, fine grain	5	1.3
Quartzite, medium/coarse	5	1.3
Quartzitic sandstone	13	3.5
Chert, brown	27	7.3
Chert, tan	35	9.4
Chert, gray	16	4.3
Chert, black	10	2.7
Socorro Peak Jasper	19	5.1
Socorro Peak Jasper, grainy	91	24.5
Chert, pink	2	.5
Chert, fossiliferous white	7	1.9
Chert, Chinle	1	.3
Chert, Fingerprint	1	.3
Chert, Jarilla	4	1.1
Jasper, dendritic	8	2.2
Obsidian	38	10.2
Rhyolite, fine grain	1	.3
Rhyolite, coarse grain	1	.3
Limestone	11	3.0
Limestone, fossiliferous	7	1.9
Total	**372**	**100.0**

Table 12. Analytical Unit 12 Artifact Types.

Artifact Type	N	%
Angular Debris	8	1.1
Flake	722	96.9
Core, Irregular	1	.1
Flake, Utilized	2	.3
Flake, Retouched	1	.1
Biface	2	.3
Unknown Ground Stone	5	.7
Metate, Unknown	4	.5
Total	**745**	**100.0**

Analytical Unit 2

Located 6 m west of Study Unit 1, Analytical Unit 2 corresponds with Study Unit 2 and contained 17 grids. We did not detect any features and only dispersed fire-cracked rock was present. This AU contained 314 lithic artifacts including 10 ground stone fragments (Table 14). This AU has a high proportion of chert and both the coarse-grained and fine-grained Socorro Peak jaspers dominate the assemblage (Table 15).

Table 13. Analytical Unit 12 Material Types.

Material Type	N	%
Chalcedony with black inclusions	81	10.9
Chalcedony with red inclusions	27	3.6
Chalcedony, clear	3	.4
Chalcedony, yellow	11	1.5
Chalcedony, other	12	1.6
Silicified Wood	87	11.7
Quartzite, fine grain	11	1.5
Quartzite, medium/coarse	7	.9
Quartzitic sandstone	5	.7
Chert, brown	24	3.2
Chert, tan	39	5.2
Chert, gray	33	4.4
Chert, black	10	1.3
Socorro Peak Jasper	31	4.2
Socorro Peak Jasper-grainy	197	26.5
Chert, pink	2	.3
Chert, white	1	.1
Chert, fossiliferous white	17	2.3
Chert, fossiliferous gray	2	.3
Chert, layered	1	.1
Chert, banded gray	1	.1
Chert, Chuska	3	.4
Chert, Jarilla	13	1.7
Jasper	3	.4
Jasper, dendritic	30	4.0
Moss agate, yellow	6	.8
Obsidian	82	11.0
Obsidian, Jemez, brown	1	.1
Granite	1	.1
Limestone	2	.3
Limestone, fossiliferous	1	.1
Total	**744**	**100.0**

Table 14. Analytical Unit 2 Artifact Types.

Artifact Type	N	%
Angular Debris	16	5.1
Flake	284	90.4
Core, Irregular	2	.6
Flake, Utilized	2	.6
Unknown Ground Stone	1	.3
Mano, Unknown	1	.3
Metate, Unknown	8	2.5
Total	**314**	**100.0**

Analytical Unit 3

This AU corresponds with Study Unit 3 and is 10 west of SU 2. We excavated 19 sq m in this area and recovered 533 lithic artifacts, including 30 ground stone fragments (Table 16). Other artifacts included an unidentifiable dart point tip and a large obsidian biface (Figure 13). Materials in this unit are dominated by coarse-grained Socorro Peak jasper (Table 17) and the unit has significantly low proportions of Rio Grande chalcedony, silicified wood, obsidian, and Jarilla chert.

Table 15. Analytical Unit 2 Material Types.

Material Type	N	%
Chalcedony with black inclusions	32	10.2
Chalcedony with red inclusions	4	1.3
Chalcedony with black and red inclusions	2	.6
Chalcedony, clear	1	.3
Chalcedony, opaque	1	.3
Chalcedony, other	2	.6
Silicified Wood	22	7.0
Quartzite, fine grain	16	5.1
Quartzitic sandstone	4	1.3
Chert, brown	22	7.0
Chert, tan	37	11.8
Chert, gray	15	4.8
Chert, black	9	2.9
Socorro Peak Jasper	37	11.8
Socorro Peak Jasper, grainy	59	18.8
Chert, pink	3	1.0
Chert, fossiliferous white	5	1.6
Chert, fossiliferous gray	2	.6
Chert, Chuska	1	.3
Chert, Jarilla	5	1.6
Chert, other	2	.6
Jasper, dendritic	1	.3
Obsidian	19	6.1
Obsidian, black opaque	1	.3
Basalt	3	1.0
Rhyolite, coarse grain	2	.6
Limestone	2	.6
Sandstone	5	1.6
Total	**314**	**100.0**

Table 16. Analytical Unit 3 Artifact Types.

Artifact Type	N	%
Angular Debris	20	3.8
Flake	475	89.1
Core, Irregular	2	.4
Flake, Utilized	1	.2
Projectile Point	1	.2
Biface	2	.4
Scraper	1	.2
Unknown Ground Stone	5	.9
Mano, Unknown	2	.4
Mano, One-Hand	2	.4
Metate, Unknown	21	3.9
Manuport	1	.2
Total	**533**	**100.0**

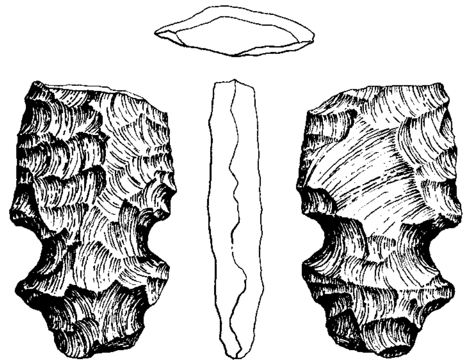

Figure 13. LA 126619 obsidian biface (actual size).

We also uncovered a small hearth in this unit (Feature 1, Figure 14), but it did not contain enough charcoal for an AMS date, nor were any burned macrobotanical present. The feature was an oval basin with 36 by 27 cm dimensions and a 10 cm depth. The fill was an ash-laden sand and there was no oxidation.

Table 17. Analytical Unit 3 Material Types.

Material	N	%
Chalcedony with black inclusions	31	5.8
Chalcedony with red inclusions	10	1.9
Chalcedony, yellow	1	.2
Chalcedony, other	3	.6
Silicified Wood	19	3.6
Silicified Wood, palm	3	.6
Quartzite, fine grain	24	4.5
Quartzite, medium/coarse	17	3.2
Quartzitic sandstone	25	4.7
Chert, brown	31	5.8
Chert, tan	31	5.8
Chert, gray	20	3.8
Chert, black	11	2.1
Socorro Peak Jasper	36	6.8
Socorro Peak Jasper-grainy	208	39.0
Chert, pink	1	.2
Chert, white	3	.6
Chert, fossiliferous white	6	1.1
Chert, banded gray	1	.2
Chert, clastic	1	.2
Chert, Fingerprint	3	.6
Chert, Jarilla	1	.2
Chert, other	1	.2
Jasper	1	.2
Jasper, dendritic	3	.6
Moss agate	2	.4
Obsidian	12	2.3
Obsidian, black opaque	2	.4
Basalt	9	1.7
Rhyolite, fine grain	4	.8
Limestone	8	1.5
Limestone, fossiliferous	2	.4
Sandstone	3	.6
Total	**533**	**100.0**

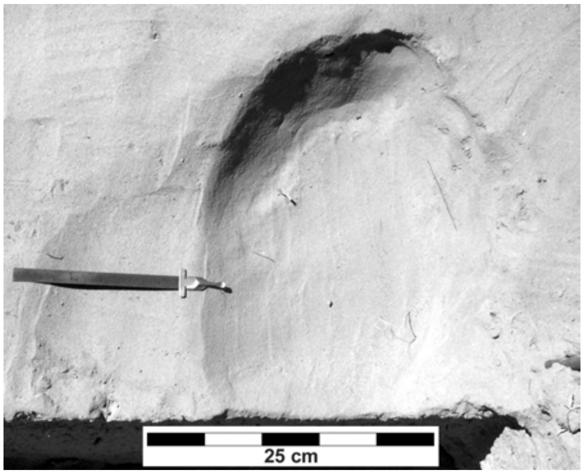

Figure 14. Feature 1.

Figure 16. Levallois style core.

Analytical Unit 5

Analytical Unit 5 corresponds with Study Unit 5. This area is north of US 380 and was located near a shovel test pit that yielded a fluted point base during the testing phase (Figure 15). Excavations in this unit consisted of 10 contiguous grids excavated from 60 to 80 cm depths to the Q2 stratum. The matrix in this unit consisted of an upper 30 to 40 cm of recent road-bed material. This stratum was slightly effervescent with carbonate flecking, caliche, and clay, and contained prehistoric cultural materials and modern trash. Within this matrix we found a dendritic jasper 'Levallois' style core that is typical during the Folsom period (Figure 16). Owing to these upper road deposits, it is likely that the fluted point base, located 10 cm below the surface, was also within this matrix. Below this disturbed stratum were apparent recent windblown Q4 deposits that overlay a thin, 10 to 12 cm deep Q3 Bk stratum .

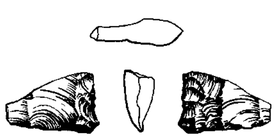

Figure 15. Fluted projectile point base (actual size).

Within the Q3 stratum, we uncovered a small ash lens measuring 1.5 by 70 cm with a 2 cm depth. A radiocarbon sample was collected, but it was insufficient for an AMS sample and it was not submitted to the radiocarbon lab. Table 18 lists the artifacts from this AU and the Levallois style core and fluted point base are included in the table. They are, however, the only materials that we collected from this upper disturbed stratum.

Within the Q3 Bk stratum, we recovered 244 lithic artifacts, including another projectile point fragment that is the 'ear' from a corner-notched dart point. It is too fragmentary to positively identify but it could be from a Shumla style point, which dates to the middle Archaic period, or it could be a late Archaic corner-notched style (Figure 17). Other artifacts include a concave scraper or spokeshave and 7 ground stone fragments. Material types (Table 19) in this area are dominated by a tan fine-grained quartzite and silicified woods and cherts are significantly low.

Table 18. Analytical Unit 5 Artifact Types.

Artifact Type	N	%
Angular Debris	5	2.0
Flake	227	92.3
Core Levallois type	1	.4
Flake, Utilized	1	.4
Flake, Retouched	1	.4
Projectile Point	2	.8
Biface	1	.4
Spokeshave	1	.4
Unknown Ground Stone	6	2.4
Metate, Unknown	1	.4
Total	**246**	**100.0**

Table 19. Analytical Unit 5 Material Types.

Material Type	N	%
Chalcedony with black inclusions	19	7.7
Chalcedony with red inclusions	4	1.6
Chalcedony, clear	1	.4
Silicified Wood	14	5.7
Quartzite, fine grain	6	2.4
Quartzite, medium/coarse	6	2.4
Quartzitic sandstone	4	1.6
Chert, brown	7	2.8
Chert, tan	12	4.9
Chert, gray	4	1.6
Socorro Peak Jasper	12	4.9
Socorro Peak Jasper-grainy	133	54.1
Chert, white	2	.8
Chert, fossiliferous white	1	.4
Chert, Fingerprint	1	.4
Chert, Jarilla	3	1.2
Jasper, dendritic	1	.4
Obsidian	7	2.8
Obsidian, Jemez	1	.4
Basalt	2	.8
Rhyolite, fine grain	1	.4
Rhyolite, coarse grain	2	.8
Schist	1	.4
Sandstone	2	.8
Total	**246**	**100.0**

Figure 17. Corner-notched projectile point fragment.

Analytical Unit 6

Analytical unit 6 corresponds with Study Unit 6 and is on the north side of US 380 in the northeast portion of the site. During the testing phase, we thought that intact Q3 strata were within this area. Our excavations in this unit consisted of 5 non-contiguous grids. None of the grids encountered intact Q3 deposits and basal caliche-gypsum was encountered within 12 cm of the modern surface. Fifty-five artifacts were recovered from these excavations (Tables 20 and 21).

Table 20. Analytical Unit 6 Artifact Types.

Artifact Type	N	%
Flake	52	94.5
Biface	1	1.8
Unknown Ground Stone	1	1.8
Metate, Unknown	1	1.8
Total	**55**	**100.0**

Table 21. Analytical Unit 6 Material Types.

Material Type	N	%
Chalcedony with black inclusions	5	9.1
Chalcedony with red inclusions	1	1.8
Chalcedony, clear	1	1.8
Silicified Wood	19	34.5
Quartzite, fine grain	1	1.8
Quartzite, medium/coarse	2	3.6
Socorro Peak Jasper-grainy	5	9.1
Chert, brown	3	5.5
Chert, tan	1	1.8
Chert, gray	1	1.8
Socorro Peak Jasper	5	9.1
Chert, pink	1	1.8
Chert, yellow	1	1.8
Chert, Jarilla	1	1.8
Jasper, dendritic	2	3.6
Obsidian	4	7.3
Sandstone	2	3.6
Total	**55**	**100.0**

Analytical Unit 7

Analytical Unit 7 corresponds with Study Unit 7 and is 25 m west of SU 3. This unit was mechanically surface stripped of Q4 deposits and we excavated 8 sq m to depths of 40 to 60 cm in the intact Q3 Bk stratum. This area contained only 23 lithic artifacts (Table 22)

composed mostly of various cherts. All materials were within a 20 cm level within the Q3 Bk stratum which was within the middle of the intact stratum.

Table 22. Analytical Unit 6 Artifacts.

Material	Flake	Used Flake	Metate Fragment
Chalcedony	2	1	-
Silicified Wood	3	-	-
Orthoquartz	-	-	1
Quartzitic sandstone	1	-	-
Chert, brown	3	-	-
Chert, red	4	-	-
Chert, white	4	-	-
Chert, banded	1	-	-
Chert, Jarilla	1	-	-
Obsidian	1	-	-
Sandstone	-	-	1
Total	**20**	**1**	**2**

The AU also contained a small hearth feature (Feature 5) that did not contain enough carbon for an AMS assay. The feature was an irregular oval basin with 58 by 37 cm dimensions and a 14 cm depth. The fill was an ash laden sand and there was no oxidation.

Analytical Unit 8

Analytical Unit 8 is Study Unit 8 and it is 25 m west of SU 7. Our excavations consisted of three non-contiguous grids in this area. This unit was explored because of "gray staining" in the adjacent stratigraphic trench and we needed to determine if the staining was cultural. The staining was located 30 cm below the modern ground surface and at the base of the Q3 Bk stratum. No cultural materials were found within the staining and only 11 chipped stone artifacts and two pieces of ground stone and two yellow ochre fragments were recovered from the excavation units below the gray staining (Table 23).

Analytical Unit 9

This AU corresponds with Study Unit 9 and is at the western edge of the site, 20 m west of AU 8. As in AU 8, we were exploring a gray stain in the stratigraphic trench. This area of the site was

Table 23. Analytical Unit 8 Artifacts.

Material	Flake	Metate Fragment	Pigment
Chalcedony	4	-	-
Orthoquartzite	2	-	-
Chert, tan	1	-	-
Jasper	1	-	-
Obsidian	3	-	-
Sandstone	-	3	-
Ochre	-	-	2
Total	**11**	**3**	**2**

the only area where we encountered intact Q3 Bw deposits above the Bk layer. The stain was in this upper Bw stratum about 30 cm below the modern ground surface and 20 cm above the Q3 Bk stratum. about 125 cm below the modern ground surface. These non-effervescent Bw sands were excavated and screened and contained no cultural materials.

Below the Bw stratum and in the Bk stratum we did recover 7 artifacts about 95 cm below the modern ground surface. These consisted of one piece of brown chert angular debris, one brown chert flake, two silicified wood flakes, one quartzite flake, one chalcedony flake, and one schist pestle.

Additional Excavations

After our excavations were completed mechanical stripping along the south side of US 380 uncovered two additional features. Both were hearths and one (Feature 6) was between Study Units 8 and 9, while the other (Feature 7) was adjacent to Study Unit 3. Feature 6 consisted of a large oval basin with 95 by 76 cm dimensions and a 15 cm depth (Figure 18). The fill of the feature was charcoal flecked gray sand and the sides and bottom of the feature were heavily oxidized. The feature was within the Q3 Bk stratum, about 60 cm below the modern ground surface and 20 cm above the Q2 stratum. Burned macrobotanical remains consisted only of 30 pieces of Atriplex/Sarcobatus (Saltbush/Greasewood) wood that probably used as fuel. An AMS radiocarbon sample (Beta 149349) dated to a 2-sigma calibrated age of AD 670 to AD 870. Since Feature 6 was discovered during the final stripping of the site, we did not discern or recover any additional features or artifacts in this area.

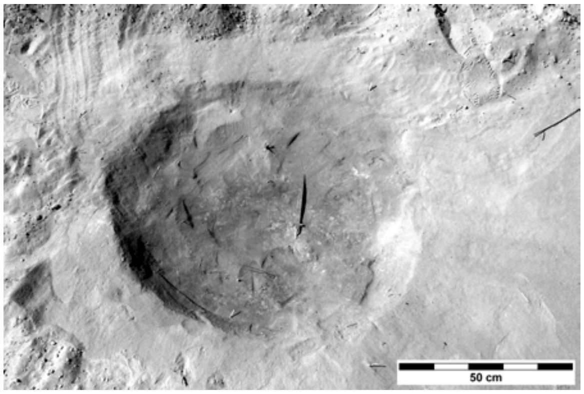

Figure 18. Feature 6 hearth.

Feature 7 was located adjacent to our AU 3 excavations. This feature consisted of an oval pit with 65 by 41 cm dimensions and a 21 cm depth. The pit had been excavated into the Q1 gypsum-caliche stratum (Figure 19) and was filled with burned rock and two burned one-hand manos, one burned unknown mano fragment, and two unidentifiable ground stone fragments. There were charcoal flecks, but no ash in the feature and the matrix was tan Q3 Bk sand. No burned macrobotanical materials were recovered from the feature.

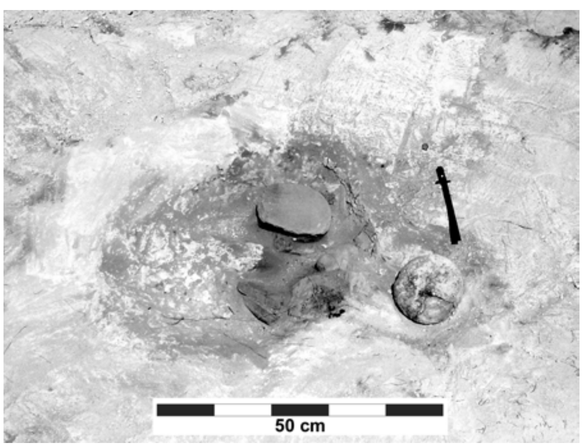

Figure 19. Feature 7 hearth.

This feature may have been a hearth used to prepare rock for stone boiling. The absence of ash-laden sand may have resulted from its placement in the gypsum-caliche stratum, which caused the deterioration of the ash. It is also possible that the elements within the feature were burned in another hearth and placed within this feature to act as a warming pit. An AMS radiocarbon sample dated to a 2-sigma calibrated age of AD 710 to AD 980 (Beta 149347).

Intrasite Comparisons

The various analytical units at LA 126619 exhibit a certain amount of redundancy in occupational function. All of the units contain some ground stone tools or tool fragments. The very small AU 9, which consisted of only two excavation units, contained only a pestle. All of the others contained varying amounts of mano and metate fragments. Most of these ground stone tools are burned and fragmentary, indicating their reuse as fire-cracked rock. Nevertheless, the presence of these tools, whether used as grinding implements or reused as heating elements, suggests the presence of domestic activities associated with hearth features and indicates that most if not all of the occupations at LA 126619 are the remains of short-term campsites occupied by small family groups.

Fire-cracked rock is also present in all of the units, except AU 9. It is diffusely and ubiquitously scattered throughout the units with no apparent concentrations. Most is composed of quartzite and limestone that is readily available along Chupadera Arroyo. Most, including the fragmentary ground stone, exhibits ragged or uneven breakage, which suggests its use for stone boiling. About 10% of the observed burned rock exhibited smooth spalled edges, indicating that it was not immersed in liquid. These may have been used for thermal retention in hearth or roasting features.

Other than burning up rocks and ground stone tools, lithic reduction is the most ubiquitous activity at LA 126619. Comparisons of the lithic materials at the site, however, suggest that differing material selection, reduction strategies, and techniques occur across the site area. We examined the reduction techniques by comparing the size and preparation of the striking platforms and the resultant flake scars on the dorsal side of the flakes.

The mean striking platform size is 18.78 sq mm (std=41.72 and the median is 4.7 sq mm. Table 24 lists the Analytical Units and the quartile distributions of striking platform size. The lower

two quartiles or half of the overall assemblage consists of platforms 4 sq mm or less. Both of these quartiles probably represent pressure flaking that occurred as either final edge preparation or rejuvenation of the edge of a formal tool. The last quartile, containing platform sizes greater than 18 sq mm probably represents flakes detached from cores. The adjusted residuals can be read as z-scores and scores higher than 1.96 or lower than -1.96 are significant at the 0.05 significance level.

Analytical Unit 1, a composite of unclustered grids in Study Units 1, 4, and 10, AU 4, AU 6, containing disturbed materials, and AU 12 all contain significantly high proportions of pressure flakes. In contrast, AU 3 and AU 5 appear to contain higher proportions of core flakes.

Table 25 lists the various types of striking platforms recorded in the LA 126619 assemblages. A simple comparison of prepared versus unprepared platforms, where cortical, single-facet, and multiple faceted are classed as unprepared, indicates significant differences in the Analytical Units (chi-square=52.66, 10df). Z-scores show Analytical Units 1, 10, and 12 have significantly high amounts of prepared platforms, while Analytical Units 3, 5, and 11 have significantly high amounts of unprepared platforms.

We recorded the various scar patterns on the dorsal flake surfaces, hoping to isolate areas with small flakes exhibiting a parallel ridge. Such flaking techniques are more common in certain Paleoindian periods, particularly Folsom, Midland, and Cody Complexes, than later Archaic periods. There is no overall difference in the proportion of flakes with one parallel dorsal ridge across the site area (chi-square=17.5, 11 df, prob.=0.09). An examination of the adjusted residuals, however, shows that Analytical Unit 5 has significantly low amounts of these flakes (z=-2.48), while Analytical Unit 12 has high amounts (z=2.78).
Table 26 lists the Analytical Units by grouped material types. The coarse-grained materials from Socorro Peak were lumped with quartzites in this table since both have similar flaking and fracture characteristics. Materials in the 'other' category include limestone, sandstone, and ochre, and materials in the igneous category include rhyolite, granite, and schist. Analytical Units 2 and 5 exhibit more coarse grained cherts

Table 24. Platform Sizes.

AU		Quartiles of Platform Size				TOTAL
		1–2 mm	2.1–4.0 mm	4.1–18.0 mm	> 18 mm	
1	Count % Within AU Adjusted Residual	49 33.1 4.0	38 25.7 -.4	32 21.6 -1.5	29 19.6 -1.8	148 100.0
2	Count % Within AU Adjusted Residual	8 12.9 -1.7	14 22.6 -.8	24 38.7 2.3	16 25.8 .1	62 100.0
3	Count % Within AU Adjusted Residual	13 14.9 -1.5	18 20.7 -1.4	19 21.8 -1.0	37 42.5 3.9	87 100.0
4	Count % Within AU Adjusted Residual	18 17.6 -.9	52 51.0 5.9	19 18.6 -1.9	13 12.7 -3.2	102 100.0
5	Count % Within AU Adjusted Residual	2 3.1 -3.7	15 23.4 -.7	23 35.9 1.8	24 37.5 2.3	64 100.0
6	Count % Within AU Adjusted Residual	3 23.1 .2	7 53.8 2.2	2 15.4 -.9	1 7.7 -1.5	13 100.0
7	Count % Within AU Adjusted Residual	1 33.3 .5	1 33.3 .2	1 33.3 .3	0 .0 -1.0	3 100.0
9	Count % Within AU Adjusted Residual	0 .0 -.7	1 50.0 .7	1 50.0 .8	0 .0 -.8	2 100.0
10	Count % Within AU Adjusted Residual	20 26.3 1.2	22 28.9 .4	14 18.4 -1.7	20 26.3 .2	76 100.0
11	Count % Within AU Adjusted Residual	11 14.5 -1.5	12 15.8 -2.3	27 35.5 1.9	26 34.2 1.9	76 100.0
12	Count % Within AU Adjusted Residual	25 33.3 2.7	11 14.7 -2.5	25 33.3 1.4	14 18.7 -1.4	75 100.0
Total		**150**	**191**	**187**	**180**	**708**

Adjusted residuals <-1.96 and >1.96 significant at .05 probability

Table 25. Platform Type by Analytical Unit.

Platform		Analytical Unit 1	2	3	4	5	6	7	9	10	11	12	Total
Cortical	Count	6	3	5	0	3	0	0	0	3	3	2	25
	% Within AU	4.1	4.8	5.7	.0	4.7	.0	.0	.0	3.9	3.9	2.7	3.5
	Adjusted Residual	.4	.6	1.2	-2.1	.5	-.7	-.3	-.3	.2	.2	-.4	
Single Facet	Count	67	36	54	55	52	3	2	2	30	48	31	380
	% Within AU	45.0	58.1	62.1	53.9	81.3	23.1	66.7	100.0	39.5	63.2	41.3	53.7
	Adjusted Residual	-2.3	.7	1.7	.1	4.6	-2.2	.5	1.3	-2.6	1.8	-2.3	
Multi-Facet	Count	3	0	2	0	0	0	0	0	1	3	2	11
	% Within AU	2.0	.0	2.3	.0	.0	.0	.0	.0	1.3	3.9	2.7	1.6
	Adjusted Residual	.5	-1.0	.6	-1.4	-1.1	-.5	-.2	-.2	-.2	1.8	.8	
Retouched	Count	1	3	1	1	0	0	0	0	0	0	5	11
	% Within AU	.7	4.8	1.1	1.0	.0	.0	.0	.0	.0	.0	6.7	1.6
	Adjusted Residual	-1.0	2.2	-.3	-.5	-1.1	-.5	-.2	-.2	-1.2	-1.2	3.8	
Stepped	Count	8	2	1	0	1	0	0	0	5	0	4	21
	% Within AU	5.4	3.2	1.1	.0	1.6	.0	.0	.0	6.6	.0	5.3	3.0
	Adjusted Residual	2.0	.1	-1.1	-1.9	-.7	-.6	-.3	-.2	2.0	-1.6	1.3	
Ground	Count	61	17	20	36	6	10	1	0	31	20	31	233
	% Within AU	41.0	27.4	23.0	35.3	9.4	76.9	33.3	.0	40.8	26.3	41.3	32.9
	Adjusted Residual	2.4	-1.0	-2.1	.6	-4.2	-3.4	.0	-1.0	1.5	-1.3	1.6	
Retouched Ground	Count	0	0	1	0	0	0	0	0	1	1	0	3
	% Within AU	.0	.0	1.1	.0	.0	.0	.0	.0	1.3	1.3	.0	.4
	Adjusted Residual	-.9	-.5	1.1	-.7	-.5	-.2	-.1	-.1	1.3	1.3	-.6	
Stepped Ground	Count	1	0	0	0	2	0	0	0	0	1	0	4
	% Within AU	.7	.0	.0	.0	3.1	.0	.0	.0	.0	1.3	.0	.6
	Adjusted Residual	.2	-.6	-.8	-.8	2.9	-.3	-.1	-.1	-.7	.9	-.7	
Battered	Count	0	0	1	0	0	0	0	0	0	0	0	1
	% Within AU	.0	.0	1.1	.0	.0	.0	.0	.0	.0	.0	.0	.1
	Adjusted Residual	-.5	-.3	2.7	-.4	-.3	-.1	-.1	-.1	-.3	-.3	-.3	
Reduced	Count	1	1	2	9	0	0	0	0	5	0	0	18
	% Within AU	.7	1.6	2.3	8.8	.0	.0	.0	.0	6.6	.0	.0	2.5
	Adjusted Residual	-1.6	-.5	-.2	4.4	-1.4	-.6	-.3	-.2	2.4	-1.5	-1.5	
Isolated Ground	Count	0	0	0	1	0	0	0	0	0	0	0	1
	% Within AU	.0	.0	.0	1.0	.0	.0	.0	.0	.0	.0	.0	.1
	Adjusted Residual	-.5	-.3	-.4	2.4	-.3	-.1	-.1	-.1	-.3	-.3	-.3	
Total		**148**	**62**	**87**	**102**	**64**	**13**	**3**	**2**	**76**	**76**	**75**	**708**

Adjusted residuals <-1.96 and >1.96 significant at .05 probability

Table 26. Analytical Unit by Grouped Material Types.

Grouped Material Type		Analytical Unit												
		1	2	3	4	5	6	7	8	9	10	11	12	Total
Rio Grande Chalcedony	Count	239	39	41	93	24	7	3	4	1	61	41	111	664
	% Within AU	14.4	12.5	7.7	13.7	9.8	13.0	13.0	25.0	14.3	15.5	11.0	14.9	13.2
	Adjusted Residual	1.8	-.4	-3.9	.4	-1.6	.0	.0	1.4	.1			1.5	
Chalcedony Other	Count	39	3	4	3	0	0	0	0	0	2	11	23	85
	% Within AU	2.3	1.0	.8	.4	.0	.0	.0	.0	.0	.5	3.0	3.1	1.7
	Adjusted Residual	2.6	-1.0	-1.8	-2.7	-2.1	-1.0	-.6	-.5	-.3	-1.9	2.0	3.2	
Silicified Wood	Count	182	22	22	82	14	19	3	0	2	49	18	87	500
	% Within AU	11.0	7.0	4.2	12.1	5.7	35.2	13.0	.0	28.6	12.4	4.8	11.7	9.9
	Adjusted Residual	1.7	-1.8	-4.7	2.0	-2.3	6.2	.5	-1.3	1.7	1.7	-3.4	1.7	
Quartzite and Coarse Chert	Count	382	79	274	99	149	8	2	2	1	48	114	220	1378
	% Within AU	23.0	25.2	51.7	14.6	60.8	14.8	8.7	12.5	14.3	12.2	30.6	29.6	27.4
	Adjusted Residual	-4.9	-.9	13.3	-8.0	12.0	-2.1	-2.0	-1.3	-.8	-7.0	1.5	1.5	
Chert	Count	537	134	150	238	40	13	12	2	2	146	126	203	1603
	% Within AU	32.3	42.8	28.3	35.1	16.3	24.1	52.2	12.5	28.6	37.1	33.9	27.3	31.8
	Adjusted Residual	.5	4.3	1.8	2.0	-5.3	-1.2	2.1	-1.7	-.2	2.3	.9	-2.9	
Jarilla Chert	Count	18	5	1	17	3	1	1	0	0	12	4	13	75
	% Within AU	1.1	1.6	.2	2.5	1.2	1.9	4.3	.0	.0	3.0	1.1	1.7	1.5
	Adjusted Residual	-1.7	.2	-2.6	2.4	-.4	.2	1.1	-.5	-.3	2.7	-.7	.6	
Obsidian	Count	246	19	12	134	7	4	1	3	0	55	38	83	602
	% Within AU	14.8	6.1	2.3	19.8	2.9	7.4	4.3	18.8	.0	14.0	10.2	11.2	12.0
	Adjusted Residual	4.4	-3.3	-7.3	6.7	-4.5	-1.0	-1.1	.8	-1.0	1.3	-1.1	-.7	
Igneous	Count	8	5	13	9	6	0	0	0	0	16	2	1	60
	% Within AU	.5	1.6	2.5	1.3	2.4	.0	.0	.0	.0	4.1	.5	.1	1.2
	Adjusted Residual	-3.3	.7	2.8	.4	1.9	-.8	-.5	-.4	-.3	5.5	-1.2	-2.9	
Other	Count	10	7	13	3	2	2	1	5	1	5	18	3	70
	% Within AU	.6	2.2	2.5	.4	.8	3.7	4.3	31.3	14.3	1.3	4.8	.4	1.4
	Adjusted Residual	-3.3	1.3	2.2	-2.3	-.8	1.5	1.2	10.2	2.9	-.2	5.9	-2.5	
Total		**1661**	**313**	**530**	**678**	**245**	**54**	**23**	**16**	**7**	**394**	**372**	**744**	**5037**

Adjusted residuals <-1.96 and >1.96 significant .05 probablity

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Table 27. Material Origin.

Material Origin		Analytical Unit												Total
		1	2	3	4	5	6	7	8	9	10	11	12	
Rio Grande Valley	Count	1148	211	284	489	97	42	17	13	6	274	243	460	3284
	% Within AU	69.1	67.2	53.3	72.1	39.4	76.4	73.9	81.3	85.7	69.5	65.3	61.7	65.1
	Adjusted Residual	4.2	.8	-6.1	4.1	-8.7	1.8	.9	1.4	1.1	1.9	.1	-2.1	
Socorro Peak	Count	467	96	244	159	145	10	5	2	1	101	110	228	1568
	% Within AU	28.1	30.6	45.8	23.5	58.9	18.2	21.7	12.5	14.3	25.6	29.6	30.6	31.1
	Adjusted Residual	-3.2	-.2	7.7	-4.6	9.7	-2.1	-1.0	-1.6	-1.0	-2.4	-.7	-.3	
Oscura Mountains	Count	7	0	1	1	0	0	0	0	0	2	7	11	29
	% Within AU	.4	.0	.2	.1	.0	.0	.0	.0	.0	.5	1.9	1.5	.6
	Adjusted Residual	-1.0	-1.4	-1.3	-1.6	-1.2	-.6	-.4	-.3	-.2	-.2	3.5	3.5	
Cerro Colorado	Count	20	1	3	12	1	2	0	1	0	5	8	30	83
	% Within AU	1.2	.3	.6	1.8	.4	3.6	.0	6.3	.0	1.3	2.2	4.0	1.6
	Adjusted Residual	-1.7	-1.9	-2.1	.3	-1.6	1.2	-.6	1.5	-.3	-.6	.8	5.5	
Jarilla Mountains	Count	18	5	1	17	3	1	1	0	0	12	4	13	75
	% Within AU	1.1	1.6	.2	2.5	1.2	1.8	4.3	.0	.0	3.0	1.1	1.7	1.5
	Adjusted Residual	-1.7	.2	-2.6	2.4	-.4	.2	1.1	-.5	-.3	-.7	2.7	.6	
Chuska Mountains	Count	1	1	0	0	0	0	0	0	0	0	0	3	5
	% Within AU	.1	.3	.0	.0	.0	.0	.0	.0	.0	.0	.0	.4	.1
	Adjusted Residual	-.6	1.3	-.8	-.9	-.5	-.2	-.2	-.1	-.1	-.7	-.6	2.9	
Total		**1661**	**314**	**533**	**678**	**246**	**55**	**23**	**16**	**7**	**394**	**372**	**745**	**100.0**

Adjusted residuals <-1.96 and >1.96 significant .05 probablity

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and quartzites and lesser amounts of the finer grained silicified woods, chalcedonies and cherts.

Table 27 lists the Analytical Units by the lithic material origin. The vast majority of cherts and silicified wood from the assemblages occur in the Rio Grande Valley gravels. Distinctive material types from the assemblages include Chuska chert from the Chuska Mountains, Jarilla chert from the Jarilla Mountains, and jasper from Socorro Peak. The Oscura Mountains may be the source of a yellow chalcedony (Amick 1994) and the dendritic jaspers from the site may be from the small Cerro Colorado peak 12 mi southwest of the project area (Robert Weber personal communication April 2000). All but the AUs with very small samples contain some materials from the Jarilla Mountains, 140 mi to the southeast. Only five flakes were identified from the Chuska Mountains, some 245 mi to the northwest, and these are in three Analytical Units. Most of the materials are from areas west of project area in the Rio Grande Valley and Socorro Peak.

Interpretation and Summary

LA 126619 contains the remains of numerous occupational episodes. Diagnostic lithic artifacts indicate occupations during the early and middle to later Archaic period. An ephemeral Paleoindian occupation is also indicated by a channel flake, lithic materials from the Chuska Mountains and a redeposited fluted projectile point base and Levallois style core. Other materials from the Jarilla Mountains, Socorro Peak, and the Rio Grande Valley indicate a mobile settlement pattern. Burned rock and ground stone are found throughout the site area, and hearth features are consistent with sites occupied by small family groups. At these small residential sites, seeds were collected, prepared, and consumed, and hunting activities are inferred by the by-products of formal tool refurbishment and the discard of broken projectile points.

The artifact density is greatest near the east-end of the site and closest to Chupadera Arroyo. As our excavations moved to the west and further from the arroyo, the occupations became more ephemeral. These sparse artifact scatters may represent a shorter occupational duration, and certainly do not exhibit overlapping or reuse occupations. Some of the materials at the west-end of the site may also be similar to LA 126620 and represent hunting and gathering activities that occur away from the campsite.

The artifact assemblages are completely consistent with hunter and gatherer materials that typically date to the Archaic period from 5000 BC to AD 400. The radiocarbon dates from the site, however, indicate a much later occupation during the Formative Period (Table 28). There are two possible reasons for the discrepancy in the artifacts and the radiocarbon dates post Archaic hunters and gatherers or complete contamination of the charcoal.

Since the artifacts closely resemble those from hunter and gatherer assemblages, it seems very unlikely that these occupations are related to any of the local sedentary Formative populations. Post Archaic hunters and gatherers are known to persist in the eastern New Mexico plains and their artifact assemblages are very similar to the Archaic, except that the bow and arrow and ceramics have been introduced into the assemblages. Since all of the recovered projectile points were Archaic dart types, and since no ceramics were recovered from the site, it seems unlikely that the dates are correct. This issue is discussed further in Chapter 9.

LA 126620

Introduction

Our investigations at LA 126620 suggest that this diffuse and dispersed lithic scatter resulted from numerous occupational episodes. Artifacts from the survey, testing, and excavations indicate occupations in the Archaic and possibly the early Archaic or late Paleoindian periods. The survey reported San Rafael and Plainview or Bajada projectile points and 24 flakes composed of cherts, quartzites, and basalt. The surface scatter measures 40 by 25 m and lies to the north of US 380 and beyond the limits of the proposed construction limits. Testing in the fall of 1999 indicated that subsurface artifacts were present outside the limits of the surface scatter and within the buffer limits of the proposed construction.

Location and Setting

The site is about 400 m east of Chupadera Arroyo and lies within a shallow swale that dips slightly to the west and northwest (Figure 20). The swale is along western side a broad ridge that parallels Chupadera Arroyo. The area is stable with no blowouts and no exposed caliche. The ridge is within a stable shrub grassland anchored by sage, ephedra, yucca and various grasses.

Strategy and Methods

Our 1999 tests and stratigraphic trench indicated an upper 7 to 10 cm lens of unconsolidated reddish sand (5YR 5/6). This appears to be a recent windblown sediment or Q4 deposit. Beneath the Q4, the deposits become more compact, slightly effervescent, and a distinct color change (5YR–2.5YR 4/5) is evident. This stratum (Q3) is 50 to 91 cm thick and exhibits a gradual increase of caliche flecking that ends on a strongly effervescent stratum with caliche nodules.

Data recovery at LA 126620 consisted of 16 sq m of excavation and a stratigraphic trench. Our hand excavations included a contiguous block of 14 sq m and two isolated units to the east of the block. These units had depths that ranged from 38 to 66 cm and averaged 45 cm. The upper recent Q4 deposits were removed by hand without screening and had a depth of 5 to 12 cm. All units were excavated to the older Q2 stratum that was discerned by caliche flecking, strong effervescence and an absence of cultural materials.

Data Recovery Results

We recovered 66 lithic artifacts from our excavations and 1999 test pits. We did not locate any features and we did not recover any fire-cracked rock. The artifacts from these excavation units were not found in consistent levels within the Q3 stratum, and there is no apparent spatial patterning. Instead, sparse artifacts were located throughout the 45 cm thick Q3 stratum. One grid could recover an artifact from the 99.60 level and an adjacent grid could contain nothing or a flake from the 99.20 level. No 10 cm level contained more than six artifacts while most contained only one or two items.

Artifacts

Table 29 lists the artifacts from both the testing (*n*=6) and excavation phases. These consist mainly of flakes, but also include an expedient flake tool and two bifaces. The bifaces include a serrated projectile point tip, and an unknown late stage fragment. The flake assemblage is composed mostly of small thin flakes with a mean length of 13.92 mm (7.31 std) and mean thickness of 2.75 mm (1.79 std). These small thin flakes suggest final tool manufacture or tool refurbishment activities. An absence of cortex on all but three of the artifacts also suggests final stage lithic reduction activities.

Table 28. LA 126619 Radiocarbon Dates.

Beta No.	Site	Feature	2 Sigma Calibrated Date	Radiocarbon Age	Intercepts
149344	LA 126619	SU 4, FS 260	AD 1020–1200	930±40 BP	AD 1100
149345	LA 126619	Feature 4	AD 650–770	1330±40 BP	AD 680
149346	LA 126619	Feature 3	AD 1050–1100	850±40 BP	AD 1200
149347	LA 126619	Feature 7	AD 710–980	1180±50 BP	AD 880
149348	LA 126619	SU 10, FS 472	AD 880–1010	1100±40 BP	AD 970
149349	LA 126619	Feature 6	AD 670–870	1270±40 BP	AD 740
149350	LA 126619	SU 4, FS 307	AD 1180–1280	1270±40 BP	AD 1250

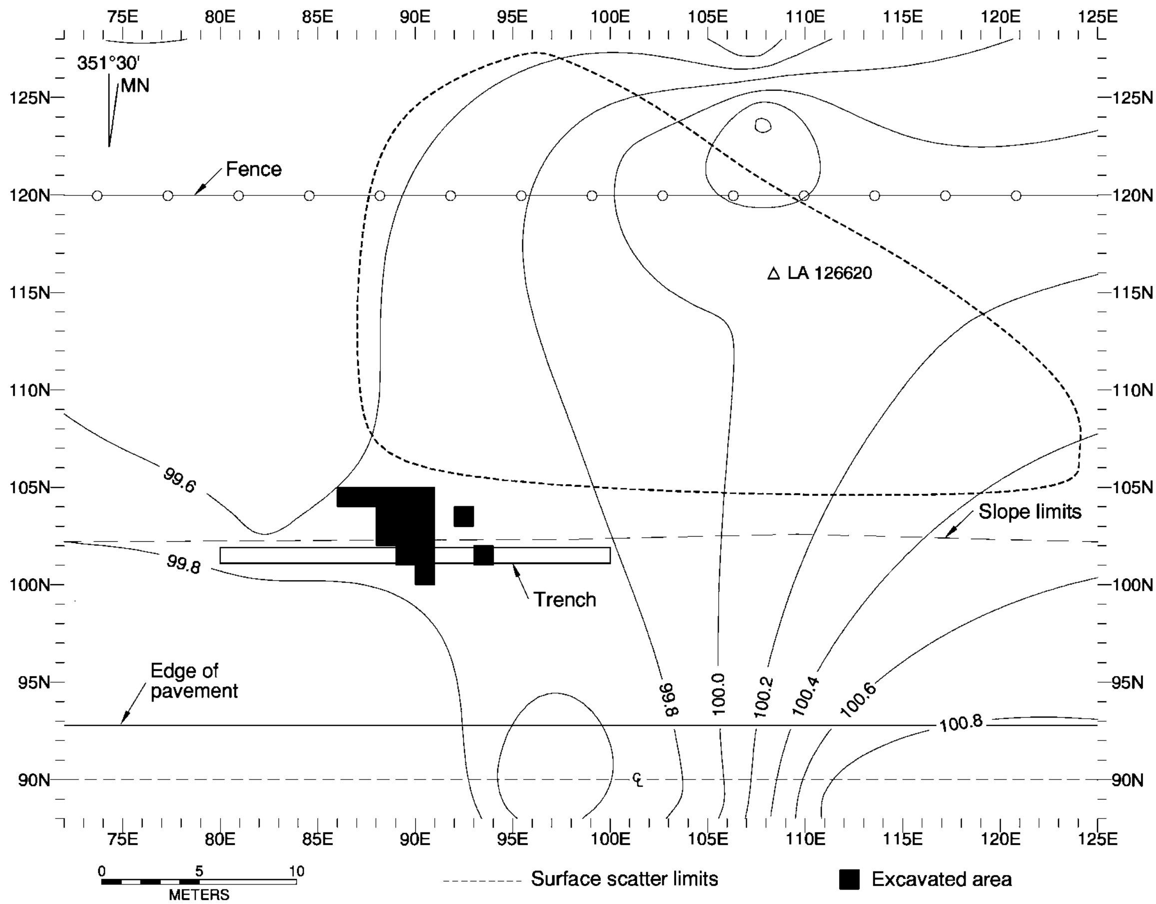

Figure 20. LA 126620 plan and excavation units.

Table 29. LA 126620 lithic artifacts.

Material	Angular Debris		Flake		Used Flake		Biface		Total	
	N	%	N	%	N	%	N	%	N	%
Chalcedony with black inclusions	1	25.0	-	-	-	-	-	-	1	1.5
Chalcedony with red inclusions	-	-	1	1.7	-	-	-	-	1	1.5
Chalcedony, clear	-	-	1	1.7	-	-	-	-	1	1.5
Silicified Wood	-	-	2	3.4	-	-	-	-	2	3.0
Quartzite, fine grained	-	-	7	11.9	1	100.0	-	-	8	12.1
Quartzite, medium/coarse grain	-	-	1	1.7	-	-	-	-	1	1.5
Chert, brown	1	25.0	17	28.8	-	-	1	50.0	19	28.8
Chert, tan	1	25.0	8	13.6	-	-	1	50.0	10	15.2
Chert, gray	-	-	11	18.6	-	-	-	-	11	16.7
Socorro Peak jasper	-	-	4	6.8	-	-	-	-	4	6.1
Socorro Peak jasper coarse grain	-	-	4	6.8	-	-	-	-	4	6.1
Rhyolite, fine grain	1	25.0	3	5.1	-	-	-	-	4	6.1
Total	4	100.0	59	100.0	1	100.0	2	100.0	66	100.0

Interpretation and Summary

We postulated three possible reasons for the paucity of materials in our excavation units. One, the materials were redeposited; two, we were on the periphery of a site area; or three, the materials are an accumulation of unrelated and very short-term events. There was no obvious evidence for colluvial or alluvial erosion in any of our units and the eolian deposits appeared as stable as other Q3 units in the area. Consequently, erosion does not appear to account for the paucity and dispersal of the materials. We did not discern an increase in artifact density as our units approached the northern limits of our excavation area. These northern units are immediately adjacent to the southern limits of site as mapped during the survey. Since we did not encounter an increase in artifact density, we do not believe that our units are peripheral to a campsite activity area. Therefore, we believe that the most plausible explanation for the diffuse and sparse artifacts is that they are the accumulation of artifacts from possibly unrelated and very short-term events. These short-term events can be related to hunting or plant-gathering activities, can last a few minutes or hours, and occur away from the main campsite areas. Usually when there is an accumulation of artifacts from such events, they are located in a specific physiographic or environmental area that is attractive over a long period. This site is located on the northwest side of a broad ridge with an overview of Chupadera Arroyo and in a slight swale that offers some protection from east and south winds.

An examination of the materials recorded by the survey indicates that the diffuse surface scatter contained no apparent concentrations and had 26 lithic artifacts in a 40 by 25 m area. The artifacts also include two projectile points, one from the middle Archaic period (San Rafael) and one from the late Paleoindian or early Archaic period. These artifacts are suggestive of non-site activities that occur away from residential campsites and the projectile points suggest that the area was used as a hunting overlook for at least some of these activities.

Our excavations confirm the diffuse and ephemeral nature of this artifact scatter and the recovery of artifacts in widespread levels of the Q3 stratum suggests that the materials have accumulated over a long period. The absence of any features or any fire-cracked rock also indicates that the area was not used as a residential campsite.

6 ANALYSIS OF THE LITHIC ASSEMBLAGES

by Janette M. Elyea

This chapter discusses the various lithic technological systems employed by the inhabitants in the project area. Since Paleoindian materials were known to exist immediately adjacent to LA 126619, we attempted to examine the materials at this site to determine if any Paleoindian materials were included in the excavated site area. Our examination of all of these technologies targets the debitage or by-products of tool manufacture. Although diagnostic projectile points from the Archaic period and a channel flake and point fragment from the Paleoindian period are included in the overall assemblage, diagnostic materials are generally lacking.

DEFINITIONS AND ANALYTICAL PROCEDURES

Artifact Types

Debitage

The unused, unretouched waste flakes include seven classifications.

Angular debris exhibits conchoidal fractures indicative of cultural manufacture but lacks definable dorsal and ventral surfaces. This is usually produced during core reduction processes and is unintentional.

Flakes exhibit distinguishable dorsal and ventral surfaces and may be the by-products of core, bifacial or unknown reduction processes.

Bifacial reduction flakes have a curvate longitudinal cross section, a prepared platform, and bi-directional dorsal flake scars. These criteria dictate a conservative classification of these items. Many by-products of bifacial manufacturing processes do not have these characteristics and would be classified as flakes.

Sharpening flakes are small, thin flakes that are the by-products of sharpening or resharpening a formal tool.

Chipped Tools

Chipped stone tools include functional classifications that are based upon their overall morphology and shape. They include used-unretouched flakes, retouched flakes, used-unretouched angular debris, scrapers, bifaces, drills, unifaces, projectile points (arrow and dart types), and spokeshaves (concave scrapers). The distance of use or retouch from the edge of the tool was measured in millimeters and the direction of the use was recorded as dorsal, ventral or both. The location of the used or retouched edge includes the right, distal, left, or proximal flake portion (with the item placed ventral side down). The shape of the utilized area was either straight, concave, convex, beaked, pointed, or wavy. The length of the used portion includes either fragmentary or complete and measurements are to the nearest millimeter. Edge angles to the nearest degree were recorded for all chipped tools.

Cores

The cores include categories based on their shape and sequence of reduction. Within this assemblage only two core types were present. These are irregular, which have flakes removed in three or more directions, and levallois style, which have a distinctive ‘turtle-back’ shape. Only 7 cores were present in the entire US 380 assemblage, and except for the 'levallois-like’ core, all were small fragments no longer useful for flake production.

Ground Stone

Ground stone items include manos, metates, and unknown. An unknown ground stone classification applies if no other determination could be made. All of the identifiable manos are one-hand forms. The metates in the assemblage are unknown fragmentary forms. A pestle is an active grinding tool with use on a pointed or projected end.

Condition

The condition or portion of all artifacts includes complete, proximal, medial, distal, lateral, and unknown fragment.

Cortex

Cortex information excludes ground stone tools, but pertains to all other artifact types. It was collected in 10 percent intervals that included none, 1–10 percent, 11–20 percent, etc. This percentage reflects only the dorsal surface of flakes and flake tools, and the entire artifact surfaces for angular debris, bifacial tools, and cores.

Platform Type

Striking platforms types include ten categories. These are cortical, single facet with one planar surface, multifacet with two or more flake scars wider than 1 mm, retouched with two or more flake scars less than 1 mm wide, stepped, ground, retouched and ground (in combination), stepped and ground, single facet and ground, and collapsed. Cortical and single facet platforms are generally unprepared striking surfaces, while stepped, ground, retouched, retouched and ground, and stepped and ground indicate platform modification or preparation. Multifaceting may be the result of intentional modification or fortuitous reduction.

Measurements

Length, width, and thickness are measurements to the nearest millimeter for all complete flake and flaked artifacts, and all complete ground stone and massive tool implements. Thickness measurements include all flaked artifact condition types whether complete or fragmentary. Platform length and thickness were measured to the nearest millimeter.

Material Types

Table 30 lists the material types identified during the analysis. Northern Jornada sources include a red jasper from the Socorro Peak area. This blood red jasper has variable texture that ranges from opaline to coarse. Yellow chalcedony is suggested by Amick (1994) as having a possible Oscura Mountain source. Dendritic jaspers are located in the Rio Grande gravels as well as Cerro Colorado Peak, 12 mi southwest of the study area. Very few useable lithic materials are found immediately adjacent to the study area. The gravels exposed along the edges of Chupadera Arroyo contain some cherts, but are too small to be useable. Some useable sized pieces of material indistinguishable from the coarse-grained variety of Socorro Peak jasper are present along the arroyo. Identifiable materials from distant scources include chert from the Chuska Mountains, about 240 mi northwest of the area, and chert from the Jarilla Mountains, about 140 mi south-southeast of the area. The Rio Grande Basin, 17 mi west, contains an abundant variety of high quality cherts, silicified woods, and chalcedonies. All but three obsidian flakes appear to originate from sources in the Jemez Mountains. These obsidians are present in the Rio Grande valley and three items with cortex appeared to derive from a cobble origin. The three black opaque obsidians originate from the Mt. Taylor Grants New Mexico area.

REDUCTION ANALYSIS

This section examines the by-products or debitage from the manufacture and maintenance of the tools used to procure and process food and technological resources. Our primary concern during this analysis is distinguishing debitage resulting from tool manufacture, tool refurbishment, and tool maintenance. In general, we expect formal tool manufacturing to occur in anticipation of a particular set of resource procurement and processing activities. Tool maintenance and refurbishment, on the other hand, is likely to be directly associated with the procurement and processing of food resources. Edged tools need to be re-sharpened periodically during use. Similarly, if a formal tool is broken during the procurement or processing of a particular resource, then we would expect hunter-gatherers to attempt to refurbish that tool rather than to expend the time and effort needed to manufacture a new implement.

Not all resource procurement activities are likely to involve the use of formal tools. In many cases, a more energy-efficient strategy might be to use simple flake or core tools. We would

expect such tools to wear rapidly during use but because new tools could be readily manufactured, worn tools would probably be discarded rather than re-sharpened or refurbished. Consequently, the debitage resulting from the use of such implements should be limited to the kinds of debris associated with the earliest stages of lithic tool production.

Table 30. US 380 Material Types.

MATERIAL	N	%
Chalcedony with black inclusions	554	9.8
Chalcedony with red inclusions	187	3.3
Chalcedony with black and red incl.	11	.2
Chalcedony, clear	12	.2
Chalcedony, yellow	29	.5
Chalcedony, opaque	4	.1
Chalcedony, other	52	.9
Silicified Wood	517	9.1
Silicified Wood, palm	5	.1
Silicified Wood, red	7	.1
Quartzite, fine grain	106	1.9
Quartzite, medium/coarse	71	1.3
Quartzitic sandstone	73	1.3
Chert, brown	424	7.5
Chert, tan	417	7.3
Chert, gray	188	3.3
Chert, black	90	1.6
Socorro Peak Jasper	436	7.7
Socorro Peak Jasper-grainy	1166	20.5
Chert, pink	21	.4
Chert, yellow	2	.0
Chert, white	9	.2
Chert, fossiliferous white	90	1.6
Chert, fossiliferous gray	4	.1
Chert, layered	1	.0
Chert, banded	9	.2
Chert, banded gray	4	.1
Chert, clastic	1	.0
Chert, brown with black inclusions	22	.4
Chert, Brushy Basin	75	1.3
Chert, Chinle	1	.0
Chert, Chuska	5	.1
Chert, Fingerprint	5	.1
Chert, Jarilla	131	2.3
Chert, other	4	.1
Jasper	6	.1
Jasper, dendritic	88	1.6
Moss Agate-yellow	6	.1
Moss Agate	13	.2
Red Moss Agate	21	.4
Obsidian, Jemez	669	11.8
Obsidian, black opaque	3	.1
Obsidian, Jemez, brown	1	.0
Basalt	20	.4
Rhyolite, fine grain	28	.5
Rhyolite, coarse grain	12	.2
Granite	1	.0
Schist	2	.0
Pumice	1	.0
Volcanic, other	1	.0
Limestone	29	.5
Limestone, fossiliferous	17	.3
Sandstone	22	.4
Ocher	3	.1
Total	**5676**	**100.0**

The analysis needed to identify these debitage profiles is basically a problem of pattern recognition. In order to discern such patterns we have examined the amount of dorsal cortex, flake size, the striking platforms, and the size of the striking platforms of the various site assemblages.

In Chapter 4, we discussed the different economic systems associated with the Paleoindian, Archaic, and Formative periods. Mobility is the essential adaptive strategy that distinguished these periods, with a highly mobile Paleoindian adaptation, a seasonal or tethered mobility in the Archaic, and a more sedentary adaptation in the Formative period.

Cortex

Cortex in the assemblages is almost non-existent and varies from 1.4% at LA 67451 to 4.6% at LA 126620. The LA 126619 assemblage has 2.4% cortex. There is no significant difference in cortex amounts among the three sites (chi-square=0.16 with 2 df). Variability in propositions of cortex across the units of LA 126619, however, is significant (chi-square=39.35 with 16 df). Cortex variability within the material types is also significant with higher than expected frequencies of cortex in the cherts and less than expected in the Jarilla cherts and obsidians.

Striking Platforms

Examination of southern Cochise assemblages from the Cox Ranch Project (Elyea 1994) reflected a distinct contrast to the northern Oshara materials. Since the Cochise materials contain low amounts of platform preparation, we wanted another measure of reduction analysis and selected platform length and width measurements. Regression analysis of these measurements indicates that the two measurements only partially correlate (R^2=0.64). We multiplied the measurements (*0.7854) to

create oval dimensions and generated a platform size. We then ran a regression analysis of platform size and flake length, which indicates that platform size has little correlation to flake size (R^2=0.217).

Small striking platforms are used during controlled tool production, final stages of tool manufacture, and tool refurbishment. Small platforms may also occur during core reduction, but controlled core reduction, used to create large flakes for expedient tools or tool blanks, requires a larger striking surface. Table 31 shows the mean platform sizes from the project. Sites strictly related to hunting activities should contain a high proportion of tool refurbishment and final stage manufacture. Residential sites with more generalized lithic reduction activities, including core reduction and early stages of tool manufacture, should contain a mixture of platform sizes, resulting in increased numbers of larger striking platforms and a greater mean platform size. The small mean striking platform size at LA 67451 is notable in contrast with the other sites and analytical units.

Table 31. Mean Platform Size in Square mm.

Site	AU	N	Mean	Std
All	-	797	14.79	-
LA 67451	All	66	4.12	4.9
LA 126619	All	709	18.78	1.5
LA 126619	1	148	16.59	3.4
LA 126619	2	62	19.58	5.3
LA 126619	3	87	30.22	4.5
LA 126619	4	102	11.98	4.1
LA 126619	5	64	20.33	5.2
LA 126619	6	13	6.95	11.5
LA 126619	7	3	6.02	24.0
LA 126619	9	2	7.07	29.4
LA 126619	10	76	16.15	4.8
LA 126619	11	76	25.48	4.8
LA 126619	12	75	16.08	4.8
LA 126620	All	22	21.46	8.5

Table 32 lists the striking platform sizes arrayed in quartiles. The two smaller categories probably represent pressure flaking, and the two larger, percussion flaking. Again LA 67451 contrasts the other sites with significant numbers of small striking platforms. Within LA 126619, Analytical Units 1, 4, and 12 also exhibit significantly high numbers of small striking platforms (Table 24).

Flake Size

Flake size has been the most measurable and replicable variable that distinguishes Archaic hunter and gatherer and Formative assemblages, and it can also distinguish special use hunting sites with the Archaic period. Further, although overall flake size measurements differentiate these assemblages, the flake thickness measurement consistently separates assemblages. Flake thickness apparently reflects the threshold between flakes struck from cores and those produced in bifacial or formal tool manufacturing processes. Although small thin flakes may result from core reduction; large, thick flakes are produced *only* during core reduction. Past studies suggest that the threshold measurement is near 5 mm (Hogan et al 1983), where flakes that exceed this measurement are likely to be the results of core reduction and not bifacial or formal tool production. The emphasis on a bifacial manufacturing technology in the Archaic period produces thinner flakes in larger quantity than in the more expedient Formative technology where there is greater emphasis on core reduction.

The US 380 lithic assemblages are composed of very thin flakes with a median of 1mm and a mean of 1.98 mm. All three sites exhibit low mean thickness with means of 1.42 mm (LA 67451), 1.77 mm (LA 126619), and 2.75 mm (LA 126620). Since there is an apparent thickness threshold at 5 mm, where flakes that exceed this thickness probably represent core reduction, we compared the proportions of flakes less than and greater than this threshold (Table 33). Again LA 67451 contrasts with the other sites and contains a significantly higher proportion of these flakes. Although the overall assemblage at LA 126619 has a higher proportion of core flakes, a comparison of the Analytical Units within the site, shows only two Analytical Units with significantly high proportions of core flakes (AUs 3 and 11).

Since tool refurbishment should produce shorter flakes than tool manufacture, we examined the length of the complete flakes. The overall assemblage has a mean length of 11.36 mm and significant differences are apparent between the sites with a mean lengths of 9.66 mm (LA 67451), 11.48 mm (LA 126619), and 13.92 mm

(LA 126620). Table 34 lists the quartiles of flake length, with those in the lowest quartile (1-6 mm) probably representing sharpening or tool refurbishment flakes. The LA 67451 assemblage is again distinguished with a significantly higher proportion of small flakes. Within the various areas at LA 126619, Analytical Units 1 and 12 have significantly high proportions of the small flakes, while Analytical Unit 11 has a low proportion (Table 35).

Table 32. Quartiles of Platform Size.

Quartiles of Platform Size		Site			Total
		LA 67451	LA 126619	LA 126620	
1–2 sq mm	Count	16	151	6	173
	% Within Site	24.2	21.3	27.3	21.7
	Adjusted Residual	.5	-.8	.6	
2.1–4 sq mm	Count	35	191	4	230
	% Within Site	53.0	26.9	18.2	28.9
	Adjusted Residual	4.5	-3.4	-1.1	
4.1–18 sq mm	Count	13	179	4	196
	% Within Site	19.7	25.2	18.2	24.6
	Adjusted Residual	-1.0	1.2	-.7	
Greater than 18 sq mm	Count	2	188	8	198
	% Within Site	3.0	26.5	36.4	24.8
	Adjusted Residual	-4.3	3.1	1.3	
Total		**66**	**709**	**22**	**797**

Adjusted residuals <-1.96 and >1.96 significant at .05 probability

Table 33. Proportions of Thin and Thick Flakes.

Site	AU	1–5 mm Thick			Greater Than 5 mm Thick			Total
		Count	Percent	Adj. Res.	Count	Percent	Adj. Res.	
67451	All	553	99.3	64.84	4	0.7	-64.84	557
126619	All	4605	96.2	-24.91	182	3.8	24.91	4787
126620	All	56	94.9	-3.98	3	5.1	3.98	59
126619	1	1581	94.4	4.81	31	5.6	-4.81	1612
126619	2	268	98.1	-1.69	16	1.9	1.69	284
126619	3	439	92.4	-4.57	36	7.6	4.57	475
126619	4	636	97.8	2.34	14	2.2	-2.34	650
126619	5	212	93.8	-1.95	14	6.2	1.95	226
126619	6	51	98.1	0.71	1	1.9	-0.71	52
126619	7	20	100.0	0.89	0	0.0	-0.89	20
126619	8	10	100.0	0.63	0	0.0	-0.63	10
126619	9	4	80.0	-1.90	1	20.0	1.90	5
126619	10	360	95.0	-1.31	19	5.0	1.31	379
126619	11	315	90.0	-6.33	35	10.0	6.33	350
126619	12	708	98.1	2.82	14	1.9	-2.82	722
Total		**5214**	**96.2**		**189**	**3.5**		**5403**

Adjusted residuals <-1.96 and >1.96 significant at .05 probability

Table 34. Quartiles of Flake Length.

Quartiles of Flake Length		Site			Total
		67451	126619	126620	
1–6 mm	Count	43	332	2	377
	% Within Site	35.5	27.4	8.3	27.8
	Adjusted Residual	2.0	-.9	-2.1	
7–9 mm	Count	37	284	4	325
	% Within Site	30.6	23.4	16.7	23.9
	Adjusted Residual	1.8	-1.3	-.8	
10–14 mm	Count	27	305	9	341
	% Within Site	22.3	25.1	37.5	25.1
	Adjusted Residual	-.7	.1	1.4	
Greater than 14 mm	Count	14	292	9	315
	% Within Site	11.6	24.1	37.5	23.2
	Adjusted Residual	-3.2	2.2	1.7	
Total		**121**	**1213**	**24**	**1358**

Adjusted residuals <-1.96 and >1.96 significant at .05 probability

The reduction analysis consistently identified certain sites and site areas with debitage profiles that suggest tool maintenance. Namely the assemblages LA 67451, LA 126619 AU 1 and AU 12 consistently contrasted with other assemblages because of their high amounts of smaller and thinner flakes that exhibited small striking platforms.

Tools

The assemblages lack large numbers of formally or expediently manufactured lithic tools. Drills, knives, bifaces, projectile points, and scrapers that were manufactured with a formal template or pre-conceived outline or shape are mostly absent, and those recovered are broken beyond repair. Only 21 formal tools (0.4% of the total) are present in the entire US 380 assemblage. A*d hoc* implements or expediently manufactured tools are also rare. These consist of 22 of the total retouched and used flakes (0.4%). Like the formal tools, they are also broken.

Projectile Points

Projectile points include a possible Folsom, two Jay style, an early Archaic, and two corner-notched middle to late Archaic points. All consist of bases or base fragments that were too fragmentary to repair and re-haft.

Bifaces

In order to produce a formal bifacial tool such as a knife or projectile point various manufacturing stages are necessary. The stages of manufacture represented by the lost or discarded bifaces provides information about activities that occurred in the site areas. For instance, broken and rejected bifaces from the early stages of manufacture suggest bifacial reduction occurred at the site. Our analysis followed Callahan's stages of bifacial manufacture (1979). This analysis basically uses a width to thickness ratio that allows the use of a template to match various stages of manufacture with an overlay image of the reduction stage.

Stage 1 is the selection of a flake blank, cobble, nodule or chunk that is appropriate for bifacial reduction. Within an archeological assemblage these would include any material that could be reduced to a preconceived concept of biface size.

Stage 2 is the initial edging of the blank. The blank is worked along its circumference creating a width/thickness ratio of 2.00 or more. Edge angles are between 55 and 75 degrees. Flake scars do not intentionally reach the center of the biface during this stage.

Table 35. LA 126619 Flake Quartiles.

Analytical Unit		Quartiles of Length				Total
		1–6 mm	7–9 mm	10–14 mm	> 14 mm	
1	Count	127	92	79	53	351
	% With AU	36.2	26.2	22.5	15.1	100.0
	Adjusted Residual	4.4	1.5	-1.4	-4.7	
2	Count	19	13	21	29	82
	% With AU	23.2	15.9	25.6	35.4	100.0
	Adjusted Residual	-.9	-1.7	.1	2.5	
3	Count	22	19	23	50	114
	% With AU	19.3	16.7	20.2	43.9	100.0
	Adjusted Residual	-2.0	-1.8	-1.3	5.2	
4	Count	49	52	59	33	193
	% With AU	25.4	26.9	30.6	17.1	100.0
	Adjusted Residual	-.7	1.3	1.9	-2.5	
5	Count	15	12	22	28	77
	% With AU	19.5	15.6	28.6	36.4	100.0
	Adjusted Residual	-1.6	-1.7	.7	2.6	
6	Count	4	2	8	5	19
	% With AU	21.1	10.5	42.1	26.3	100.0
	Adjusted Residual	-.6	-1.3	1.7	.2	
7	Count	2	1	1	0	4
	% With AU	50.0	25.0	25.0	.0	100.0
	Adjusted Residual	1.0	.1	.0	-1.1	
8	Count	0	2	2	0	4
	% With AU	.0	50.0	50.0	.0	100.0
	Adjusted Residual	-1.2	1.3	1.1	-1.1	
9	Count	1	0	0	1	2
	% With AU	50.0	.0	.0	50.0	100.0
	Adjusted Residual	.7	-.8	-.8	.9	
10	Count	24	19	27	33	103
	% With AU	23.3	18.4	26.2	32.0	100.0
	Adjusted Residual	-1.0	-1.2	.3	2.0	
11	Count	13	20	36	39	108
	% With AU	12.0	18.5	33.3	36.1	100.0
	Adjusted Residual	-3.7	-1.3	2.0	3.1	
12	Count	55	52	27	21	155
	% With AU	35.5	33.5	17.4	13.5	100.0
	Adjusted Residual	2.4	3.2	-2.4	-3.3	
Total Count		**331**	**284**	**305**	**292**	**1212**
Total % Within AU		**27.3**	**23.4**	**25.2**	**24.1**	**100.0**

Adjusted residuals <-1.96 and >1.96 significant at .05 probability

Stage 3 is the primary thinning of the biface, which creates a lenticular cross-section with a width/thickness ratio between 3.00 and 4.00 and edge angles between 40 and 60 degrees. This stage of manufacture eliminates major humps, ridges, hinge or step-fractures, and concavities. During this stage the flake scars contact the center of the biface.

Stage 4 is the secondary thinning process that creates a flat cross-section with a width/thickness ratio in excess of 4.00. Edge angles are between 25 and 45 degrees. This process may result in flake scars that travel beyond the center line and undercut previous scars from the opposite margin. This process generalizes the contemplated biface shape, and

Table 36. Grouped Material Types.

Grouped Material Types		Site 67451	Site 126619	Site 126620	Total
Rio Grande Chalcedony	Count	96	665	3	764
	% Within Site	17.0	13.2	4.6	13.5
	Adjusted Residual	2.6	-1.8	-2.1	
Chalcedony Other	Count	0	85	0	85
	% Within Site	.0	1.7	.0	1.5
	Adjusted Residual	-3.1	3.3	-1.0	
Silicified Wood	Count	27	500	2	529
	% Within Site	4.8	9.9	3.1	9.3
	Adjusted Residual	-3.9	4.3	-1.7	
Quartzite	Count	24	1379	13	1416
	% Within Site	4.2	27.3	20.0	24.9
	Adjusted Residual	-12.0	11.7	-.9	
Chert	Count	294	1605	43	1942
	% Within Site	52.0	31.8	66.2	34.2
	Adjusted Residual	9.4	-10.8	5.5	
Jarilla Chert	Count	56	75	0	131
	% Within Site	9.9	1.5	.0	2.3
	Adjusted Residual	12.7	-11.7	-1.2	
Obsidian	Count	67	606	0	673
	% Within Site	11.9	12.0	.0	11.9
	Adjusted Residual	.0	1.0	-3.0	
Igneous	Count	0	60	4	64
	% Within Site	.0	1.2	6.2	1.1
	Adjusted Residual	-2.7	1.2	3.9	
Other	Count	1	71	0	72
	% Within Site	.2	1.4	.0	1.3
	Adjusted Residual	-2.4	2.6	-.9	
Total		**565**	**5046**	**65**	**5676**

Adjusted residuals <-1.96 and >1.96 significant at .05 probability

Table 37. Material Type Origins.

Material Origin		Site 67451	Site 126619	Site 126620	Total
Rio Grande Valley	Count	457	3284	57	3798
	% Within Site	84.2	65.1	87.7	67.2
	Adjusted Residual	8.9	-9.6	3.5	
Socorro Peak	Count	25	1569	8	1602
	% Within Site	4.6	31.1	12.3	28.3
	Adjusted Residual	-12.9	13.3	-2.9	
Oscura Mountains	Count	0	29	0	29
	% Within Site	.0	.6	.0	.5
	Adjusted Residual	-1.8	1.9	-.6	
Cerro Colorado	Count	5	83	0	88
	% Within Site	.9	1.6	.0	1.6
	Adjusted Residual	-1.3	1.5	-1.0	
Jarilla Mountains	Count	56	75	0	131
	% Within Site	10.3	1.5	.0	2.3
	Adjusted Residual	13.0	-12.0	-1.2	
Chuska Mountains	Count	0	5	0	5
	% Within Site	.0	.1	.0	.1
	Adjusted Residual	-.7	.8	-.2	
Total		**543**	**5045**	**65**	**5653**

Adjusted residuals <-1.96 and >1.96 significant at .05 probability

work may proceed in a patterned manner as from tip to base.

The US 380 assemblages contained only 12 bifaces and as with other tools, they were broken and too fragmentary for repair or further reduction. Nine of these were stage 4 or virtually completed tools and three of these were probably projectile point tips. Only one stage 2 and two stage 3 bifaces were located, all from LA 126619. The absence of stage 1 and paucity of stage 2 and 3 bifaces suggests that little bifacial manufacturing occurred in the project area.

MATERIAL SELECTION

Table 36 lists the sites by grouped material types. The coarse-grained materials from Socorro Peak were lumped with quartzites in this table since both have similar flaking and fracture characteristics. Materials in the 'other' category include limestone, sandstone, and ochre, and materials in the igneous category include rhyolite, granite, and schist.

Table 37 lists the sites by the lithic material origin. The vast majority of cherts and silicified wood from the assemblages occur in the Rio Grande Valley gravels. Distinctive material types from the assemblages include Chuska chert from the Chuska Mountains, Jarilla chert from the Jarilla Mountains, and jasper from Socorro Peak. The Oscura Mountains may be the source of a yellow chalcedony (Amick 1994) and the dendritic jaspers from the site may be from the small Cerro Colorado peak 12 mi southwest of the project area (Robert Weber personal communication April 2000). Only five flakes were identified from the Chuska Mountains, some 245 mi to the northwest, and these are in three Analytical Units at LA 126619. Most of the materials are from areas west of project area in the Rio Grande Valley and Socorro Peak.

CONCLUSIONS

The US 380 assemblages consist mainly of small flakes. Half of the complete flakes recorded in the analysis are under 10 mm long and fall within the parameters of debitage from tool refurbishment or final tool manufacture. These small flakes with small striking platforms indicate that tool refurbishment was the main lithic reduction activity at the US 380 sites. There is little evidence for bifacial or tool manufacture that started with a large flake from a core and was reduced into a useable tool. Rather, the evidence would suggest that tools and bifaces were carried to the site, used and refurbished, and then removed as the inhabitants moved to other areas. Mostly unusable and non-repairable tools were all that were discarded. The lack of core and bifacial reduction is probably dictated by the lack of locally available raw lithic resources.

7 PLANT REMAINS FROM LA 126619

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INTRODUCTION

During the spring of 2000, excavations were undertaken by the University of New Mexico Office of Contract Archeology (OCA) at three sites along US highway 380 roughly 20 miles east of San Antonio, Socorro County, New Mexico. Situated in the northern portion of the Jornada del Muerto basin, the sites are located along Chupadera Arroyo. One of the sites, LA 126619, is a multicomponent site that is possibly Archaic period in age, but may have a modest Folsom presence as well. Numerous occupation episodes were evident, with scattered firecracked rock and burned ground stone fragments present throughout the site area. The evidence suggests the repeated use of the area for short-term campsites by small groups.

Flotation samples from 6 buried hearths were submitted for paleoethnobotanical analysis. Results were meager, with both carbonized plant macrofossils and wood charcoal poorly represented. No identifiable plant taxa were found apart from wood charcoal from one feature.

Methods

Flotation samples were processed by water separation by OCA laboratory personnel using the bucket method. A 2.0 liter increment of sediment is added to a bucket of water and briefly stirred to release plant macrofossils into suspension. The liquid is decanted into a chiffon square anchored over a screen that catches the buoyant material. This process is repeated from 3 to 8 times or until the water is clear and no longer contains plant materials. This component, the light fraction, is gently rinsed and then placed on clean paper in racks to dry. The remaining sludge, or heavy fraction, is screened and rinsed and then allowed to dry.

After the light fraction has dried completely, it is put through a graduated series of geological screens that created 5 size classes: (1) greater than 4.0 mm; (2) between 2.0 and 4.0 mm; (3) between 1.0 and 2.0 mm; (4) between 0.5 and 1.0 mm; and (5) less than 0.5 mm. This strategy enhances the ease and reliability of microscopic sorting and identification, and is useful when subsampling is necessary for large samples. Each size class is weighed and placed into labeled coin or manila envelopes, which are stored together in ziploc sample bags. The heavy fraction was not examined for plant remains.

The full sort analysis method was used for all samples, with counts made of the number of items assigned to each taxonomic category. Size classes 1–5 were completely analyzed. Sorting was carried out using an Olympus binocular stereozoom microscope with a magnification range of 10X to 110X. Carbonization was the primary criterion used to distinguish those plant parts with the highest probability of affiliation with the prehistoric occupation from recent contaminants (Minnis 1981). Uncarbonized plant parts were also identified and counted as a means of evaluating the nature and degree of disturbance present in sampled loci. For future reference, examples of uncarbonized taxa were removed and stored in polyethylene vials that were put in the sample bag. Additional evidence of disturbance was obtained from other biotic components such as microvertebrate bones, fecal pellets, mollusks, and insect exoskeletal fragments, which were counted and recorded. All non-wood charcoal carbonized items were removed and placed in labeled polyethylene vials that were then stored in ziploc bags.

Wood charcoal was also analyzed. Samples were obtained from flotation sample light fractions. Ideally, 30 fragments were analyzed from each float, with the judgmental selection of 20 from the 4.0 mm screen and 10 from the 2.0 mm screen. This ideal was achieved in just one of the samples due to poor preservation. Fragments had to be of sufficient size to display a complete growth ring or unequivocal diagnostic features and to permit effective handling that usually involved snapping the specimen transversely to expose a fresh cross-section and, where needed, radial and tangential views.

Identifications of recovered materials were confirmed by comparison with modern seed and wood specimens in the author's collection. The taxonomy used in this study follows Martin and Barkley (Martin and Hutchins 1980–81). Identified taxa are shown in Table 38. Some entries are preceded by "cf.", indicating "compare with". This is used to indicate those identifications that are probable rather than absolute, the identification given representing the best match among an incomplete pool of possibilities or for which an insufficient number of diagnostic features remain. Because it signifies a lower level of identification confidence, it must not be omitted when referring to any of the taxa so designated. Some entries consist of or contain letters that indicate a range of values for those taxa for which it was unnecessary or impractical to count every item: A = 1–10; B = 11–50; C = 51–100; D = 101–500; and E = >500.

Results

The results of the flotation analysis are presented in Table 39. All of the flotation samples were taken from hearth features located 30 to 80 cm below the existing ground surface. Volumes ranged between 1.0 and 30.0 liters. All were found to contain evidence for post-occupational disturbance in the form of insect exoskeletal parts and fecal pellets that were often quite abundant. Uncarbonized seeds were also found in five samples; their presence is in all likelihood largely due to the activity of rodents and ants. Taxa identified include cf. borage family, purslane, spurge, dropseed and rice grass.

Wood charcoal was present in four of the six features, three of which, offered pieces that appeared to be suitable for analysis (Table 40). Results here were also disappointing, as many of the pieces proved to be too incomplete to achieve even a family level identification. The exceptions are Features 3 and 6, where, even in small fragments, the unmistakable anatomy of saltbush/greasewood was clearly evident. Both of these genera contain shrubby species that are found in alkaline soils at elevations up to 6500 feet. Saltbush is found throughout New Mexico whereas greasewood is restricted to the northwestern and southeastern parts of the state (Carter 1997:110, 356). Both produce small diameter woody stems that are well-suited for use in small-sized hearths.

The macrofossil record was disappointing, as just one of the hearths produced burned material. Feature 3 yielded five small items, three of which were superficially similar to maize cupule fragments and glumes. The remaining specimens offered insufficient characters for even the most basic identification.

CONCLUSIONS

Apart from documenting the use of locally available wood for domestic fuel needs, the assemblage from LA 126619 offers no additional insights into plant uses by Archaic occupants of the site area. Ground stone tools found on the site clearly indicate that vegetal resources were exploited, but this aspect of the subsistence system remains unknown.

Table 38. Plant Taxa Recovered from LA 126619.

Taxon	Common Name	Part
Angiospermae		
Monocotyledonae		
Gramineae	Grass Family	
Oryzopsis hymenoides (R.&S.) Ricker	Ricegrass	Floret[2], Caryopsis[2]
Sporobolus sp.	Dropseed	Caryopsis[2]
Dicotyledonae		Wood[1]
cf. Boraginaceae	Borage Family	Nutlet[2]
Chenopodiaceae	Goosefoot Family	
Atriplex/Sarcobatus	Saltbush/Greasewood	Wood[1]
Euphorbiaceae	Spurge Family	
Euphorbia sp.	Spurge	Seed[2]
Portulacaceae	Purslane Family	
Portulaca sp.	Purslane	Seed[2]

[[1] = Carbonized, [2] = Uncarbonized]

Table 39. Plant Remains Recovered from LA 126619.

Feature	**1**	**3**	**4**	**5**	**6**	**7**	**Total**
Volume Liters	**4.5 L**	**2.5 L**	**1.0 L**	**10.0 L**	**30.0 L**	**8.0 L**	**56.0 L**
Carbonized	**-**	**-**	**-**	**-**	**-**	**-**	**-**
Unknowns	**-**	**5**	**-**	**-**	**-**	**-**	**5**
Total	**-**	**5**	**-**	**-**	**-**	**-**	**5**
Uncarbonized							
cf. Boraginaceae	-	-	-	-	-	A	-
Euphorbia	-	-	-	A	A	B	-
Oryzopsis	-	-	-	A	-	A	-
Oryzopsis lemma/palea	-	-	-	-	-	B	-
Portulaca	-	A	A	A	A	A	-
Sporobolus	-	-	-	A	-	A	-
Unknown	-	-	-	-	A	A	-
Disturbance							
Insect parts	D	B	B	D	D	D	-
Fecal pellets	D	D	D	D	D	E	-

[All entries are seeds/fruits unless otherwise indicated; A = 1–10; B = 11–50; C = 51–100; D = 100–500; E>500

Table 40. Wood Charcoal Taxa from LA 126619.

	Feature 3 Hearth FS 322	**Feature 4 Hearth FS 326**	**Feature 6 Hearth FS 424**	**Total**
Atriplex/Sarcobatus	2	-	30	32
Dicotyledonae	9	1	-	10
Unknown	4	-	-	4
Total	**15**	**1**	**30**	**46**

8 GEOARCHEOLOGICAL STUDIES

by William H. Doleman

INTRODUCTION

During the course of the US 380 excavation project a geoarcheologist from the Office of Contract Archeology visited all three archeological sites chosen for excavation: LA 126619, LA 67451, and LA 126620. The overall goals of the geoarcheological study were based on questions generated by the preliminary study conducted as part of the project testing program (Elyea and Doleman 2000) and were designed to achieve a better understanding of the depositional context of excavated cultural materials, as well as to elucidate evidence for past environmental conditions. Excavation-related geoarcheological investigations were conducted at the sites in order to acquire data necessary to addressing several specific issues posed in the data recovery plan. These issues fall under six headings:

1. Intrasite variation in soil characteristics.
2. Intersite variation in soil characteristics.
3. Correlation with Mockingbird Gap stratigraphic sequence.
4. Relationship between archeological deposits and soil/stratigraphic units.
5. Evidence for project area paleoenvironments.
6. Evidence for bioturbation of otherwise intact cultural deposits.

The geoarcheological component of the data recovery plan for the US 380 excavation project proposed a simple Quaternary stratigraphic sequence for the tested sites, based upon pedological characteristics of deposits documented in one or more small trenches excavated at each site. The testing study also noted significant differences in soil stratigraphy on the west and east sides of Chupadera arroyo, as well as apparent variations within some sites' deposits. Data acquired during the present study offer the potential for addressing all of these questions.

PHYSIOGRAPHIC AND GEOMORPHIC SETTING

The project area lies on both sides of Chupadera Arroyo, the major tributary of a broad basin (Chupadera Basin), which is a northern extension of the Jornada del Muerto. The latter is one of two south-trending basins that lie east of the Rio Grande Valley and form part of the Rio Grande Rift tectonic system. These basins are generally nearly flat, internally or poorly drained, and underlain by varying thicknesses of largely fluvial, late Tertiary and Quaternary deposits. At present, Chupadera Arroyo is an intermittent stream that runs periodically, usually carrying runoff from summer precipitation events.

The project area landscape exhibits a typical basin floor geomorphic environment with an eolian sand sheet overlying stripped, late Pleistocene deposits with well-developed pedogenic features. Sand sheets are low-angle eolian deposits that form in association with true sand seas, or commonly as the major component of dune fields (Wells et al. 1990:523; see also Fryberger et al. 1979). Sand sheets tend to form in warm-climate environments with available fine-grained sediment supplies, but when conditions such as coarser average grain size and binding vegetation (suggesting a comparatively moister rather than drier climate) inhibit true dune formation (Kocurek and Neilson 1986). Sand sheets are extremely common in lower-elevation parts of New Mexico, covering basin floor and other flat to gently-sloping landforms (e.g. Blair et. al 1990a, 1990b; Hall 2001; Wells et al. 1990), and are often composed of. a sequence of stratigraphic units with associated soils representing multiple episodes of deposition, separated by unconformities and followed by periods of landscape stability and soil formation (Holliday 1989; Muhs 1985).

This report documents a similar sequence for a sand sheet in the northern Jornada del Muerto.
To the west of the arroyo, the very gently undulating surface slopes upwards very slightly away from the arroyo—which constitutes a local base level—and onto the generally south-southwest sloping basin floor. To the east, the slope is slightly more pronounced and rises gradually eastward towards uplifted outcrops of Paleozoic rocks (outliers of the Oscura range comprised of Abo, Yeso, and San Andres formations) some 7–8 miles (11–13 km) to the east. This surface is probably a bajada or piedmont composed of sediments derived from the Paleozoic rocks, with the course of Chupadera Arroyo defining the landform's termination and marking an important boundary between areas of markedly different parent materials: basin sediments to the west, and Paleozoic rock-derived alluvium to the east.

The Pleistocene unit that underlies the sand sheet is a carbonate- and gypsum-rich fine-grained deposit that exhibits a highly eroded, and weathered undulating topography. Where exposed, this unit (Q1, see below) exhibits polygonal joints that may be desiccation features associated with long-term weathering. The sand sheet on top of this differs on the west and east sides of Chupadera Arroyo. To the west of the wash, dunes are composed of light-colored (7.5YR) eolian sands. To the east of the wash, the sand sheet is much thicker overall, with only occasional exposures of the Q1 unit south of the road. Here the sand sheet is composed of thick very orange dunes (5YR) overlying a red-brown loamy sand (2.5YR) containing a clay that is demonstrably of pedogenic origin.

The overall greater thickness of the deposits east of the wash was first thought to be due to being downwind from a major source of unconsolidated fine-grained sediments. One hypothesis offered in the testing report for the color difference on the east side of the arroyo is that the underlying reddish deposits represent a true argillic horizon, and that the overlying orange dunes are a result of recent eolian reworking of this material and a subsequent lessening of color or chroma in the derived deposits. An alternative hypothesis offered is that the wash—which drains a sizable basin bounded by frequently red-colored Paleozoic rocks—served as a red sediment source for the east-side sand sheet. The present study indicates that some of the reddening in the east-side deposits represents oxidized pedogenic clays, but it is also likely that much of the reddening can be traced to differences in parent material between the west and east sides.

Initial inspection of surface deposits east of Chupadera Arroyo also suggested the possibility of correlating stratigraphic sequences at tested sites with that described by Dr. Robert Weber for the Mockingbird Gap site (Weber 1997; Weber and Agogino 1997). This possibility was partially born out by the present study.

METHODS

Soils/stratigraphic data and samples were collected from mechanically excavated trenches at the three sites as well as from a series of five mechanically excavated trenches along the margins and in the bottom of Chupadera Arroyo. All trenches were oriented parallel to the highway right-of-way. Three contiguous trenches were excavated at LA 126619 along the south margin of the excavated area, totaling approximately 120 m in length, and five separate profiles were documented. One 15–20 m trench each was also excavated at LA 67451 (three documented profiles) and LA 126620 (one documented profile). The long trenches at the sites, and five trenches excavated in the bottom of Chupadero Arroyo, offered a more comprehensive picture of project area soil-stratigraphy than was available in the limited testing phase study, and allowed assessment and reconciliation of the intrasite stratigraphic variations observed during the testing phase.

The mechanically excavated trenches in Chupadera Arroyo were also oriented parallel to the highway right-of-way (or transversely to the arroyo flow axis). Two long trenches were mechanically excavated at the arroyo margins for the purposes of documenting the interface of basin-floor and arroyo deposits, while a series of three deep trenches was excavated into the arroyo floor to ascertain the nature and variation of alluvial arroyo deposits.

On-site trenches were studied until a soil-stratigraphic model was developed, and then

representative points were chosen for detailed profile descriptions. Model development was aided by consultation with the excavating archeologists, and by inspection of the walls of excavated units. All detailed profiles were documented according to standard soil description techniques similar to those employed in the testing phase. All profiles were photographed, and samples of all identified soil stratigraphic units were taken for laboratory analysis. In addition, where relevant, other exposures were photographed and/or sampled. Soil characteristics were identified and described using standard soil geomorphic methods (Birkeland 1984; Birkeland, et al. 1991). Munsell charts were used to describe soil colors (Munsell Color, 1990).

Arroyo trenches were sufficiently deep (3–4 m), that—for safety's sake—one side of each was stepped back to facilitate inspection and photography without requiring direct entry into the trench. Detailed profile documentation was conducted in some, and photographs and notes were taken at all arroyo trenches for the purposes of identifying terrestrial and alluvial deposits and their relationships. Sediment samples were taken from the arroyo profiles wherever they could be safely acquired.

Prior to profile documentation, two days were spent in reconnaissance of the project area landscape within an approximate 5 km radius. This activity included visiting various related landforms and documenting the relationship between landforms and mapped soils for the area (Johnson 1988). As a result, a model of soil-landscape relationships is being developed that will help explain intersite variations in soil-stratigraphy.

Designation and interpretation of Quaternary stratigraphic units was based on field inspections and observed variations in stratigraphic evidence and pedogenic characteristics of deposits exposed in excavation profiles. At the archeological sites, four general Quaternary stratigraphic units—all but the earliest entirely eolian in origin—were identified (the "Q5" units identified in the testing report are subsumed under "Q4" in the present study). In addition, a number of alluvial units were documented in the arroyo trenches. Identification of stratigraphic breaks and Quaternary units was based on observed changes in depositional structure, clear boundaries (except in occasional cases of boundaries blurred by biological and erosional processes), as well as marked changes in pedogenic characteristics such as color, structural development, hardness, carbonates and pedogenic clays. By definition, the gypsum-rich deposits found at the base of most excavated units were designated unit Q1, with overlying units given successively higher numbers. In some cases, the relationship of a given unit to other units was helpful in unit identification. In the discussions and tables that follow, standard soil geomorphic designations are given to the various stratigraphic units and soil horizons.

All designations begin with "Q", to indicate a Quaternary (Pleistocene-Holocene) origin, and are followed by the unit number (1–4, oldest to youngest). Parent material for most documented deposits is clearly eolian in origin; in cases where the parent material is alluvial rather than eolian, an "a" parent material designation follows the unit indicator. The unit is followed by a soil horizon designation consisting of the capital letter master horizon together with lower case subhorizon indicators. The master horizons A (upper zone of leaching and organic accumulation, commonly absent in buried soils), and B (lower zone of illuvial clay accumulation and mineral precipitation) are most common. One C horizon (unaltered parent material) was documented, and unit Q4 is often denoted as Q4C because it lacks any observable pedogenic features. Commonly observed soil subhorizons are "k" (carbonates), "t" (pedogenic clay), and "w" (weak or cambic B evidenced by slight reddening due to iron oxides). In older soils, clay and carbonates accumulate together, resulting in a "Btk" or "Bkt" designation, depending on which dominates. In a few cases where a soil horizon exhibited further subdivisions, a numerical designation is appended (e.g., Q2Btk1, Q2Btk2). The convention of appending a "b" to buried soils (Q1–Q3) was not used, as the relationship of the various soils to overlying units is obvious.

The uppermost stratigraphic unit—designated Q4—is a recent unit identified on the basis of preserved depositional bedding and a general lack of all but occasional very weak of pedogenic characteristics. With the exception of

alluvial units in the arroyo, all older units lack evidence of depositional bedding. Unit Q3 was generally recognized on the basis of weak-moderate pedogenic features (distinct color change, carbonates, pedogenic clays, lack of depositional bedding). Unit Q2 was recognized on the basis of moderate to well-developed pedogenic features, including distinct color change, extensive carbonate development, and pedogenic clays. As noted, unit Q1 is the nearly white, highly calcareous, gypsum-rich unit described by Weber and found at the bottom of excavation units throughout the project area. In a few locations, this unit either underlies or overlies alluvial materials of similar age. In the arroyo bed, identification of this unit is difficult owing to subsurface hydrologic effects, including dissolution and re-precipitation. Reconnaissance of the project area indicates that the gypsiferous Q1 unit (or "gypsite") underlies almost all surface deposits and controls local topography on scales of 1s to 10s of meters. In all cases, the identified units occur in the same vertical sequence (Q4 and Q1 at the top, Q1 at the bottom), although not all units are present in a given documented excavation unit.

AGE ESTIMATION AND CORRELATION OF IDENTIFIED SOIL/STRATIGRAPHIC UNITS

In soil geomorphic studies, an important distinction is made between deposits and soils. In the US 380 project area, several geomorphic processes contribute to the formation of deposits. The most important of these are:

a) the deposition of dune and sheet sands by blowing wind (primarily through wind-ripple migration and grain-fall on the lee side of plants and other surface-flow impediments), in which sand-sized grains (0.0625–2 mm) move by saltation and brief aerial suspension across the land surface;

b) the settling of air-borne dust particles (<0.0625 mm);

c) alluvial processes—mainly sheetwash—which transport pebble-sized (4–64 mm) and smaller particles short distances;

d) in the case of Chupadera Arroyo, fluvial processes in which running water transports (potentially) the full range of clasts from clays to boulders.

In contrast, soils form in deposits with stable surfaces (non-eroding and non-aggrading) after deposition has ceased. Soils are the product of a variety of biological, chemical and physical processes on the deposit, which collectively alter the content, arrangement, chemistry, and mineralogy of the original deposit or parent material.

The longer a landscape surface remains stable (usually because active sedimentation and erosion have ceased and vegetation has colonized the surface), the longer underlying deposits remain relatively intact and the longer soil-forming processes operate. As a result, emerging soil characteristics become more pronounced. It is this relationship that makes soil properties useful for estimating the age of deposits and, hence their degree of intactness. In any given deposit, soils form as a vertical arrangement of related horizons, with the characteristics of each reflecting the processes that dominate at the horizon's depth (e.g., leaching or precipitation of certain minerals). In basin environments such as the project area, it is also common for the upper portion of older soil/deposit formations (usually the A and portions of the B horizon) to be wholly or partially stripped during the formation of subsequent ones, with the result that older deposits and their associated soils are represented only by lower horizons that—owing to their greater age—are more strongly developed. The result is a sequence of stratigraphic units in which each overlying unit evidences a lesser degree of soil development. The soil-stratigraphic units identified in the present study constitute such a sequence.

In arid regions, two soil characteristics are of particular importance in estimating deposits' age: carbonates (CaCO3) and pedogenic clay. Both carbonates and pedogenic clays can be derived from eolian dust and/or soil weathering processes. In the project area, eolian dust is the primary source of both. In the case of carbonates, the mild acidity of rain leads to the dissolution of eolian-derived carbonate dust and its re-precipitation at a depth in the soil that is determined by a variety of factors (Machette

1985). Particularly in fine-grained sandy sediments such as those characteristic of the project area, clays brought in as eolian dust are translocated downwards by infiltrating precipitation and are deposited as clay films, which are evident as grain coatings, bridges between grains, and—in the case of very well-developed argillic horizons—as films on ped faces and in tubular pores. Pedogenic clay was consistently observed only in soils on the east side of Chupadera Arroyo. It is likely that the arroyo—which contains abundant clays—has long served as a source of wind-borne clay for down-wind deposits. In addition, parent material on the east side may have had a higher overall clay content to begin with (see below).

Carbonate development in particular is an important aid in recognizing and classifying stratigraphy and soils in arid environments. During both archeological testing and excavation phases, hydrochloric acid (HCl, 10% solution) was used extensively in the field to distinguish between the three upper stratigraphic units: Q4 (generally no effervescence unless derived from nearby calcareous deposits), Q3 (usually moderately effervescent), and Q2 (highly effervescent). As noted, carbonate development in soils is a general indicator of age in arid environments. This relationship has been well studied and geomorphologists use a carefully-defined series of "stages" to describe soil pedogenic carbonates (Birkeland 1984; Gile et al. 1965, 1966; Machette 1985). Carbonate development stage is based on macroscopic characteristics, including the presence of carbonate filaments and nodules, and overall whitening of the soil matrix that represents coating of grains and clasts and plugging of inter-grain pores by precipitated carbonates. In fine-grained sediments, Stage I (common to unit Q3) represents weak but definite soil development and is characterized by few filaments and grain coatings. In Stage II (characteristic of unit Q2), filaments are common and nodules range from few to common, and larger clasts become completely coated and/or develop carbonate "pendants" on the bottom. In Stage III (characteristic of unit Q1), nodules are common, and the matrix is almost entirely plugged resulting in over 90% whitening of the soil. No Stage IV carbonates were observed.

In the Palo Duro Wash area, which drains the Los Pinos Mountains, ca. 40 km to the northwest, Treadwell (1996) identified a series of alluvial terraces, each with a characteristic level of carbonate development. Her age estimates are based both on carbonate development and on correlation with similar sequences in New Mexico. Her unit Qt6 exhibits less that Stage I development and its estimated age is ca. 1–2ka (1000–2000 years old), suggesting that Stage I carbonates are an indicator of > 1000 years age. Her unit Qt5 exhibits Stage II carbonate development and is estimated at 8–15ka age. Two other units, Qt4 and Qt3, are characterized by Stage III and III+ carbonate development and are estimated to be 75–120ka and 120–240ka, respectively.

With some exceptions, Treadwell's carbonate development/age estimates are similar to those determined elsewhere in New Mexico (Gile et al. 1981; Blair et al. 1990), and indicate the following general conclusions: Stage I carbonate development indicates an age greater than ca. 2000 years; Stage II indicates an age of ca. 8–10ka years or greater, but less than ca. 75ka, while Stage III carbonate development indicates great antiquity and definite Pleistocene age. Based on this, prehistoric cultural materials are expected to occur in non-modern soils with less than Stage I, Stage I, and I–II carbonate development. Most of the Stage II soils documented in the present study are sufficiently well-developed that they are likely too old to contain cultural materials. For example, most of the project area Q2 soils appear at least as well-developed as Stage II soils in the southern Tularosa Basin (Blair et al. 1990). Blair's "Q2Btk" is estimated to be in excess of 15ka, on the basis of correlation with eolian and alluvial Desert Project units documented by Gile et al. (1981) in the Rio Grande Valley north of Las Cruces. Extensive archeological excavations in the area studied by Blair (Doleman et al. 1991) yielded no evidence of cultural materials occurring in the Q2 stratigraphic unit. Thus, it is tentatively concluded that deposits designated "Q2" in the present study are too old to contain prehistoric cultural remains. The potential correlation between the soil-stratigraphic sequence documented at the Chupadera Arroyo sites with those identified elsewhere in New Mexico is further discussed in the conclusions to this chapter.

It is on the basis of this well-established relationship between carbonate development stage and soil/deposit age that Unit Q3 is thought to date to prehistoric times, although the date of inception for unit Q3 is open to question, and the unit may not include the area's oldest known occupations (Paleoindian). According to Robert Weber (personal communication, November 2, 1999), however, the Q3 unit identified at LA 67451 is correlated with a unit at the Mockingbird Gap site (LA 26748) that contains PaleoIndian through Archaic cultural materials. Similarly, as noted above, the degree of carbonate development present in stratigraphic units identified as Q2 is sufficiently great that the unit's age probably pre-dates human occupation of the New World (i.e., 10s of 1000s of years).

Finally, the degree of soil development in Unit Q3 indicates that the deposits, together with any cultural remains are likely relatively intact. The role of bioturbation in disturbing such deposits, however, is less well understood, although such disturbance is likely to result mostly in vertical, not horizontal displacement of artifacts (Doleman 1995). Evidence for bioturbation was common in the documented profiles, and this evidence and its implications are further discussed in the conclusions. In any event, unit Q3 is deemed to represent a depositional unit that is correlated with much of the area's prehistoric occupation, and which—when it contains artifacts—constitutes "intact deposits" with the potential for yielding distributions of cultural remains with a useful degree of spatial integrity. The unit also has potential for containing intact cultural features.

IDENTIFICATION OF SOIL/STRATIGRAPHIC UNITS DURING EXCAVATION

Effervescence alone is insufficient to determining carbonate development stage, because carbonates can be inherited, particularly in eolian materials. In addition, truly pedogenic carbonates exhibit distinctive morphologies such as filaments, grain coating, and nodules that inherited carbonates do not manifest. In the present project, however, a general correlation between the degree of effervescence and stratigraphic units identified in the geoarcheological study indicates that the use of HCl during archeological testing to distinguish between Q3 and Q2 units was effective.

PROFILED SOILS IN THE PROJECT AREA

Despite the project's basin-floor setting, a surprising variety of soils have been mapped in the project area (Johnson 1988). Table 41 lists soils found in the project area, including those found on archeological sites. The association of these soils with particular sites and project sub-areas must be considered general at best, owing to the limitation of low-resolution soil maps such as those provided in Johnson (1988; see discussion on pp. 3–13).

Two important soil orders are represented: aridisols ("id" suffix, soils of arid regions), and entisols ("ent" suffix, young, weakly-formed soils). Within these orders, three suborders are present: typical ("orth" classification component), argillic ("arg" classification component), and alluvial ("fluv" classification component). The prefixes (e.g., "Gypsic") and descriptors (e.g., "Ustollic") in the soil classifications represent variations in soil temperatures, moisture regimes and chemistry that reflect the soils' position in the landscape. Of important note are argillic soils (e.g., the Bucklebar sandy clay loam), which are of sufficient age to have well-developed argillic (clay-rich) horizons. In the Desert project area, the Bucklebar soil's argillic horizon is thought to be latest Pleistocene in age (> 10,000 years; Gile et al. 1981:72–73). In contrast, entiosols such as the Bluepoint loamy fine sand are relatively recent in age.

The soils mapped in the project area are also correlated with surface color variations noticeable to the casual viewer. Table 42 lists project area soils by predominant color. Three color groups are present: (a) brown soils dominated by 7.5YR hues, (b) reddish-brown soils dominated by 5YR hues, and (c) yellowish-brown soils dominated by 10YR hues. As noted above, an important question addressed by the present study concerns the obvious differences between soils west of (lighter and browner) and

Table 41. Project area soils[1] (Note: all are deep, well- [to excessively] drained, with rooting depth of 60+ inches, and rated very poor-poor for all plant and habitat types [one Afair])

Soil Map Unit Number & Site Association	Soil Map Unit (Classification)	Terrain	Parent Material (Avg. Clay %)	Permea- bility	Water Capacity	Runoff	Erosion Hazard	Potential Vegetation
ON-SITE SOILS								
645 LA 126617, LA 126618, LA 126619, LA 67451, LA 126620, Mockingbird Gap site	Yesum, overblown-Yesum complex (Coarse-loamy, gypsic, thermic Typic Gypsiorthid)	Hummocky, sand-mantled bajadas and basin-floor surfaces in Jornada del Muerto	Alluvium—gypsum-, limestone-, sandstone- derived; eolian surface layer (5–10)	Low-moderate	Low-very low	Slow-meduim	Water: slight-moderate Wind: v high	Black grama, ricegrass, dropseeds, bush muhly; some galleta, sage, Mormon tea, coldenia, yucca
653 S end Mockingbird Gap site	Bucklebar sandy clay loam (fine-loamy, mixed, thermic Typic Haplargid)	Bajadas and broad swales	Alluvium—sand-stone, siltstone, and shale-derived (10–30)	Moderate	High	Slow	Water: slight Wind: moderate	Alkali sacaton, vine-mesquite, galleta, saltbush, blue grama
620 LA 126621, LA 126622	Bluepoint loamy fine sand (mixed, thermic Typic Torripsamment)	Alluvial fans, plains, terraces	Alluvial and eolian material (2–6)	Rapid	Low	Slow	Water: slight Wind: v high	Ricegrass, dropseeds (incl. giant), black grama
NEARBY SOILS								
651 Chupadera Arroyo bed	Barana loam (fine-silty, mixed, thermic Ustollic Haplargid)	Plains and swales	Mixed alluvium (15–35)	Moderately slow	High-very high	Slow	Water: slight Wind: v high	Alkali sacaton, galleta, vine-mesquite, saltbush
627 E of Mockingbird Gap site	Berino-Doña Ana association (fine-loamy, mixed, thermic Typic Haplargids)	Bajadas, plains, fan terraces (probably mostly Berino)	Alluvial and eolian material (5–35)	Moderate	Moderate-high	Slow	Water: moderate Wind: v high	Black grama, galleta, bush muhly, some ricegrass and blue grama
636 E of LA 126615 in Cañada Quemado arroyo	Campana-Yesum association (Campana: Fine-loamy, mixed, thermic Calcic Gypsiorthid) (Yesum: Coarse-loamy, gypsic, thermic Typic Gypsiorthid)	Fan terraces and bajadas (also swales, knools, dissected arroyo margins)	Alluvium—gypsum-, limestone, sand-stone derived; eolian mantle (5–30)	Moderate	Moderate-low	Slow-medium	Water: moderate Wind: v high	Campana: alkali sacaton, galleta, vine-mesquite; some grama, Mormon tea; Yesum: coldenia, dropseed, sage, Mormon tea

1 Reference:
Johnson, William R.
1988 *Soil Survey of Socorro County Area, New Mexico*. U.S. Department of Agriculture, Soil Conservation Service. Washington, DC.

Table 41. Continued

Soil Map Unit Number & Site Association	Soil Map Unit (Classification)	Terrain	Parent Material (Avg. Clay %)	Permea-bility	Water Capacity	Runoff	Erosion Hazard	Potential Vegetation
635 E. of LA 126620	Wink-Pajarito complex (Wink: Coarse-loamy, mixed thermic Typic Calciorthid) (Pajarito: Coarse-loamy, mixed thermic Typic Camborthid)	Hummocky, sand-mantled plains, bajadas, fan terraces (probably mostly Wink)	Eolian and alluvial material (3–20)	Moderately rapid	Moderate	Slow	Water: slight Wind: v high	Black grama, bush muhly, dropseeds, ricegrass
601 Arroyo SE of 126622	Oscura silty clay loam (fine, mixed [calcareous], thermic Ustic Torrifluvent)	Floodplains of intermittent drainages	Alluvium—siltstone and shale-derived (35–50)	Slow	Moderate	Medium	Water: moderate	Sacatons, galleta, vine-mesquite, saltbush

Table 42. Project area mapped soils: color, clay content, pH, and salinity as a function of depth[1]

Soil Mapping Unit	Depth (in)	Color	Clay Percent	Soil pH	Salinity (mmhos/cm)
BROWN SOILS (7.5YR)					
635: Wink-Pajarito Complex: WINK (Typic Calciorthid)	0–2 2–60	7.5YR 6/4 7.5YR 6/4–8/2	3–10 8–18	7.4–8.4 7.4–8.4	<2 <2
635: Wink-Pajarito Complex: PAJARITO (Typic Camborthid)	0–2 2–60	7.5YR 6/4 7.5YR 5/4–N 8/0	5–12 15–20	7.4–8.4 7.9–8.4	<2 <2
636: Campana-Yesum Association: CAMPANA (Calcic Gypsiorthid)	0–3 3–32 32–60	7.5YR 5/4 7.5YR 5/4–6/4 5YR 7/4–5/4	5–15 18–30 —	7.4–8.4 7.4–8.4 —	<2 2–4
636: Campana-Yesum Association: YESUM (Typic Gypsiorthid)	0–1 1–37 37–60	7.5YR 6/4 7.5YR 6/4–N 8/0 5YR 7/3	5–10 —	7.4–8.4 —	<2 —
645: Yesum, Overblown-Yesum Complex: OVERBLOWN YESUM (Typic Gypsiorthid)	0–8 8–37 37–60	7.5YR 6/4 7.5YR 6/4–N 8/0 5YR 7/3	5–10 —	7.4–8.4 —	<2 —
645: Yesum, Overblown-Yesum Complex: YESUM (Typic Gypsiorthid)	0–1 1–37 37–60	7.5YR 6/4 7.5YR 6/4–N 8/0 5YR 7/3	5–10 —	7.4–8.4 —	<2 —
REDDISH BROWN SOILS (2.5–5YR)					
627: Berino-Doña Ana Association DOÑA ANA (Typic Haplargid)	0–6 6–45 45–60	(5-) 7.5YR 5/4 (5-) 7.5YR 5/4–8/2 7.5YR 7/2	5–15 18–35 15–25	7.4–8.4 7.9–8.4 7.9–8.4	<2 2–4 2–4
627: Berino-Doña Ana Association BERINO (Typic Haplargid)	0–10 10–31 31–60	5YR 5/4 5YR 5/4 5YR 7/3	5–10 18–35 18–35	6.6–8.4 7.4–8.4 7.9–9.0	<2 2–4 2–4
651: Barana Loam (Ustollic Haplargid)	0–3 3–23 23–60	5YR 5/3 5YR 5/4–7.5YR 6/4 5YR 6/4	15–25 18–35 18–35	7.4–8.4 7.4–8.4 7.4–8.4	<2 <2 <2
653: Bucklebar Sandy Clay Loam (Typic Haplargid)	0–4 4–24 24–33 33–60	5YR 4/4 2.5YR 4/4–5YR 4/4 5YR 5/4 5YR 5/4	20–30 25–35 10–25 10–30	7.4–8.4 7.4–8.4 7.4–8.4 7.9–8.4	<2 <2 <2 <2
YELLOWISH BROWN SOILS (10YR)					
620: Bluepoint Loamy Fine Sand (Typic Torripsamment)	0–5 5–60	10YR 6/4 10YR 6/4–7.5YR 7/4	2–6 2–6	7.4–9.0 7.9–9.0	<2 <4

1 Reference:
Johnson, William R.
1988 *Soil Survey of Socorro County Area, New Mexico*. U.S. Department of Agriculture, Soil Conservation Service. Washington, DC.

east of (redder) of the Chupadera Arroyo. Comparison of Tables 41 and 42 shows that the redder soils in Table 42 (all argillic aridisols) are far more common east of the arroyo. Thus, the area east of the arroyo is dominated by older soils with argillic horizons. One important characteristic of such diagnostic horizons is a reddened color (rubification) resulting from illuviation of oxidized clays. This fact in turn supports the alternative hypothesis offered in the testing report that the redness of soils east of the arroyo is due to their greater age and the presence of argillic horizons. In fact, given the presence of Paleozoic rock-derived alluvium on the east side of the arroyo as a source of parent material, the redness of the soils east of the arroyo is likely due to a combination of both greater age and argillic horizon development, as suggested above, as well as inherited parent material characteristics.

RESULTS

Observations on the geomorphic setting and soils at the three excavated sites and Chupadera Arroyo appear below. Because the sites' location with respect to Chupadera Arroyo is pertinent to understanding their deposits, the sites are discussed from west to east, followed by the arroyo discussion.

LA 126619

LA 126619 lies along the western margin of Chupadera Arroyo. The surface is characterized by coppice dunes up to 1 meter or more in thickness and intervening blowouts. Some blowouts bottom out on the Q1 gypsite. At the west edge of Chupadera Arroyo, the undulating surface of the Q1 drops in a terrace-like fashion to the wide bottom of the wash. The Q1 “terraces" are variably capped with a Q2–Q4 sequence. Q1 exposures are less common on the south side of the road as well as in the western portion of the site, but are common south of the right-of-way, where they commonly exhibit polygonal jointing resulting from extensive weathering.

A series of connected trenches were mechanically excavated parallel to the right-of-way on the south side of the road on the south margin of the excavated areas at the site. A total of five profiles was documented during excavation. As was apparent during the testing phase, the site's stratigraphy is complex. A total of nine separate horizons was identified, comprising the four Quaternary units discussed above. Table 43 presents profile data for the most complete section—Profile 2 located at ca. Grid 92 m E. Figures 21–24 show the various profiles documented in the LA 126619 trenches, from west to east at profile points (Profiles) 5, 4, 2, and 1. Figure 25 is a fence diagram that shows the soil horizons documented at each profile point, their relative thicknesses, as well as their elevational relationships. Reddish-hued (5YR) strata are also indicated for comparison with hues documented in Chupadera arroyo and at the two sites east of the arroyo.

Profiles at LA 126619 reveal a full eolian sequence overlying the gypsum-rich Q1, although significant local variations are present. The individual units are described below.

Unit Q1—which could also be designated a C horizon owing to its age and degree of erosion—consists of a 7.5YR loamy sand of probable eolian origin. The deposit ranges from hard to extremely hard and contains great quantities of presumably secondary gypsum and carbonate that both obscure other possible pedogenic characteristics, including pedogenic clay and structure. The upper boundary exhibits considerable topographic variation and has in some places apparently been reworked into the lower portions of the overlying Q2.

Unit Q2 is a 5YR (7.5YR in one profile) eolian loamy sand to sandy loam that is slightly hard to hard in consistence, with weak to moderate subangular to angular blocky structure. For the most part, the unit’s upper horizons have been stripped, although Bw and Bwk horizons are present in the thickest Q2 profile at Profile2 (Fig. 23). Carbonates are abundant and exhibit stage I+ to II+ morphology. The unit’s lower boundary with Q1 ranges from smooth to irregular and, as noted, in some places is indistinct owing to possible reworking of Q1, a possibility that is supported by the presence of gypsum in lower portions of the profile (e.g., the Q2Bky in Profile 2, Fig. 25). Q2’s upper boundary varies markedly in clarity and topography (indicative of variable erosion and reworking), but rises gradually to the east and Q2 appears to have partially filled in relict Q1 topography, particularly in a Q1“hollow” repre-

Table 43. LA 126619 Profile 2

						CARBONATES					LOWER BOUNDARY		
Depth (cm)	Stratum and Horizon	Dry Color	Structure (type, size, grade)	Texture (gravel %)	Clay Films (amount, distinctness, location)	Effervescence	Filaments	Nodules	% Whitened	Stage	Distinctness	Topography	Comments, Parent Material, Interpretation
0–60	Q4C	7.5YR6/6	Massive	Sand (0)	None Observed	None			0		Clear (2–5 cm)	Smooth?	Eolian sand; some fine, discontinuous laminations; lower portion might be weak Bw
60–65	Q4C2	7.5YR6/6	Massive	Sand (0)	None Observed	None			0		Clear (2–5 cm)	Wavy	Eolian sand; some laminations; small clast (FCR?) just above lower boundary
65–85	Q3Bw	5YR6/6	Granular, very coarse, massive-weak peds	Sand (0)	None Observed	Weak			0		Gradual (5–15 cm)	Wavy	Eolian sand; structure weakly expressed; possible FCR just above lower boundary
85–100	Q3Bk	5YR6/6	Subangular-angular blocky(?), very coarse, massive-weak peds	Sand (0)	None Observed	Moderate			>0		Gradual (5–15 cm)	Wavy	Eolian(?) sand; hardness difference detectable with knife
100–125	Q2Bw	5YR5/6	Subangular blocky, coarse, weak peds	Loamy sand (0)	None Observed	Moderate	Few/faint?		0	I	Gradual (5–15 cm)	Smooth	Eolian(?) sand; hardness difference (than above) detectable with knife
125–135	Q2Bwk	5YR5/6	Angular blocky, very coarse, weak peds	Loamy sand (0)	None Observed	Moderate	Common?		0	I+	Gradual (5–15 cm)	Smooth	Eolian(?) sand; hardness difference (much harder than above) detectable with knife
135–173	Q2Bk(U)	5YR6/6	Angular blocky, very coarse, moderate peds	Loamy sand (0)	None Observed	Strong	Common		30	II+	Clear (2–5 cm)	Smooth	Eolian(?) sand; nodules and whitening (7/6) more stongly expressed near bottom
173–185	Q2Bky	5YR7/4	Subangular blocky, coarse, moderate peds	Loamy sand (0)	None Observed	Strong			40	?	Abrupt (<2 cm)	Wavy	Massive, fine eolian(?) sand; highly calcareous, non-nodular may be reworked Q1Byk
185–	Q1Byk	7.5YR7/4	Subangular-angular blocky? peds	Loamy sand (0)	None Observed	Moderate			80	I?	Uncertain	Uncertain	Eolian(?) sand; cicada holes and many gypsum filaments; extremely hard

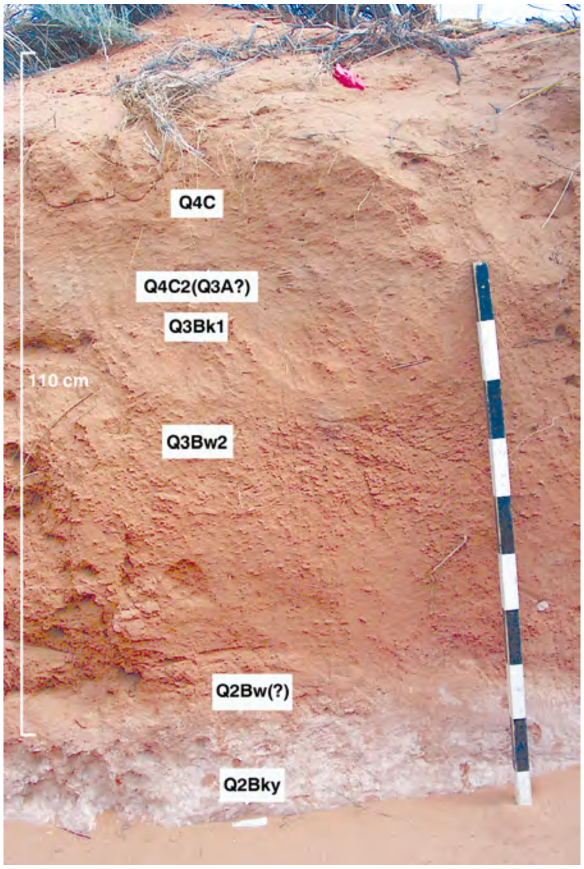

Figure 21. Soil stratigraphy at LA 126619 Profile 5. Rough surface of Q3Bw profile probably reflects insect bioturbation.

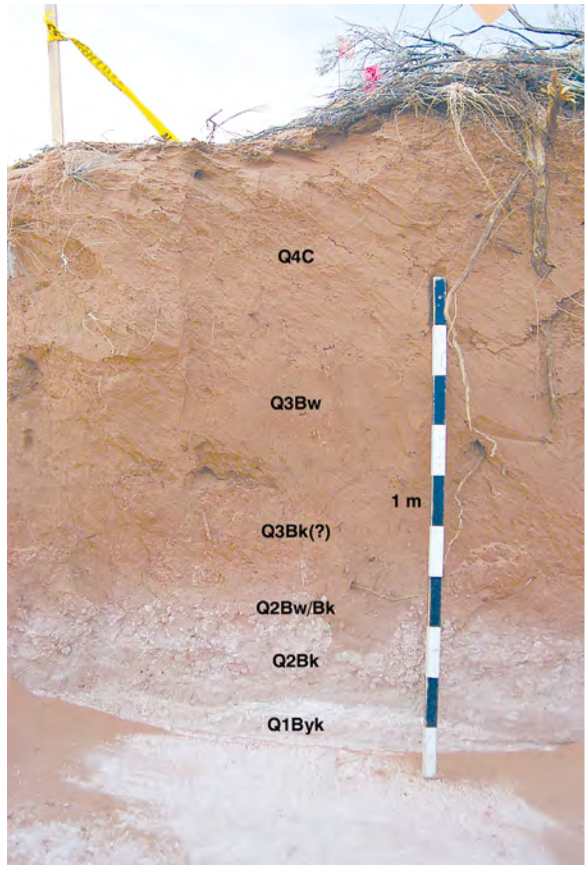

Figure 22. Soil stratigraphy at LA 126619 Profile 4. Note thick, laminated Q4 deposit.

sented at Profile 2. The unit also shows evidence of extensive bioturbation by insects (e.g., Fig. 24).

Unit Q3 is an eolian sand (to loamy sand in lower portions of some profiles), with generally soft consistence and massive to weak granular to subangular blocky structure. Both 7.5YR and 5YR hues are present. 5YR hues are correlated with the Q3Bk in Profiles 4–2 (and lack thereof in Profile 5), but not Profile 1. Preservation of horizons is variable with both Bw and underlying Bk horizons present in all but Profile 5, where a probable A horizon caps the unit's thickest expression. Q3 deposits always contain at least some CaCO3, but carbonate morphology is generally limited to sub-stage I (very few filaments), although enough filaments are present in Profile 3 to warrant stage I designation. Some carbonates may be inherited rather than pedogenic. The uncertain nature of the lowest Q3 horizon at Profile 4 may reflect reworking of underlying Q2. The upper boundary of unit Q3 is generally abrupt to clear and smooth and more closely approximates the surface topography. Like Q2, it rises gradually to the east, although its thickest expression is at the west end of the site and not at Profile 2 as in the case of Q3. Lateral variations in unit Q3 thickness, horizonation, carbonate morphology, and color may reflect diachronous deposition of the unit Q3, with the 7.5 YR Q3 in Profile 5, which lacks a Bk horizon, being younger than Q3 deposits to the east, especially the 5YR Bw/Bw horizons in Profile2.

Unit Q4 is an eolian sand of recent origin as evidenced by well-preserved depositional structure and a lack of any pedogenic features. All carbonates are inherited. The unit includes both pre- and post-road sub-units, as well as a possibly older component (Q4C2, lacks preserved bedding) at Profiles 5 and 2. This unit

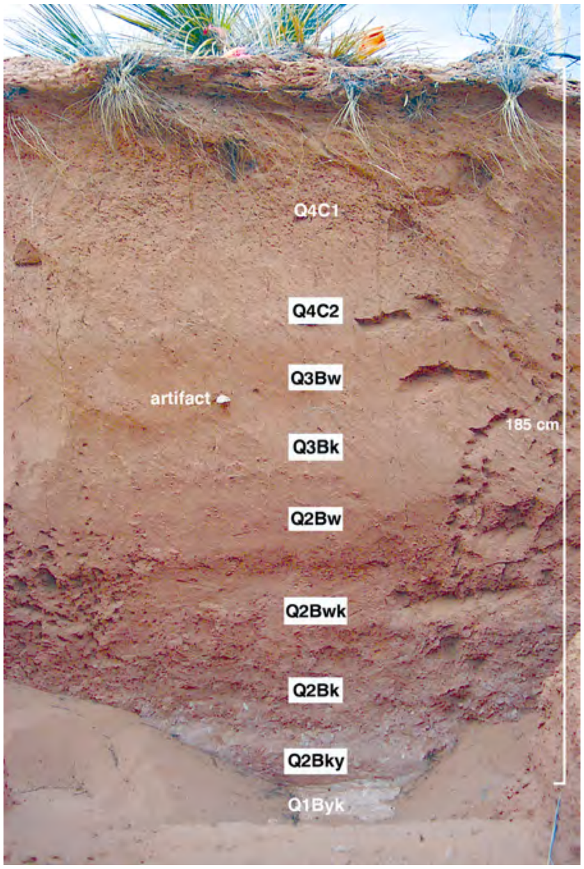

Figure 23. Soil stratigraphy at LA 126619 Profile 2. Note artifact in upper Q3 deposit.

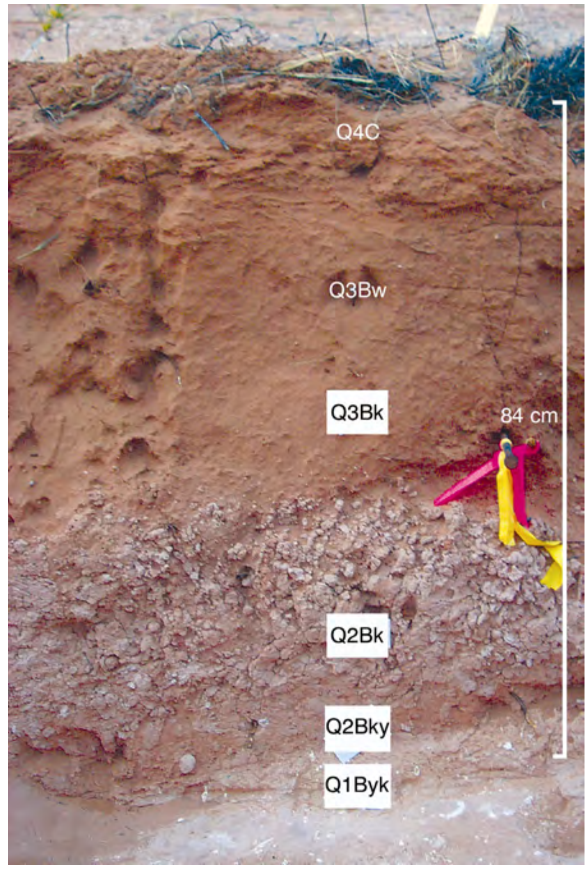

Figure 24. Soil stratigraphy at LA 126619 Profile 1. Note heavy cicada bioturbation of Q2 deposits.

is similar to recent dune-forming sands documented elsewhere in New Mexico (e.g. the Tularosa Basin [Blair et al. 1990a, 1990b]), which are thought to have been produced by grazing-induced destabilization of vegetative cover. However, Neilson (1986) has suggested a more complex model that combines both climatic change and grazing effects.

Data from the five profiles at LA 126619 indicate considerable variety in the overall thickness of and variable preservation of post-Q1 depositional units, as evidenced in Figure 25. Together with the variety of sub-horizons present in the thicker sections, this suggests that the original, depositional units in which the soils formed—in particular Q2 and Q3—varied in thickness on local scales of 1s to 10s of meters. Thicker deposits formed thicker and more varied horizon suites that tended to be better preserved. The 35 cm of Q3 (comprising two subhorizons), and 85 cm of Q2 (comprising four subhorizons) in Profile 2 are examples of this conclusion. In fact, as noted above, Unit Q3's variability may reflect the diachronous deposition noted in similar units elsewhere in New Mexico (e.g., in the southern Tularosa Basin [Blair et al. 1990a, 1990b], and Wells et al. [1990]).

Evidence of bioturbation was present in all profiles, not only in the form of obvious krotovina produced by burrowing rodents (burrows 5–10 cm in diameter), but in smaller insect burrows, probably produced by cicadas (see discussion in Weber 1997). Insect burrows are obvious in Q2 sediment profiles (e.g. Fig. 24), but generally not visible in fresh Q3 profiles. Figure 26 shows obvious relict insect burrows in Q3 sediments near Profile 2 that had weathered for over two weeks prior to taking of the photograph. Almost all of the roughness of the Q3 profile surface in the photograph represents relict burrows, while one large burrow is particularly prominent. This indicates

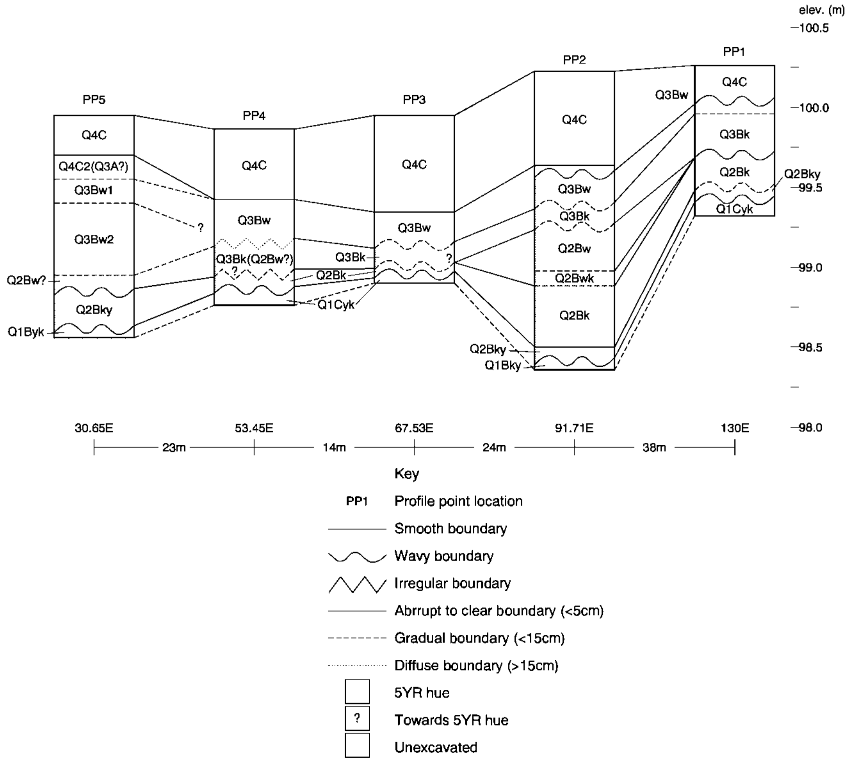

Figure 25. Fence diagram of soil stratigraphy at LA 126619.

that Q3 sediments, as hypothesized in the testing report, have been heavily bioturbated. The potential effects of bioturbation on archeological deposits is further discussed in the conclusions.

LA 67451

LA 67451 lies just east of the Chupadera Arroyo margin and is due north-northeast of the Mockingbird Gap site. The surface is characterized by sand sheet deposits with more continuous vegetation and lower and fewer coppice dunes than those observed at LA 126619. As noted above, the soils and sediments in the area east of the wash differ radically in color from those to the west in being notably more red or orange. This was originally thought to be due to the eolian origin of the sediments and their primary source (Chupadera Arroyo). It is more likely, however, that the soils' color derives in part from the presence of oxidized illuvial clays, as well as the nature of the parent material.

A single trench was mechanically excavated parallel to the right-of-way. The trench was excavated after archeological excavations were complete, allowing it to be placed directly across the excavated area. Three profiles were documented. Seven to eight separate horizons were identified, comprising the four Quaternary units discussed above. Table 44 presents profile data for the most complete section—Profile 1 located at ca. Grid 106 m E. Figures 27–29 show the soil stratigraphy at various points in the trench, including Profiles 1 and 3. Figure 30 is a fence diagram (similar to Fig. 25) of the stratigraphy at LA 67451 and LA 126620 (see below) that shows the soil horizons documented at each profile point, their relative thickness and elevational relationships, with reddish- (5YR) and red-hued (2.5YR) strata indicated for comparison with hues documented at LA 126619 west of the arroyo and with arroyo bottom deposits.

Table 44. LA 67451 Profile 1

						CARBONATES					LOWER BOUNDARY		
Depth (cm)	Stratum and Horizon	Dry Color	Structure (type, size, grade)	Texture (gravel %)	Clay Films (amount, distinctness, location)	Effervescence	Filaments	Nodules	% Whitened	Stage	Distinctness	Topography	Comments, Parent Material, Interpretation
0–12	Q4C	5YR4/6	Granular, coarse, massive-weak peds	Loamy sand (0)	None observed	Moderate					Abrupt (<2 cm)	Smooth	Slightly platy structure
12–17	Q3A(c?)	5YR4/4	Subangular blocky, coarse, massive-weak peds	Loamy sand (0)	None observed	Weak					Clear (2–5 cm)	Smooth-wavy	No in-place peds
17–44	Q3Bw	2.5YR3/6	Subangular-angular blocky(?), coarse, weak peds	Sandy loam (0)	None observed	None					Clear (2–5 cm)	Irregular	
44–51	Q3Bk	2.5YR3/6	Subangular blocky, coarse, weak peds	Loam (0)	None observed	Strong-violent	Few/faint		25	I	Clear (2–5 cm)	Irregular	Discontinuous boundary on tops of Q2Btk “cones” (polygons)
51–80	Q2Btk	2.5YR5/4	Granular, very coarse, moderate-strong peds	Silty clay loam (0)	Very few-few faint, coatings and bridges	Violent		Common	50	II	Abrupt (<2 cm)	Smooth	
80–88	Q2/Q1?	2.5YR4/4	Granular, coarse, weak peds	Silty loam (0)	Very few, faint, bridges?	Violent				?	Abrupt (<2 cm)	Smooth	“Red Sand”
88–170	QA1Cyk	2.5YR5/4	Massive (no true structure)	Silty clay loam (0)	None Observed	Strong violent					Clear-Gradual (2–15 cm)	Smooth	Silty clay loam variant
88–170	QA1Cy?	2.5YR5/4	Massive (no true structure)	Loam (0)	None Observed	Strong violent					Clear-Gradual (2–15 cm)	Smooth	Loam variant
170–	QA1Cy	7.5YR7/4	Massive (no true structure)	Loamy sand (0)	None observed	Weak					Uncertain	Uncertain	

Figure 26. Relict cicada burrows in weathered Q3 profile near LA 126619 Profile 2.

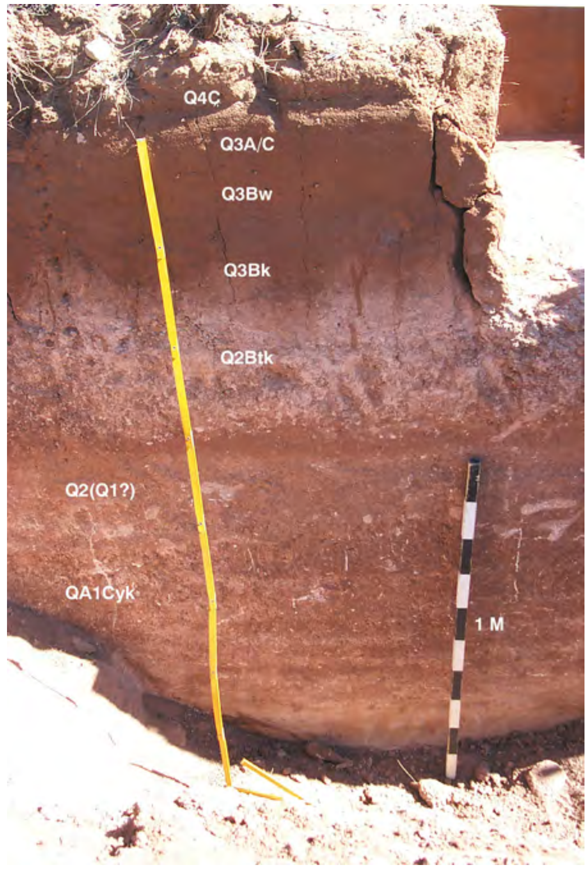

Figure 27. Soil stratigraphy at LA 67451, 106.20E.

The soil stratigraphy documented at LA 67451 during the excavation phase differs from that recorded during the testing phase in terms of the sub-horizons identified within the Q3 unit. Most notably, the argillic sub-horizons noted during testing were determined not to have sufficient evidence of illuvial clay to warrant such designation. Instead three subhorizons—a possible Q3A, Q3Bw, and Q3Bk—were recognized. The soil-stratigraphic sequence identified at LA 67451 is briefly summarized below.

Unit Q1 is a massive, hard to extremely hard, 2.5YR silty clay that probably represents arroyo-margin pond deposits, whose ephemeral nature is evidenced in the abundant large (2–3 cm) gypsum crystals that characterize the deposit. Carbonates are abundant in the upper portions of Q1, but lack distinctive morphology. Augering in the bottom of the trench revealed a thick complex of alluvial deposits—including apparent channel sands—below the pond clays.

The unit's upper boundary is smooth and abrupt, undoubtedly typical of the Bucklebar soil mapped and drops off to east and west, suggesting that LA 67541 is located on a Q1 topographic high.

Unit Q2 is an eolian silty clay loam with some pedogenic clay (few, faint grain coatings and bridges), slightly hard-hard consistence, moderate granular structure, and well-developed stage II carbonate morphology, all characteristics indicative of significant soil development. Color is generally 2.5YR. The Q2Btk is a true, if weakly-developed argillic horizon and is in the project area and that occurs predominantly on the east side of Chupadera Arroyo (Table 41). Unit Q2 appears to follow the relict Q1 topography, and in Profile 1 appears to incorporate some reworked Q1. The upper boundary of unit Q2 is clear to abrupt and varies from smooth to irregular, probably as a function of variable erosion and reworking.

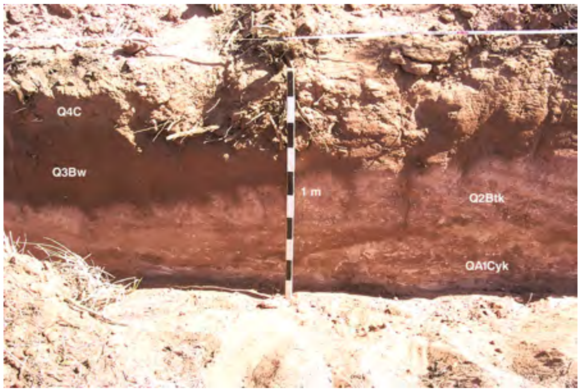

Figure 28. Soil stratigraphy at LA 67451, 110.60 E. Note cross-sectioned polygonal joints and rounded, weathered upper boundary in top of unit Q2, as well as upward-propagating cracks in Q3.

An interesting phenomenon—not noted during testing—is a distinctive horizontal polygonal structure to the Q2 unit, which is best expressed in the profile at 110.60 E, where Q3 can be seen filling a Q2 "hollow" and penetrating into the Q2 joint structure (Fig. 28). This polygonal structure probably represent the results of long-term shrink-swell effects produced by repeated seasonal wetting and drying of clay-rich sediments. In addition to the downward penetrations of Q3 into the resultant cracks, upward-propagating cracks upwards extend through the Q3 unit. The polygonal structure of the Q2 unit may be evidence of considerable antiquity, possibly greater than that of the Q2 unit documented west of the arroyo at LA 126619.

Unit Q3 is an eolian 2.5YR–5YR sandy loam to loamy sand with soft to slightly hard consistence, massive to very weak subangular - angular blocky structure and very faint pedogenic clay (coatings and bridges). Bw, Bwk and Bw2 (or C) horizons are present as is an apparent weak A horizon (Profile 1) that is unlikely to be a cultural stain since all artifacts recovered at the site were lower unit Q3 contexts (Chapter 5). CaCO3 is weak to absent in the upper parts of Q3 (A, Bw), but fairly abundant in the Bk horizon which exhibits stage I to I+ carbonate morphology (few to common filaments and 10–20 % whitening). As noted, the unit's lower boundary is variable and some reworking of Q2 is likely. The unit's upper boundary is generally abrupt and smooth with a

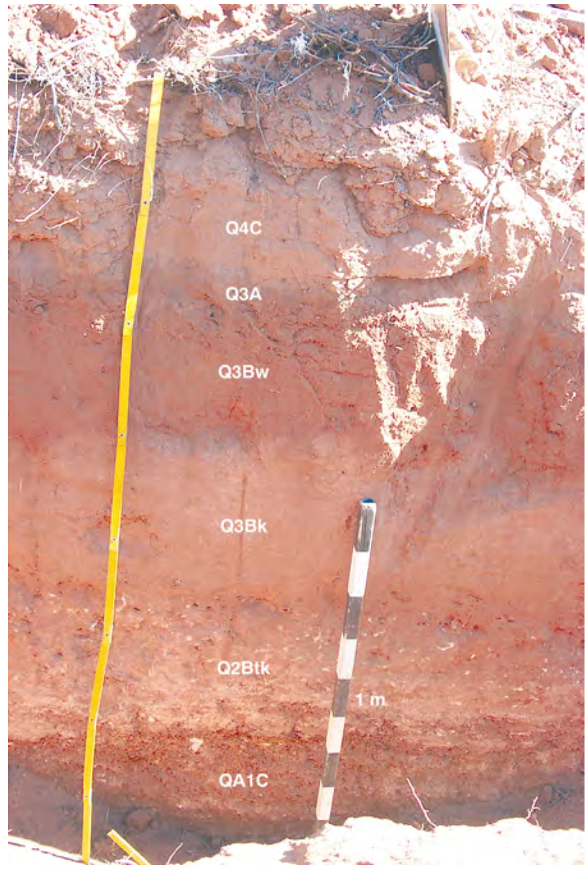

Figure 29. Soil stratigraphy at LA 67451 Profile 3. Note distinct whitening in Q3Bk horizon.

more even topography than that of units Q2 and Q1, indicating that unit Q3 filled in pre-existing irregularities, and that the unit may be more intact than at LA 126619.

In comparison with LA 126619 (Table 43), the Q2 and Q3 Bk subhorizons at LA 67451 appears to contain more CaCO3 and better-developed pedogenic carbonate morphology. In addition, more pedogenic clay is present in both the Q2 and Q3 buried soils, although this may be a function of the greater clay content of the parent materials as well as proximity to an upwind source of aerosolic clay (the arroyo). Finally, as noted, the polygonal jointing of unit Q2 might reflect greater weathering and age, but this, too, could as easily be a function of the higher clay content. Thus, only the greater carbonate development in the Q2 and Q3 soils remains as a possible indicator of greater age than at LA 126619. For unit Q3, at least, this seems unlikely, given the two radiocarbon dates derived from Q3 context, date that are entirely consistent with those from Q3 deposits at

LA 126619. Thus, it can be tentatively concluded that the Quaternary units at LA 67451 are at least roughly correlated with those documented west of the arroyo.

As noted above, and as was observed during testing, soil colors in the LA 67451 profile exhibit markedly redder hues (5–2.5YR) than those at LA 126619 (7.5–5YR). This difference is correlated with an overall finer texture (loamy sand-silty loam versus sand-loamy sand) in all three of the upper Quaternary units (Q1–Q4). These facts suggest that illuvial clay alone may not account for the color differences between the two locales. Were this the case—as was proposed in the testing phase report—the clay-produced color and texture differences should be limited to lower, B horizons. This conclusion leaves only the testing report-suggested hypothesis to the effect that the finer-grained arroyo sediments and inherited red color are responsible. Comparison of LA 67451 deposits with the arroyo sediments, however, leaves even this hypothesis in doubt (see below).

LA 126620

LA 126620 lies ca. 150 m east of LA 67451. The site surface is characterized by similar eolian sheet sands with the same orange-red colored surface deposits as those observed at LA 67541. One isolated exposure of the gypsum-rich Q1 was noted south of the road, suggesting that the site is underlain by this unit at varying depths. One trench was excavated at the site, directly through the excavated area following data recovery activities. The site's stratigraphy is highly variable, owing largely to the effects of the extreme topography of the basal unit Q1 on the overlying units' stratigraphy. Figures 31 and 32 show the range of stratigraphic and strato-topographic variations present, while the relationship of the site's stratigraphy to that at LA 67451 is depicted in Figure 30. One profile was documented at ca. Grid 91.20E, while two other points were briefly described. Table 45 is a composite profile based on the stratigraphy observed in the trench. All four Quaternary units are represented, but, unlike LA 126619 and LA 67451, all but unit Q4 exhibit undulating topography and thickness—with the greatest variation in the older units. Younger units are commonly inset into older ones, suggesting highly variable and localized preservation and the possibility that—despite being apparently eolian in origin—they were deposited in small alluvial channels (Fig. 25 shows a Q2–Q4 sequence inset into a channel in underlying Q1 stratigraphy).

Unlike LA 67451, unit Q1 consists of both eolian (Q1Cyk) and possibly alluvial (Q1Cy) deposits, overlying an older alluvial gravel unit. A complex alluvial and subsequent eolian history is implied by the variable stratigraphy (Fig. 31). Q1 deposits are 5Yr in hue, mostly sandy in texture, contain pervasive gypsum and variable carbonates. Depth to the Q1 varies from 0 cm at ca. 88 E to 145 cm just over 3 m to the east (Profile 1).

The Unit Q2 buried soil is eolian in origin and exhibits only Bk1 (2.5 YR loam) and Bk2 (5YR loamy sand) subhorizons, with the upper one having stronger pedogenic characteristics, including stage II carbonate morphology (few, faint filaments, 40% whitening). The upper boundary is clear and wavy, clearly indicating truncation by erosion, while both the Bk1 and Bk2 boundaries follow the surface of the Q1/pre-Q1 gravel, suggesting that Q2 deposits mapped onto Q1.

Unit Q3 is an eolian loamy sand with a 2.5YR Bw1 horizon overlying 5YR possible Bw2 and Bk horizons. The Q3A horizon of LA 67451 is absent, while the Bw2 has faint evidence of illuvial, pedogenic clay. The Bk horizon exhibits common carbonate filaments and 10 percent whitening indicative of stage I carbonate morphology. The upper boundary is abrupt and smooth and more or less level, indicating that Q3 deposition filled the relict Q1/Q2 topographic.

As at LA 67451, unit Q4 is a recent eolian loamy sand with soft consistence, no structure, and inherited carbonates. Unlike LA 67451, the unit is uniformly thin (10–15 cm thick).

The soil stratigraphy at LA 126620 differs from that at LA 67451 in two other important ways. First, overall redness is somewhat less (albeit greater than at LA 126619). Secondly, textures are slightly less fine-grained, clay is less common, and clay films are not present to the extent to warrant argillic horizon designations as at LA 67451, the Q2 unit exhibits well-

Table 45. LA 126620 Profile[1]

						CARBONATES					LOWER BOUNDARY		
Depth (cm)	Stratum and Horizon	Dry Color	Structure (type, size, grade)	Texture (gravel %)	Clay Films (amount, distinctness, location)	Effervescence	Filaments	Nodules	% Whitened	Stage	Distinctness	Topography	Comments, Parent Material, Interpretation
0–10	Q4C	5YR4/6	Single-grain	Loamy sand (0)	None Observed	Weak					Abrupt (<2 cm)	Smooth	Cannot hold vertical face
10–64	Q3Bw1	2.5YR4/6	Subangular-angular blocky?, coarse-very coarse, massive-weak	Loamy sand (0)	None Observed	None					Clear (2–5 cm)	Smooth	Some vertical cracks; very weak peds
64–88	Q3Bw2?	5YR4/6	Angular blocky?, coarse?, massive	Loamy sand (0)	Very few?, faint?, bridges	None					Clear (2–5 cm)	Wavy	Definitely harder with darker color; very weak peds; almost no oriented clay
88–123	Q3Bk	5YR5/6	Subangular-angular blocky?, coarse?, massive-weak	Loamy sand (0)	None observed	Moderate-strong	Common		10	I	Abrupt-clear (<5 cm)	Wavy	CaCO3 filament fairly common; very weak peds, if any
123–140	Q2Bk	2.5YR6/4	Granular-blocky, coarse-very coarse, massive?	Loam (0)	None observed	Violent	Few/ faint?	Few/ faint?	40	II	Gradual (5–15 cm)	Wavy	Weak peds; some cicada burrows (esp. to west); one cobble with CaCO# pendant
125–145	Q2Bk2	5YR4/6	Granular?, uncertain, massive	Loamy sand (0)	None observed	Moderate-strong					Uncertain	Uncertain	Found only west of 91.20E in deepest Q1 “hollow”
140–	Q1Cy	5YR7/3	No true structure	Sand (0)	None observed	None					Uncertain	Uncertain	Almost pure gypsum with vertically-oriented crystals

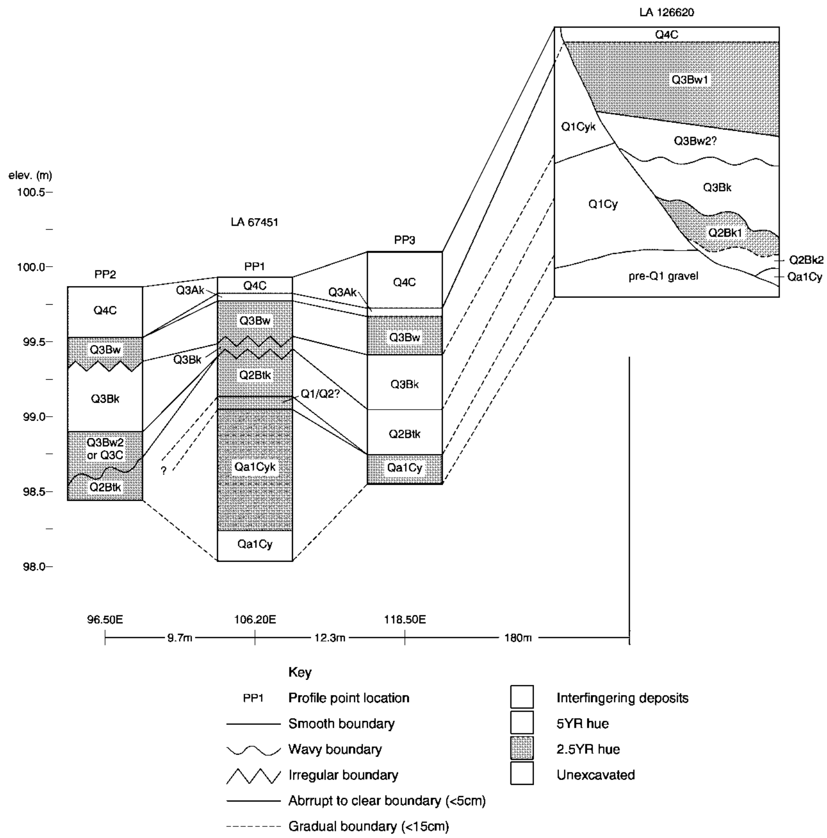

Figure 30. Fence diagram of soil stratigraphy at LA 67451 and LA 126620.

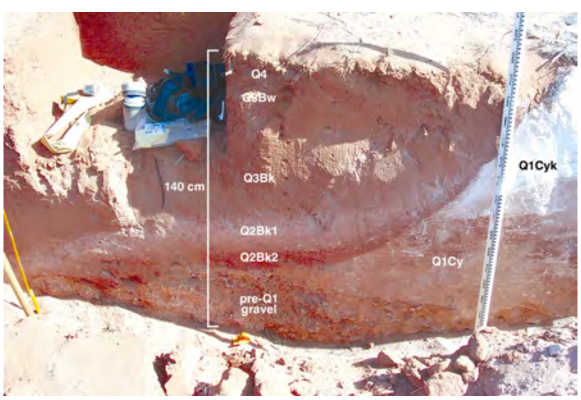

Figure 31. Soil stratigraphy at LA 126620 89-91 E. Note Q2/Q3 sequence inset into heavily eroded Q1 topography.

developed Stage II carbonate morphology, but in the form of both faint filaments and nodules. Under the testing project-derived hypothesis that deposits at LA 67451 were derived in part from Chupadera Arroyo, the differences between that site and LA 126620 might be attributed to the latter's being more distant and hence less influenced by the arroyo. Given that inherent parent materials differences are more likely the source of deposit redness at LA 67451, however, and alternative explanation of the lighter colors present at LA 126620 is required. Differences in strato-topography suggest that the two sites represent somewhat different depositional environments, with fluvial processes playing a greater role at LA 126620, despite its location farther from the arroyo. Alternatively, a variation of the original hypothesis seems possible as well–namely that the deposits at LA 126620 are in part derived from and thus somewhat younger than those at LA 67451. This possibility in turn suggests diachronous deposition, particularly in the case of unit Q3, which is consistently less red than at LA 67451.

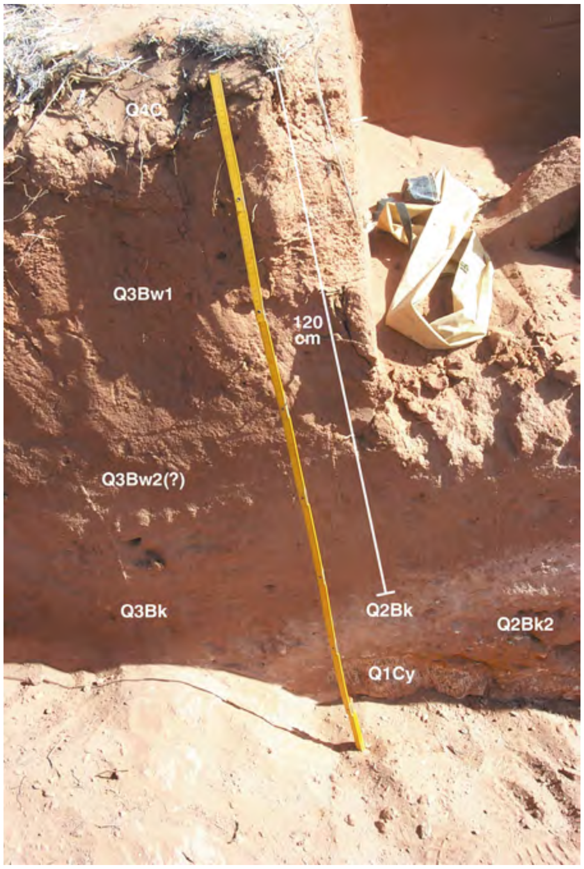

Figure 32. Soil stratigraphy at LA 126620 Profile 1. Note east-diving Q2.

Chupadera Arroyo

In the project area, Chupadera Arroyo averages ca. 200–300 m wide and is essentially flat-bottomed. In the vicinity of the highway, the arroyo bottom lies ca. 4 m below the surrounding terrain, and vegetation consists of grasses and occasional woody shrubs distributed in small patches separated by barren sediments. The latter often exhibit polygonal dessication cracks attesting to their elevated clay content and periodic inundation. About 300 m to the south, the arroyo bottom has been engulfed by the same hummocky eolian deposits that characterize the area around LA 126619 to the west.

Five trenches (numbered 1–5 from west to east) were mechanically excavated ca. 20 m to the south of the highway, all oriented parallel to the road. Two were placed across the sloping interfaces between the arroyo bottom and the elevated terrain to the west (Trench 1) and east (Trench 5), while three were spaced at even intervals on the bottom. Two profile points were documented in Trench 1, one each in Trenches 2–4, and five in Trench 5. Table 46 lists the stratigraphy observed in the central trench (No. 3). All arroyo-bottom profiles exhibited the same general stratigraphy as that in Table 46. Although the upper Q4 units exhibit marked ped structure, the platy nature of the Q4C1 peds is a probable product of compaction by bridge construction traffic and not pedogenesis. The Q4C2 peds may be a similarly-produced phenomenon, preserved dessication features such as those noted on the surface, or, possibly, truly pedogenic. Figures 33–35 show the stratigraphy at representative profiles in the west margin, arroyo bottom, and east margin trenches, respectively. Figure 36 is a fence diagram showing the relative thickness and elevational relationships of the soil-stratigraphic units identified in the five arroyo trenches, with reddish-hued (5YR) strata indicated for comparison with hues documented at site west and east of the arroyo (identification of 5YR colors was based on field Munsell color measurements and/or inspection of color photographs of trench profiles; Trench 5 Profiles 2 and 1 are similar to Profile 3 and were excluded).

Because of the alluvial depositional environment, identification of soil horizons and their correlation with depositional units and soil horizons identified in the eolian setting adjacent to the arroyo was somewhat tentative and based on the assumption that each eolian unit identified at the archeological sites would be represented by at least one correlative unit in the arroyo. Thus, the uppermost deposits were assumed to be Q4 correlates, while underlying deposits were assigned Q-designations based on stratigraphic position, texture, color, evidence for geomorphic origin and other similarities to terrestrial eolian units. A detailed sedimentological analysis of the deposits documented in the five trenches would undoubtedly shed more light on the relationship between arroyo and terrestrial stratigraphy, but was beyond the scope of the present investigation.

Table 46. Chupadero Arroyo Trench 3 Profile

						CARBONATES					LOWER BOUNDARY		
Depth (cm)	Stratum and Horizon	Dry Color	Structure (type, size, grade)	Texture (gravel %)	Clay Films (amount, distinctness, location)	Effervescence	Filaments	Nodules	% Whitened	Stage	Distinctness	Topography	Comments, Parent Material, Interpretation
0–30	Q4C1	7.5YR5/4	Platy, coarse-very coarse, moderate-strong	Silty clay loam (0)	Very few-common, faint/distinct/ prominent, pores/ pedfaces/ coatings	Moderate					Clear (2–5 cm)	Smooth	Mostly eolian; platy "peds" are probably a product of construction traffic; CaCO3 is inherited
30–65	Q4C2	7.5YR5/4	Subangular blocky, coarse-very coarse, moderate-strong	Silty clay (0)	Common-many, distinct/ Prominent, pores/ pedfaces/ coatings	Moderate					Gradual (5–15 cm)	Wavy	Mostly eolian; blocky "peds" are better expressed at top and probably a product of construction traffic
65–90	Q3? (upper)	7.5YR6/4	Subangular blocky, coarse, moderate	Sandy loam (0)	Very few, faint, coatings and bridges	Moderate					Diffuse (>15 cm)	Smooth	Massive light tan (eolian?) sand without bedding; peds are better expressed at top; lower portion lighter; possible "Q3" unit
90–115	Q3? (lower)	7.5YR6/4	Angular blocky?, very coarse, moderate	Loamy sand (0)	Very few, faint, coatings and bridges	Moderate					Abrupt (<2 cm)	Wavy	Massive light tan (eolian?) sand without bedding; peds are better expressed at top; lower portion lighter; possible "Q3" unit
115–165	Qa?	7.5YR7/4	None observed	Sand (0)	None observed	Weak					Abrupt (<2 cm)	Wavy	Alluvial sand with laminar bedding and some clay lenses (clay drapes); some gypsum
165–265	Qa1Cy1	7.5YR7/3	Angular blocky?, very coarse, strong?	Silty clay (0)	Very few, faint, ped faces	Moderate					Clear (2–5 cm)	Smooth	Massive gypsum-rich alluvial clay, with many thick gypsum filaments
265–300	Qa1Cy2	7.5YR7/3	Angular blocky? very coarse?, strong?	Silty clay loam (<10)		Moderate					Uncertain	Uncertain	Softer, gypsiferous fine alluvial sand with limonitic stains (some with gypsum "Cores", clay "pockets", few gypsum filaments,; occasional water-worn volcanic cinders

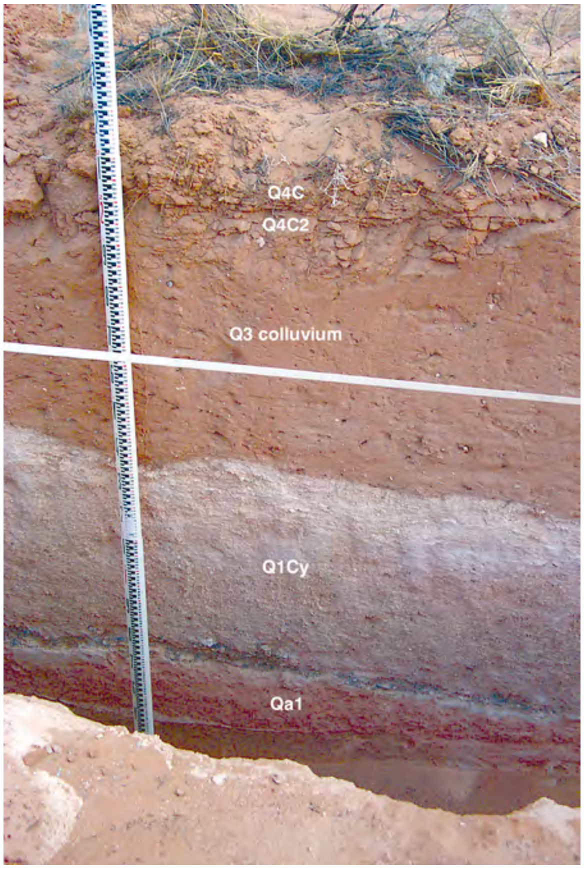

Figure 33. Soil stratigraphy at Chupadera Arroyo Trench 1 (west arroyo margin) Profile 1. Note dispersed fine gravels in Q3 colluvium inset into eroded and weathered Q1.

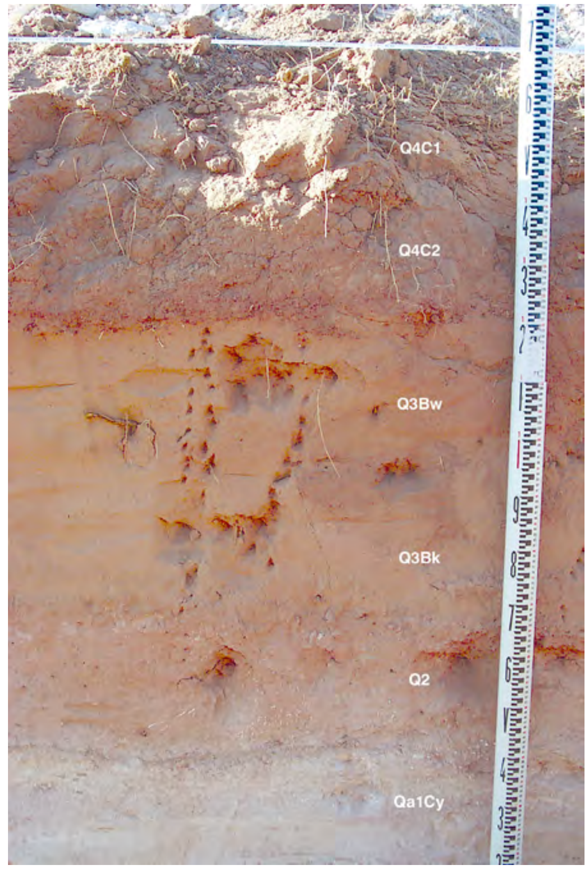

Figure 34. Soil stratigraphy at Chupadera Arroyo Trench 3 (central arroyo bottom). Note platy structure of Q4C1 and level stratigraphy of all units.

All sediments identified as Q1 are clearly alluvial in origin, with the upper portions usually consisting of 5YR clays with visible sedimentary structure common, abundant gypsum crystals and filaments and variable carbonate content. The Q1 topography varies somewhat across the bottom of the arroyo and the upper boundary ranges from clear to diffuse and smooth to wavy. As noted, the upper portions are underlain by a complex alluvial stratigraphy that includes channel sands, floodplain silts, and gravel lenses. Weber's 1997 discussion of Chupadera Arroyo stratigraphy supplies considerable detail on the arroyo's pre-Holocene stratigraphy and its implications for association Pleistocene environments.

Deposits tentatively identified as Q2 appear alluvial in origin as well, exhibiting alluvial depositional structure and an overall sandier texture. Color is generally 7.5YR, although 5YR hues were documented in two arroyo-margin profiles. Carbonate content is generally high but variable. Q2 units are relatively consistent in thickness and appear to follow the Q1 topography. Q2 deposits appear to be absent from the arroyo margins, suggesting post-Q2 widening of the arroyo.

Q3 deposits are generally sandy (to loamy sand) in texture and—with the exception of the western arroyo margin—appear primarily eolian in origin (both eolian and alluvial sediments are present in eastern margin deposits). All exhibit 7.5YR hues. The colluvial wedge of Q3 deposits noted on the western margin (Fig. 33) may have developed after the post-Q2 arroyo-widening hypothesized above. It is possible that the eolian Q3 deposits in the central portion of the arroyo are wind-reworked alluvial material.

Figure 35. Soil stratigraphy at Chupadera Arroyo Trench 5 (east arroyo margin), view east-northeast from Profile 5. Note west-diving terraced unit Q1 and inset Q2–Q4 units.

As noted, deposits identified as Q4 exhibit platy structure in the upper portion and a moderate-strong subangular blocky structure in the lower part that represent the effects of construction compaction and dessication rather than true pedogenisis.

Overall, the latest Pleistocene to Holocene stratigraphy in Chupadera Arroyo appears to reflect a change in predominant geomorphic dynamics from fluvial to eolian processes, a change that is consistent with known climatic changes. A more important point, however, is the total lack of 2.5YR-hued sediments and the restriction of 5YR hues to Q1 and a few Q2 deposits (Fig. 36). From this it is clear that the 2.5YR and 5YR hues documented at sites east of the arroyo are not due to the deposits' eolian derivation from arroyo sediments.

The inescapable conclusion is that the red color of the soils east of the arroyo is not attributable to derivation from fine-grained sediments in the arroyo itself. Since evidence for extensive illuvial clays is lacking in the soils east of the arroyo, the originally proposed hypotheses have been negated. An alternative explanation is provided below.

DISCUSSION

The following discussion addresses the research questions posed in the research design that appeared in the testing report.

Intrasite Variation in Soil Stratigraphy

Intrasite variations in soils at the three excavated sites observed during the testing phase were largely resolved by inspection of long trench sections. At LA 126619, where the greatest variation was observed, all variations can be explained in terms of a refined Quaternary sequence that is similar to that documented during testing, but which includes newly identified soil sub-horizons that may reflect diachronous deposition of unit Q3. The revised sequence is as follows (from bottom to top): Q1Byk (exhibiting a variably weathered surface), Q2Bky (Q2 unit consisting of reworked Q1Byk); Q2Bk (A Stage II–II+ carbonate horizon), Q2Bw (color and structural cambic horizon), Q3Bk (calcareous horizon), Q3Bw (color and structural cambic horizon), a probable Q3A (an organically-stained horizon) that may also be of later age, and various later pre- and post-road deposits collectively designated Q4.

Some of these sub-horizons are only locally preserved, and this fact may account for some of the intersite variations observed, as well. For example, the Q2Bw and Q3Bw sub-horizons are preserved together only in the central portion of the excavated area at LA 126619, and are entirely absent from the eastern, more eroded portion of the site near the arroyo margin. In the extreme western portion of the site, all but a thin portion of the Q2Bw sub-horizon been eroded, but is overlain by a thick Q3 accumulation that underlies a thick Q4. Here, unit Q3 exhibits A/Bw1/Bw2 horizon but lacks both a calcareous Bk and any 5Yr deposits; the Q3 here may thus be younger. Thus differences in the various

profiles can be explained in part by differential erosion and preservation of the various Q-units, but diachronous deposition of unit Q3 was probably involved as well.

Comparison of the geoarcheological observations with excavation results indicates that no cultural materials were recovered from Q2 contexts. In many, if not most cases, cultural materials were recovered from the lower portions of the Q3 unit.

Data collected from the trenches in the two sites east of the arroyo tend to confirm the soil stratigraphic sequences developed during the testing phase, although important differences in color and texture can be related to the influences of arroyo proximity. Neither of these sites contained extensive cultural materials, but what materials were documented were recovered from deposits designated Q3. At LA 67451, this unit consists of a possible weakly-developed A horizon overlying variable Bw and Bk sub-horizons whose degree of development appears to be a function of variable reworking. At LA 67451, the Q3 unit overlies a heavily weathered Q2Bk. This weathering produced pronounced polygonal jointing similar to that observed in certain Q1 exposures. This jointing has propagated upwards over time through both Q3 and later Q4 units, and is responsible for apparent mixing of materials at the Q3/Q2 boundary.

At LA 126620, the Q2 unit does not exhibit the heavy weathering observed at LA 67451, possibly owing to the site's markedly different erosional and depositional history. With the exception of a subtle, but distinct difference in color and texture (sandier at LA 1226620), the Q3 sub-horizons at LA 126620 are similar to those at LA 67451.

Intersite Variation in Soil Stratigraphy

The testing phase geoarcheological report suggested that marked color differences between deposits on the west and east side of Chupadera Arroyo could be attributed to parent material differences. It was hypothesized that the reddish color of deposits east of the arroyo reflected their eolian derivation from reddish alluvial deposits in the arroyo bottom that were in turn erosionally derived from Paleozoic rocks that bound the stream's drainage basin. Two lines of evidence gathered during the excavation phase argue against this hypothesis, however. The first is that no markedly red (2.5YR hue) deposits were observed in the arroyo trenches. The second is that the landscape reconnaissance conducted as part of the geoarcheology study revealed that much of the landscape on the east side of the arroyo is characterized by a relict Pleistocene haplargid soil (Bucklebar sandy clay loam; Q2Btk at LA 67451 and Q2Bk at LA 126620) that is either exposed at the surface or shallowly buried beneath younger Holocene deposits that are largely derived from it. The Bucklebar soil is old enough (latest Pleistocene, Gile et al. 1981:73, Table 28) to have developed a pronounced clay rich argillic horizon, and derives its color in part from this horizon. The Q3 and Q4 units at LA 67451 and LA 126620 overlie the original Bucklebar, however, and lack sufficient pedogenic clay to account for their color.

More likely, the cultural material-bearing Q3 stratigraphic units documented at LA 67451 and LA 126620, as well as the overlying Q4 materials owe their reddish color to being eolian deposits derived by reworking of the relict Bucklebar soil. More importantly, however, the Bucklebar developed in alluvial and colluvial deposits shed from red, highly oxidized Paleozoic rock outcrops a few kilometers to the east. In the project area, these materials are probably the distal-end of the alluvial piedmont discussed by Kirkpatrick and Weber (1996). Thus, in the long run, the reddish- to yellowish brown of the Bucklebar and its derivative deposits east of the arroyo owe their color to red rocks that are on the order of 10^8 years in age and lie east of the project area, and not to similar rock outcrops upstream.

Differences in pegogenic characteristics, particularly between the Q2 and Q3 buried soils on the west and east side of Chupadera Arroyo, may reflect differences in age, parent material, or soil-forming factors. (Differences between LA 67451 and LA 126620 are minimal and can largely be accounted for by differences in parent material). In comparison with LA 126619 (Table 43), the Q2and Q3 Bk subhorizons at LA 67451 and LA 126620 appear to contain more CaCO3 and better-developed pedogenic carbonate

morphology. More pedogenic clay is present in both the Q2 and Q3 buried soils, particularly at LA 67451, a fact that is in part a function of the greater clay content of the parent materials as well as proximity to an upwind source of aerosolic clay (the arroyo). The polygonal jointing of unit Q2 observed at LA 67451 might reflect greater and associated weathering, but could be a function of shrink-swell common to soils with higher clay content. Thus, only the greater carbonate development in the Q2 and Q3 buried soils east of the arroyo remains as a possible indicator of greater age than at LA 126619. As noted earlier, this seems unlikely for unit Q3 at least, given the two radiocarbon dates derived from Q3 contexts at LA 67451. These dates completely overlap those from Q3 deposits at LA 126619. Thus, it can be tentatively concluded that the Quaternary eolian sequence observed east of the arroyo is at least roughly correlated with that documented west of the arroyo.

Correlation with Mockingbird Gap Stratigraphic Sequence

Direct comparison of the soils documented at LA 67451 and LA 126620 with the Mockingbird Gap soil sequence described by Weber is not possible without documenting soil profiles at the Mockingbird Gap site—a field activity that lies outside the scope of the present project. Discussion of this issue in the field with Dr. Weber, however, indicated that all but Clovis-age materials were recovered from the unit identified as Q3, and that in various places across the landscape, this unit varies in age as a function of locally-specific reworking histories. Weber did indicate that Clovis materials were found in the upper portion of the Q2 unit, although no cultural materials of any kind were recovered from the Q2 at either LA 67451 or LA 126620. As noted above, the model of variable reworking of the Bucklebar soil probably accounts for observed differences between these two sites.

Relationship between Archeological Deposits and Soil/Stratigraphic Units

The Quaternary soil stratigraphic sequence identified in the testing phase geoarcheological report was generally confirmed by the excavation study, and the Q3 stratigraphic unit appears to be the original context for all recovered cultural materials. Most materials appear to have come from the lower portions of the Q3 unit, at least at the two most productive sites, LA 126619 and LA 67451. This fact is consistent with the artifacts' apparent early Archaic age.

As noted in the introduction, the soil-stratigraphic sequence identified in the vicinity of Chupadera Arroyo defines a sand sheet that developed on a Pleistocene basin-floor landscape. The highly undulating topography of the Q1 unit indicates a highly-eroded paleolandscape. Field reconnaissance of the area within a few kilometers of the excavated sites revealed surface outcrops of Q1 throughout the area, including topographic highs standing 10s of meters above the immediate project area. This confirms Weber's (1997) suggestion concerning the Q1 "gypsite" as a relict landscape upon which is draped the late Pleistocene to Holocene sand sheet of units Q2–Q4.

It was also noted that this sand sheet and its buried soils appears to correlate with soil-stratigraphic sand sheet sequences elsewhere in New Mexico. Table 47 presents a comparison of the buried soil-stratigraphic sequence documented herein with others in New Mexico in terms of identified soils, carbonate morphology, and researchers' estimated ages. With the exception of some recent units, all of the documented sequences exhibit a nearly identical suite of deposits and associated soils with similar characteristics. Treadwell's Qt6 unit in the Palo Duro Canyon terrace suite chronosequence appears to straddle the mid-late Holocene and recent periods as does Hall's 120–1000 year-old parabolic dunes unit.

Blair et al. (1990a, 1990b) correlated their sequence with that of the Desert Project (Gile et al. 1981) based on similarities in soil development and radiocarbon dates and suggested that the Desert Project/Tularosa Basin record might represent a regionally applicable record of climatically-driven erosion, deposition, stabilization, and soil formation cycles. Indeed, the Desert Project was a seminal research project that established numerous important soil-geomorphic and chronological relationships for arid regions around the world, including the use of carbonate morphology to estimate soil and

associated deposit ages. Hall (2001) specifically addressed the question of relationships between the Mescalero Sands sequence and the Tularosa Basin one and concluded that direct correlations do exist, thus further extending the regionality of the model. Finally, Wells et al. (1990) document a climatically-driven sequence that is also quite similar, but considerably further removed, being located in the San Juan Basin of northwest New Mexico. Similarities in soil characteristics and estimated ages in the Chaco Dune field suggest the possibility of a state-wide model (see also Blair et al's. discussion of similar sequences in Arizona and Texas). If these sequences truly document a large-scale regional climatic history, they may well correlate with that discussed by Neilson (1986) for the late Pleistocene, and early and late Holocene periods.

Another important similarity among the sequences in Table 47 is that—where noted—intact prehistoric cultural materials occur either only in the late Holocene unit of each sequence, or, in the case of the Chaco Dune field (Wells et al. 1990), the Mescalero Sands (Hall 2001), and Palo Duro Canyon (Treadwell 1996, 1998) in both the late Holocene and recent units (presence of cultural materials was not discussed in Gile et al. 1981). In the Chaco, Mescalero and Palo Duro cases, the recent units include deposits dating as old as 1000–2000 years BP, while the recent units are thought to be < 200 years old in the Tularosa Basin and present studies.

Although the similarities among the sequences in Table 47 clearly imply temporal correlation at geological time scales, the detailed timing of the climatic events reflected in the various units may be variable from one region to another. This possibility is particularly important for unit Q3 and its correlates. Although the stage I carbonate morphology of these units implies a minimum age of 2000 years (Treadwell 1996; Gile et al. 1981; and Blair et al. (1990) the younger radiocarbon ages recovered from Q3 contexts in the present project, as well as in the Tularosa Basin (Table 47) suggest a younger minimum age for Q3. Such an age would be consistent with the minimal stage I carbonates observed in the US 380 Q3. Furthermore, the maximum age of Q3—in the Chupadera and Tularosa basins at least—may not be as great as implied by correlation with the Desert Project Organ Alluvium (> 8000 years, Table 47). In the Tularosa Basin, the earliest radiocarbon date from Q3 contexts is 4075 years BP (Table 47), considerably later than the dated inception of the Organ alluvium. This difference in maximum ages may be attributable to differences in the response of eolian versus alluvial geomorphic systems to the same climatic factors. Nonetheless, a younger maximum age for unit Q3 implies a significantly greater period of erosion following stabilization and soils formation in unit Q2. It is also possible that earlier Holocene eolian deposits were entirely reworked into the presently observed Q3 during the long Q2-Q3 hiatus, a possibility that is consistent with the evidence for reworking of Q2 in Q3 deposits at several US 380 profiles. This possibility, together with its implications for understanding the discrepancy between the age implied by technological attributes for the US 380 sites' lithic assemblages and the recovered radiocarbon dates is further discussed in Chapter 9.

Evidence for Project Area Paleoenvironments

All of the soil-stratigraphic sequences in Table 47 are thought by their authors to reflect prehistoric variations in climate and their effects on vegetation, soil moisture, and sediment mobility. Of particular interest is the detailed discussion presented by Wells et al. (1990). They note that the presence of sand sheets (their Qe1, Qe2 and Qe3 units, correlative with the present project's Q2–Q4 units) implies sand sheet forming conditions, which include lower overall sand mobility, increased vegetation, moister ground conditions, and thus "a more mesic environment than those associated with many dunes" (1990:538). They also note that association of parabolic dunes (common in the Chaco dune field) with moister environments is consistent with this model of the formation of the Chaco sand sheet, and that late Pleistocene sand sheets (presumably represented by the Qe1 soil) are consistent with other paleoclimatic reconstructions. That is, there was enough, but not too much sand, the temperature was warmer, but not as hot as today, and there was more moisture than today (see also Betancourt and Van Devender 1981; Phillips et al. 1986).). As such the period comprising the terminal Pleistocene and early Holocene (ca. 15,000–

Table. 47. Comparison of Project Area Buried Soil-Stratigraphic Sequence with Others in New Mexico: Horizon Suites, Carbonate Morphology, and Estimated Age.

Study Area	Location	Chupadera Arroyo, Northern Jornada del Muerto	Palo Duro Canyon	Desert Project	Southern Tularosa Basin	Mescalero Sands, Southeastern NM (Hall 2001)	Chaco Dune Field, San Juan Basin, NM
	Reference(s)	Present report	Treadwell 1996, 1998	Gila et al. 1981	Blair et al. 1990a, 1990b	Hall 2001	Wells et al. 1990
	Parent Materials	Eolian	Terrace suite chronosequence	Multiple landforms, mostly alluvial	Eolian and lacustrine	Eolian	Eolian
Quaternary Units	Recent	Q4C, No pedogenic CaC03, <150 yrs	Qt6 A/Bw/C, <Stage I, <1000 yrs (cal. Date AD 1065)	Recent No pedogenic CaC03 <150 yrs	Q4C(A), No pedogenic CaC03, <150 yrs	Coppice dunes, no CaC03, 120–0 yrs Parabolic dunes, no CaC03, 1000–120 yrs	Qe3, no pedogenesis, <1900 yrs, (1650–1360 RCYBP)
	Mid-Late Holocene	Q3(A)/Bw/Bk, <Stage I (-), ca. <7000 1270–930 RCYBP+	Qt6 A/Bw/C, <Stage I, <1000 yrs (cal. Date AD 1065)	Organ alluvium, Stage I CaC03, <7,000 yrs	Q3A/Bw/Bk, Stage I CaC03, >4075–440 RCYBP	Unit 2 A/no B, No. CaC03, 6000–2500 yrs	Qe2 Bw–Btj, Stage I CaC03, 5600–2800
	Latest Pleistocene-Early Holocene	Q2Bw/Bk/Btk, Stage I–II+, ca. 15,000–8,000 yrs.	Qt5 Bk/Btk, Stage II, 15,000–8,000 yrs	Isaack's Ranch alluvium, Stage I CaC03, >8,000 yrs (9400 RCYBP)	Q2Btk/Bk, Stage II CaC03, 15,000–9,400 yrs	Unit 1 sand Bt/no Bk, Stage I (?), 12,000–9,000 yrs.	Qe1 Bt/Bw/Bk or Btk/Bk, Stage II (-I) CaC03, ca. 16,000–12,000 yrs
	Late Pleistocene	Q1C/Ky, Stage III, ca. 100,000–25,000 yrs	Qt4 Bw/Bk/Btk, Stage III	Jornada II alluvium, Stage IV CaC03, 250,000–25,000 yrs	Q1Btk/K, Stage III–IV CaC03, 250,000–50,000 yrs	"Caliche" K, Stage III, >50,000–20,000 yrs	Pleistocene alluvium

Notes: Age presented in years before present (yrs); "RCYBP" indicates ages based on radiocarbon age determinations; AD date is tree-ring calibrated.

9,000 BP) corresponds to the estimated age of Qe1 deposits, and had perfect environmental conditions for formation of sand sheets, being warmer and drier than glacial maximum, but cooler and wetter than today, with seasonal precipitation being more balanced.

Wells et al. (1990) also suggest that well-developed Qe1 soils represent 5000–6000 years of landscape stability following deposition of the sand sheet. Following this period of soil formation, came a period of increased aridity (the "Altithermal" of Antevs 1962 and Hack 1942, among others) from ca. 5800–2200 years. Earlier researchers in the Chaco Dune Field (e.g., Wells et al. 1983) and elsewhere (Kottlowski et al. 1965) proposed that it was during this period that the bulk of mid-Holocene eolian deposits such as the Chaco Dune Field Qe2 unit were laid down. This early model has since been challenged by Price et al. (1988), who conclude that the mid-Holocene aridity was not as responsible for eolian deposition as previously thought (see also Van Devender and Spaulding's [1979] rejection of the Altithermal concept for all but the Great Basin). Closer to the present project area, Blair et al. (1990a, 1990b) also suggest that the Tularosa Basin unit Q3 (correlative with the Chupadera Arroyo Q3) represent deposition during the Altithermal. Thus, researchers continue to disagree over the validity of the Altithermal concept and its role in mid-Holocene eolian deposition.

Most researchers do agree, however that the Quaternary depositional units represent periods of greater aridity and sediment mobility, while the soils developed in those deposits represent ensuing periods of greater effective moisture and vegetative stabilization of deposits. In this respect, the eolian sequences in the Tularosa Basin, the Mescalero sands, and the Chaco Dune Field are similar. The concentration of almost all prehistoric archeological remains in mid-late Holocene deposits—a pattern possibly characteristic of vast portions of the arid southwest—could imply that all but the earliest (i.e., Paleoindian) and latest prehistoric (late Formative) occupations were characterized by greater aridity. The evidence for diachronous deposition of mid-late Holocene eolian deposition noted in the present study as well as in the Tularosa Basin and Chaco Dune Field studies suggests that deposition and soil formation during the interval was internally complex.

Finally, observations made in the Chupadera Arroyo trenches reflect the greater overall aridity of the Holocene period, as well. With the exception of some Q1 deposits (undoubtedly Pleistocene in age), Holocene-age arroyo bottom deposits are all eolian or colluvial in origin. The arroyo bottom is characterized by a thick (0.5–1.25 m) sequence of apparently eolian deposits (possibly reworked alluvial materials) overlying Pleistocene-age materials. This suggests that the modern ephemeral nature of Chupadera Arroyo flow has been in effect since Q2 times, that is, since the late-terminal Pleistocene.

Evidence for Bioturbation of Otherwise Intact Cultural Deposits

Evidence for bioturbation of cultural deposits at the excavated sites was encountered in the form of krotovina, including large animal burrows (averaging ca. 10 cm diameter) and smaller insect burrows (ca. 1–2 cm diameter). The former are easily recognized owing to the presence of fills derived from other, usually overlying stratigraphic units, and were likely excavated by rodents such as Kangaroo rats. The smaller burrows were probably produced by insects—most likely cicadas. The insect burrows are noticeable in most unit Q2 and some Q1 profiles, but are only detectable in weathered Q3 profiles as differentially-eroded topography (Fig. 26). The apparent abundance of insect burrowing in the Q3 deposits particularly at LA 126619, suggests that the Q3 materials were subjected to more faunalturbation than the larger and more obvious rodent burrows imply. Hall (2001:40–42) also noted the subtle, but important, evidence for extensive cicada-burrowing in weathered profiles of his Unit 2 sand (equivalent to unit Q3 in the project area) in the Mescalero Sands area (Hall's Figure 36, p. 42 bears a strong resemblance to Figure 26). In the Tularosa Basin, Johnson (1997:21–22) noted similar evidence for bioturbation by cicadas and rodents in sediments containing archeological deposits.

While the fact of bioturbation in archeological deposits is certain in open-air localities—which comprise most of the world's non-architectural sites (Johnson et al. 2001:4)—its effects are less

well known and the processes involved are complex. A recent issue of *Geoarchaeology: an International Journal* (v. 17, No. 1) is entirely devoted to the role of bioturbation in both soils formation and alteration of archeological deposits (see summary by Johnson et al. 2001). In fact, increasing recognition of the role of bioturbation in soil formation has led to a new general soil formation model called the "dynamic denudation-soil evolution-biomantle theory". This theory was developed in part in response to previous models of the origin of "stone lines" in Quaternary landscapes (e.g., Johnson and Balek 1991). Stone lines, common in soils of the Midwest among other regions, were originally thought to be the product of erosion of fine-grained materials from gravel-bearing deposits, formation of lag deposits, and subsequent reburial (see extended review of stone line explanations in Johnson and Balek 1991:386–387). In fact the biomantle concept ("a differentiated zone in the upper part of soils produced largely by bioturbation", Johnson 1990:84) recognizes that bioturbation is a major, rather than incidental component of soil formation. The concept can actually be traced back to Charles Darwin (1881) and his observation that earthworms slowly bury the larger clasts in an otherwise stable landscape by ingesting soil fines and excreting them on the surface (see Armour-Chelu and Andrews 1994, Stein 1983 for archeological examples).

Most studies and models of the effect of bioturbation on the vertical and horizontal distribution of clasts and artifacts in affected deposits predict gradual burial through processes similar to the earthworm model. In reality, however, the interaction of a variety of related processes in complex idiosyncratic histories can yield complex results. Both surface and buried zones of concentrated clasts and/or artifacts can be produced (Johnson 1990). Examples of bio-processes that can raise clasts to the surface are tree-throw, an example of "floralturbation" (Schaetzel et al. 1990), and burrowing by medium to large animals, or "faunalturbation" (see Balek 2001 for an excellent review). Although tree-throw raises clasts of all sizes (by lifting entire sediment blocks), faunalturbation tends to translocate a smaller size-range of clasts and artifacts upward, leaving behind those whose size exceeds average burrow diameter (Johnson 1990:90). Thus, in the case of faunalturbation there is an expectable relationship between the size of the burrowing animal species and the degree to which clasts or artifact of differing sizes will be vertically segregated through faunalturbation. The net result of faunalturbation is a tendency toward vertical size-sorting of clasts and artifacts, with larger items being buried and smaller items being translocated upward.

Faunalturbation by larger animal species also tends to affect the horizontal integrity of archeological deposits more so than smaller ones. For example, in a discussion of earthworm turbation, Van Nest (2001) finds that the fine-scale spatial relationships of artifacts remains intact despite considerable vertical translocation through. In contrast, an experimental study by Bocek (1992) found that gopher burrowing produced considerable lateral translocation of artifacts as well, although the effects were generally limited to the upper 10 cm, rather than spanning the entire 30 cm deep "rodent zone". Bocek's results also suggest that, in the 1000 years since the site was occupied, the content of any given 1x2 m unit could have been replaced as much as 11 times. Finally, the time frames associated with significant translocation, vertical or horizontal, range from 10s (e.g. Darwin's and Bocek's studies) to as much as 2000 years (Peacock and Fant 2001).

Interestingly, neither the model of overall gradual burial of artifacts via bioturbation, nor the model of upward transport of smaller artifacts in cases of burrowing by medium-large animals was confirmed in Doleman's study of the vertical distribution of artifacts in the Tularosa Basin unit Q3 (Doleman 1992). In an analysis of the vertical distribution of artifacts classified by size and shape index (length/thickness), Doleman not only confirmed the expectation that vertical size sorting of artifacts occurs in eolian surface deposits (Wandsnider 1989; see also Duncan and Doleman 1991; Schutt 1992), but found evidence of vertical size-sorting within intact Q3 deposits similar to unit Q3 in the present study. In both cases, smaller and flatter artifacts tended to be buried in surface contexts and to lie deeper in buried deposits. This pattern is the reverse of the general conclusions reviewed above, which are that faunalturbation tends to bury large artifacts and raise smaller ones.

Doleman suggested that bioturbation was responsible for this pattern, but more recently (Doleman in press) has suggested the possibility that repeated blowout formation and infilling may play a role, arguing that, if active surface eolian processes tend to produce the observed pattern in shallow contexts, perhaps repeated cycles resulting in overall aggradation would produce similar results in thicker deposits. Interestingly, Swift and Doleman's study of sandblast weathering (pitting) of 13 obsidian artifacts from the same contexts suggested that repeated blowout formation and infilling took place in at least some "intact" archeological deposits; in fact, the single obsidian artifact with the greatest amount of surface-pitting was excavated from a unit Q3 context (Swift and Doleman 1991). Whether blowout formation and infilling and/or a different form of bioturbation that those observed by other researchers can result in the vertical patterning observed in the Tularosa Basin remains to be evaluated by further research.

In addition to the rodent and cicada burrows observed in excavated deposits at site near Chupadera Arroyo, abundant evidence of the nocturnal activities of burrowing animals including rodents and reptiles was observed on a daily basis during the project. Although their activities, plus those of insects (probably cicadas), undoubtedly affected the archeological materials left by the sites' prehistoric occupants, those effects are not entirely clear. It is quite likely, however, that considerable vertical mixing of both medium and small artifacts (equivalent to rodent [average 10 cm diameter] and insect [1–2 cm diameter] burrows respectively)—including charcoal specimens—took place. In light of the bioturbation time frames discussed above, and given the apparent age of many archeological chipped stone specimens (1000s of years) the mixing may have been quite extensive.

9 SUMMARY AND INTERPRETATIONS

by Janette M. Elyea and William H. Doleman

LA 67451, LA 126619, and LA 126620 are composed of lithic assemblages that are characterized by large quantities of small flakes. These assemblages are conditioned by the lack of locally available lithic resources. Both sedentary farmers of the Formative period and mobile hunters and gatherers of the Archaic period will use local lithic materials when available. Whether mobile or sedentary, both groups have knowledge of the availability and quality of local stone sources. The highly mobile Paleoindian, with an adaptation that moves to mobile faunal resources, may not always have knowledge of the local lithic resources. They solve this potential lack of knowledge with a highly portable and curated tool kit, which consists of specialized tools, formalized cores, and bifaces. Archaic foragers, having information about local lithic resources, and knowing that they were moving to an area that lacked these raw materials, would employ a similar strategy. Sedentary farmers, traveling to specialized extractive sites, would also carry the tools needed for resource procurement.

It is clear from the small flakes in the US 380 assemblages that a highly curated lithic technology was employed. It also appears that most of these small flakes came from formal tools that were used, re-sharpened and removed from the sites. Except for a large, possibly renewable, obsidian biface (Figure 13) that was probably lost in the sand, only small, broken, unusable, and non-renewable tools were discarded.

Based on the recovered tool fragments, we assume that similar tools were being used, refurbished, curated, and removed from the sites. At LA 126619 this includes scrapers, drills, spokeshaves, bifaces, and projectile points. At LA 67451 it includes projectile points and scrapers and at LA 126620 it includes bifaces and projectile points. Additional activities at LA 126619 include seed grinding, stone boiling and roasting of unknown resources. All areas of LA 126619 exhibit a variety of activities. This variety, which includes extraction, processing, and consumption of seed, meat, and unknown resources, suggests that the site was occupied numerous times by family groups.

The artifacts at LA 67451 suggest fewer extractive activities. There is no evidence for seed extraction or processing, or roasting or stone boiling of any resources. The assemblage at this site includes the smallest flakes within the project area. The projectile point, scrapers, and small flakes are the types of artifacts that we would expect at a hunting encampment, occupied mainly by males. Only a small portion of this site, which extends north of the construction area, was excavated, however, and other tool types representing different and more varied activities may be present. This site also appears to be the remains of an early Archaic Jay component and many of these sites appear to represent a hunting adaptation, which lacks ground stone and fire-cracked rock.

LA 126620 consists of a diffuse and sparse artifact scatter. The projectile points recovered during survey, and our recovered fragment, indicates a high proportion of tools. With no obvious evidence for erosion, the dispersed cultural materials suggest a composite of very short-term occupations that may have lasted from a few minutes to a few hours.

Cultural and Temporal Affiliation

Based on the lithic debitage assemblages and the associated projectile points LA 126619 contains early Archaic Jay, and middle to late Archaic occupations. A sparse Paleoindian component (probably Folsom) is also indicated by a channel flake, parallel flakes, and lithic materials from distant sources. The artifacts at LA 67451

Table 48. Radiocarbon Dates from LA 67451 and LA 126619

Beta No.	Site	Feature	2 Sigma Calibrated Date	Radiocarbon Age	Intercepts
149342	LA 67451	—	AD 700–900	1210 40	AD 790
149343	LA 67451	—	AD 1470–1660	310 40	AD 1530
144344	LA 126619	SU 4 FS 260	AD 1020–1200	930 40 BP	AD 1100
144345	LA 126619	Feature 4	AD 650–770	1330 40 BP	AD 680
144346	LA 126619	Feature 3	AD 1050–1100	850 40 BP	AD 1200
144347	LA 126619	Feature 7	AD 710–980	1180 50 BP	AD 880
144348	LA 126619	SU 10 FS 472	AD 880–1010	1100 40 BP	AD 970
144349	LA 126619	Feature 6	AD 670–870	1270 40 BP	AD 740
144350	LA 126619	SU 4 FS 307	AD 1180–1280	1270 40 BP	AD 1250

indicate an early Archaic Jay component. The radiocarbon dates from these sites, however, indicate Formative occupations (Table 48). If the dates are correct, the region was used for several centuries by Formative groups. In this region, the development of the sedentary cultures in the northern Jornada del Muerto followed the general trends established for the plateau Anasazi to the northwest and for the Mogollon to the south. Influences from both groups are noted in the area particularly in the ceramic assemblages that include both northern graywares and southern brownwares (Marshall and Walt 1984:35–38). Throughout much of the Southwest, the adoption of agriculture and the beginning of a sedentary lifestyle begins between about AD 1 and AD 500. During the early portion of this period, groups may have been only partially sedentary, continuing to forage during certain parts of the year.

By the time of our earliest radiocarbon dates, agriculturalists in both the San Antonio region and further south in the Jornada Mogollon region had adopted a full or bi-seasonal settlement pattern with a reliance on agriculture. We expect these adaptations to have a heavy reliance on wild or undomesticated food sources, but we suspect that most if not all of these were collected on a daily basis within a half days range of the settlement. We also suspect that some stone tools were expended during these foraging forays. We do not believe that the collected wild resources were either field processed or field consumed. Our expectations of wild plant procurement sites, is the occasional isolated tool, discarded as it was broken. One Formative special extraction site that would leave evidence of a campsite with refurbished and discarded tools is a hunting encampment, but we would not expect associated ground stone tools at such a specialized procurement site.

Other than the radiocarbon dates, we have no other evidence for Formative occupations at the three sites. There are no ceramics, no broken arrow points, and no structures. In one of the few comparisons of Jornada Mogollon agricultural lithic assemblages (including lithic and ceramic scatters) and Archaic lithic assemblages, the Archaic assemblages exhibited more refined techniques associated with bifacial reduction than the Mogollon assemblages (Seaman 1988).

In the southern and eastern portions of New Mexico, the persistence of an Archaic-like adaptation into the protohistoric period has been a long established concept and there is the possibility of mobile hunter-gatherers incorporating certain material traits, perhaps through trade, of nearby sedentary groups.

Some models suggest contemporaneous agriculturalists and mobile hunters and gatherers, where two distinct adaptations occur throughout the ceramic period— both using the bow and arrow and ceramic vessels. These archeological sites appear to be the remains of hunters and gatherers, but contain ceramics and arrow projectile points have been labeled the Neoarchaic.

Excavations of Neoarchaic sites in southeastern New Mexico have yielded radiocarbon dates from AD 1050 to 1400. All are non-structural, open lithic and ceramic scatters. Jornada brownware or El Paso brown wares are the most common ceramic type and Chupadero Black-on-white is the most common painted ware. All of these Neoarchaic sites are located in the eastern plains or the Pecos Valley and have not been found in the basin and range areas of New Mexico.

Two lines of evidence suggest that the US 380 sites are not Neoarchaic. First, the assemblages at LA 126619 indicate a variety of activities including seed grinding, stone boiling and roasting, and this variety suggests that the site was occupied numerous times by family groups. Such extractive and consumption activities probably were not occurring so close to the large populations known to occupy the Rio Grande during this era. Large sedentary populations like those along this area of the Rio Grande, largely consume the wild resources with a foraging radius, leaving little for nomadic bands of foragers.

Second, the lithic material types are mostly from the west, not east of the site area. An analysis of lithic material types indicates that 89.7% of the materials at LA 67451 and 97.8% of the material at LA 126619 are from the Rio Grande Valley, Socorro Peak, and Cerro Colorado areas--all west of the sites. Groups utilizing these resources would also have part of their foraging and collecting ranges in these western areas.

Finally, the hearths and radiocarbon dates could be from either Formative or Neoarchaic groups on their way to trade with Pueblo populations in the San Antonio area. Since the assemblages do not fit the expected profiles, these could be small very short-term or overnight camps where few cultural materials were lost or discarded. No pottery was broken and no arrowpoints were lost or discarded.

Possible Contamination of the Radiocarbon Dates

Owing to the absence of any artifacts that can be associated with Formative phases, we cannot dismiss possible contamination of the samples. A possible source of contamination could have been the Trinity atomic bomb. The Trinity Test Site is 12 miles (19 km) south of the project area and the atomic cloud drifted north and northeast of the test area. Although atomic bombs are known to produce massive quantities of C^{14}, conversations with Beta Analytic personnel indicate that contamination from the Trinity site is highly unlikely. Although living plants easily absorb carbon from atomic blasts, inert charcoal samples should not absorb the carbon. Rains after the bomb could have caused filtering of non-carbonized, contaminated, plant material into the soils, but pre-treatment of the samples should have removed any such contamination.

Another possible source of contamination is grass or range fires. A series of fires could have crossed the study area, and the possibility that such fires occurred every few centuries is not unreasonable. Filtration and bioturbation of the charcoal from these fires could have contaminated our samples.

Geomorphic and Stratigraphic Association

In fine-grained sediments, Stage I carbonate development (characterized by few filaments and grain coatings) represents weak but definite soil development, and is thought to indicate an minimum age of ca. 2000 years for the soil and the deposit in which it is developed (Treadwell 1996; Gile et al. 1981; and Blair et al. (1990). The fact that all intact cultural materials recovered from the US 380 project sites were within unit Q3 deposits with apparent Stage I carbonate development suggests a similar minimum age for archeological materials recovered from Q3.

As noted in Chapter 8, however, carbonate development in unit Q3 is locally variable both within and between the sites, ranging from sub-stage I to stage I. In addition, the soil-stratigraphic sequence documented at the US 380 project sites bears strong similarities to sand sheet sequences recorded elsewhere in New Mexico, including the southern Tularosa Basin (Blair et al. 1990a, 1990b), the Mescalero Sands (Hall 2000), and the Chaco Dune Field (Wells et al. 1990). All appear to represent similarly-timed sequences of climatic episodes and associated landscape evolution. In all of these

cases, the penultimate unit that contains the bulk of the area's archeological remains, is characterized by locally variable, weak soil and carbonate development that suggests diachronous deposition of the unit during the mid-late Holocene. Suggested beginning dates range from ca. 7300–5600 years BP. Furthermore, in all but the Chaco Dune Field, the unit's soil is capped by a locally preserved A horizon reflecting a former grassland that developed after the region's principal prehistoric occupation.

In the closest such study, the Tularosa Basin sequence, deposits equivalent to unit Q3 were correlated with the Desert Project's Organ Alluvium, whose inception has been radiocarbon dated at least 7300 years BP. Radiocarbon ages derived from cultural contexts in the Tularosa Basin, however, range from 4075–440 years, and radiocarbon dates representing earlier occupations have yet to be documented. These dates suggest a younger maximum age for Q3 than that implied by correlation with the Desert Project Organ Alluvium. They also indicate a minimum Q3 age considerably younger than 2000 years, which is consistent with the sub-stage I carbonates observed in some profiles. These facts have two important implications for understanding both the radiocarbon dates and lithic artifact assemblages recovered from the US 380 sites.

First, it is possible, if not likely that portions of unit Q3, including artifacts and thermal features, were deposited during the late Holocene and Formative period. Second, it is possible that the mid-late Holocene deposition event reflected in unit Q3 and its state-wide correlates was preceded by an extended period of net erosion that accounts for the extensive stripping of the older, underlying unit (Q2) and the absence of early Holocene deposits. If so, then it is also possible that any archeological deposits predating the mid-Holocene would have been reworked by subsequent erosion and deposition of Unit Q3. Such reworking would undoubtedly have removed earlier features and any datable charcoal contained within them.

Finally, the extensive bioturbation of unit Q3 and Q2 deposits at the US 380 sites by both rodents and insects (Chapter 8) indicates that with the exception of the largest artifacts (> ca. 10 cm), all originally intact cultural materials at the sites have been subjected to disturbance and potential vertical translocation, with the oldest materials having experience the greatest effects. Although artifacts would not be destroyed by such processes, progressive fragmentation and eventual destruction of older charcoal specimens and their original feature contexts is likely to have occurred, with the result that only later features are sufficiently preserved to provide datable charcoal. Thus, both early Holocene geomorphic dynamics and bioturbation may account for the apparent discrepancy between radiocarbon dates and artifact assemblages recovered from Q3 deposits at the US 380 sites.

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APPENDIX 1

Radiocarbon Sample Analysis

BETA ANALYTIC INC.

RADIOCARBON DATING SERVICES

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Director

RONALD E. HATFIELD
Laboratory Manager

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ANALYTICAL PROCEDURES AND FINAL REPORT

FINAL REPORT

This package includes the final date report, this statement outlining our analytical procedures, a glossary of pretreatment terms, calendar calibration information, billing documents (containing balance/credit information and the number of samples submitted within the yearly discount period), and peripheral items to use with future submittals. The final report includes the individual analysis method, the delivery basis, the material type and the individual pretreatments applied. Please recall any correspondences or communications we may have had regarding sample integrity, size, special considerations or conversions from one analytical technique to another (e.g. radiometric to AMS). The final report has also been sent by fax or e-mail, where available.

PRETREATMENT

Results were obtained on the portion of suitable carbon remaining after any necessary chemical and mechanical pretreatments of the submitted material. Pretreatments were applied, where necessary, to isolate ^{14}C which may best represent the time event of interest. Individual pretreatments are listed on the report next to each result and are defined in the enclosed glossary. When interpreting the results, it is important to consider the pretreatments. Some samples cannot be fully pretreated making their ^{14}C ages more subjective than samples which can be fully pretreated. Some materials receive no pretreatments. Please read the pretreatment glossary.

ANALYSIS

Materials measured by the radiometric technique were analyzed by synthesizing sample carbon to benzene (92% C), measuring for ^{14}C content in a scintillation spectrometer, and then calculating for radiocarbon age. If the Extended Counting Service was used, the ^{14}C content was measured for a greatly extended period of time. AMS results were derived from reduction of sample carbon to graphite (100 %C), along with standards and backgrounds. The graphite was then sent for ^{14}C measurement in an accelerator-mass-spectrometer located at one of six collaborating research facilities, who return the results to us for verification, isotopic fractionation correction, calendar calibration, and reporting.

THE RADIOCARBON AGE AND CALENDAR CALIBRATION

The "Conventional C14 Age (*)" is the result after applying C13/C12 corrections to the measured age and is the most appropriate radiocarbon age (the "*" is discussed at the bottom of the final report). Applicable calendar calibrations are included for organic materials and fresh water carbonates between 0 and 10,000 BP and for marine carbonates between 0 and 8,300 BP. If certain calibrations are not included with this report, the results were either too young, too old, or inappropriate for calibration.

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PRETREATMENT GLOSSARY

Pretreatment of submitted materials is required to eliminate secondary carbon components. These components, if not eliminated, could result in a radiocarbon date which is too young or too old. Pretreatment does not ensure that the radiocarbon date will represent the time event of interest. This is determined by the sample integrity. The old wood effect, burned intrusive roots, bioturbation, secondary deposition, secondary biogenic activity incorporating recent carbon (bacteria) and the analysis of multiple components of differing age are just some examples of potential problems. The pretreatment philosophy is to reduce the sample to a single component, where possible, to minimize the added subjectivity associated with these types of problems.

"acid/alkali/acid"

The sample was first gently crushed/dispersed in deionized water. It was then given hot HCl acid washes to eliminate carbonates and alkali washes (NaOH) to remove secondary organic acids. The alkali washes were followed by a final acid rinse to neutralize the solution prior to drying. Chemical concentrations, temperatures, exposure times, and number of repetitions, were applied accordingly with the uniqueness of the sample. Each chemical solution was neutralized prior to application of the next. During these serial rinses, mechanical contaminants such as associated sediments and rootlets were eliminated. This type of pretreatment is considered a "full pretreatment". On occasion the report will list the pretreatment as "acid/alkali/acid - insolubles" to specify which fraction of the sample was analyzed. This is done on occasion with sediments (See "acid/alkali/acid - solubles"

Typically applied to: charcoal, wood, some peats, some sediments, textiles

"acid/alkali/acid - solubles"

On occasion the alkali soluble fraction will be analyzed. This is a special case where soil conditions imply that the soluble fraction will provide a more accurate date. It is also used on some occasions to verify the present/absence or degree of contamination present from secondary organic acids. The sample was first pretreated with acid to remove any carbonates and to weaken organic bonds. After the alkali washes (as discussed above) are used, the solution containing the alkali soluble fraction is isolated/filtered and combined with acid. The soluble fraction which precipitates is rinsed and dried prior to combustion.

"acid washes"

Surface area was increased as much a possible. Solid chunks were crushed, fibrous materials were shredded, and sediments were dispersed. Acid (HCl) was applied repeatedly to ensure the absence of carbonates. Chemical concentrations, temperatures, exposure times, and number of repetitions, were applied accordingly with the uniqueness of each sample. The sample, for a number of reasons, could not be subjected to alkali washes to ensure the absence of secondary organic acids. The most common reason is that the primary carbon is soluble in the alkali. Dating results reflect the total organic content of the analyzed material. Their accuracy depends on the researcher's ability to subjectively eliminate potential contaminants based on contextual facts.

Typically applied to: organic sediments, some peats, small wood or charcoal, special cases

"collagen extraction"

The material was first tested for friability ("softness"). Very soft bone material is an indication of the potential absence of the collagen fraction (basal bone protein acting as a "reinforcing agent" within the crystalline apatite structure). It was then washed in de-ionized water and gently crushed. Dilute, cold HCl acid was repeatedly applied and replenished until the mineral fraction (bone apatite) was eliminated. The collagen was then dissected and inspected for rootlets. Any rootlets present were also removed when replenishing the acid solutions. Where possible, usually dependant on the amount of collagen available, alkali (NaOH) was also applied to ensure the absence of secondary organic acids.

Typically applied to: bones

"acid etch"

The calcareous material was first washed in de-ionized water, removing associated organic sediments and debris (where present). The material was then crushed/dispersed and repeatedly subjected to HCl etches to eliminate secondary carbonate components. In the case of thick shells, the surfaces were physically abraded prior to etching down to a hard, primary core remained. In the case of porous carbonate nodules and caliche, very long exposure times were applied to allow infiltration of the acid. Acid exposure times, concentrations, and number of repetitions, were applied accordingly with the uniqueness of the sample.

Typically applied to: shells, caliche, calcareous nodules

"neutralized"

Carbonates precipitated from ground water are usually submitted in an alkaline condition (ammonium hydroxide or sodium hydroxide solution). Typically this solution is neutralized in the original sample container, using deionized water. If larger volume dilution was required, the precipitate and solution were transferred to a sealed separatory flask and rinsed to neutrality. Exposure to atmosphere was minimal.

Typically applied to: Strontium carbonate, Barium carbonate
(i.e. precipitated ground water samples)

"none"

No laboratory pretreatments were applied. Special requests and pre-laboratory pretreatment usually accounts for this.

"acid/alkali/acid/cellulose extraction"

Following full acid/alkali/acid pretreatments, the sample is rinsed in $NaClO_2$ under very controlled conditions (Ph = 3, temperature = 70 degrees C). This eliminates all components except wood cellulose. It is useful for woods which are either very old or highly contaminated.

Applied to: wood

"carbonate precipitation"

Dissolved carbon dioxide and carbonate species are precipitated from submitted water by complexing them as amonium carbonate. Strontium chloride is added to the ammonium carbonate solution and strontium carbonate is precipitated for the analysis. The result is representative of the dissolved inorganic carbon within the water. Results are reported as "water DIC".

Applied to: water

BETA ANALYTIC INC.
RADIOCARBON DATING LABORATORY
CALIBRATED C-14 DATING RESULTS

Calibrations of radiocarbon age determinations are applied to convert BP results to calendar years. The short term difference between the two is caused by fluctuations in the heliomagnetic modulation of the galactic cosmic radiation and, recently, large scale burning of fossil fuels and nuclear devices testing. Geomagnetic variations are the probable cause of longer term differences.

The parameters used for the corrections have been obtained through precise analyses of hundreds of samples taken from known-age tree rings of oak, sequoia, and fir up to about 10,000 BP. Calibration using tree-rings to about 12,000 BP is still being researched and provides somewhat less precise correlation. Beyond that, up to about 20,000 BP, correlation using a modeled curve determined from U/Th measurements on corals is used. This data is still highly subjective. Calibrations are provided up to about 19,000 years BP using the most recent calibration data available (Radiocarbon, Vol 40, No. 3, 1998).

The Pretoria Calibration Procedure (Radiocarbon, Vol 35, No. 1, 1993, pg 317) program has been chosen for these calendar calibrations. It uses splines through the tree-ring data as calibration curves, which eliminates a large part of the statistical scatter of the actual data points. The spline calibration allows adjustment of the average curve by a quantified closeness-of-fit parameter to the measured data points. A single spline is used for the precise correlation data available back to 9900 BP for terrestrial samples and about 6900 BP for marine samples. Beyond that, splines are taken on the error limits of the correlation curve to account for the lack of precision in the data points.

In describing our calibration curves, the solid bars represent one sigma statistics (68% probability) and the hollow bars represent two sigma statistics (95% probability). Marine carbonate samples that have been corrected for δ 13/12C, have also been corrected for both global and local geographic reservoir effects (as published in Radiocarbon, Volume 35, Number 1, 1993) prior to the calibration. Marine carbonates that have not been corrected for δ 13/12C are adjusted by an assumed value of 0 ‰ in addition to the reservoir corrections. Reservoir corrections for fresh water carbonates are usually unknown and are generally not accounted for in those calibrations. In the absence of measured δ 13/12C ratios, a typical value of -5 ‰ is assumed for freshwater carbonates.

(Caveat: the correlation curve for organic materials assume that the material dated was living for exactly ten years (e.g. a collection of 10 individual tree rings taken from the outer portion of a tree that was cut down to produce the sample in the feature dated). For other materials, the maximum and minimum calibrated age ranges given by the computer program are uncertain. The possibility of an "old wood effect" must also be considered, as well as the potential inclusion of younger or older material in matrix samples. Since these factors are indeterminant error in most cases, these calendar calibration results should be used only for illustrative purposes. In the case of carbonates, reservoir correction is theoretical and the local variations are real, highly variable and dependant on provenience. Since imprecision in the correlation data beyond 10,00 years is high, calibrations in this range are likely to change in the future with refinement in the correlation curve. The age ranges and especially the intercept ages generated by the program, must be considered as approximations.)

CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

Variables used in the calculation of age calibration → (Variables: est. C13/C12=-25:lab. mult=1)

Laboratory number: **Beta-123456**

Conventional radiocarbon age[1]: **2400±60 BP** ← The uncalibrated Conventional Radiocarbon Age (± 1 sigma)

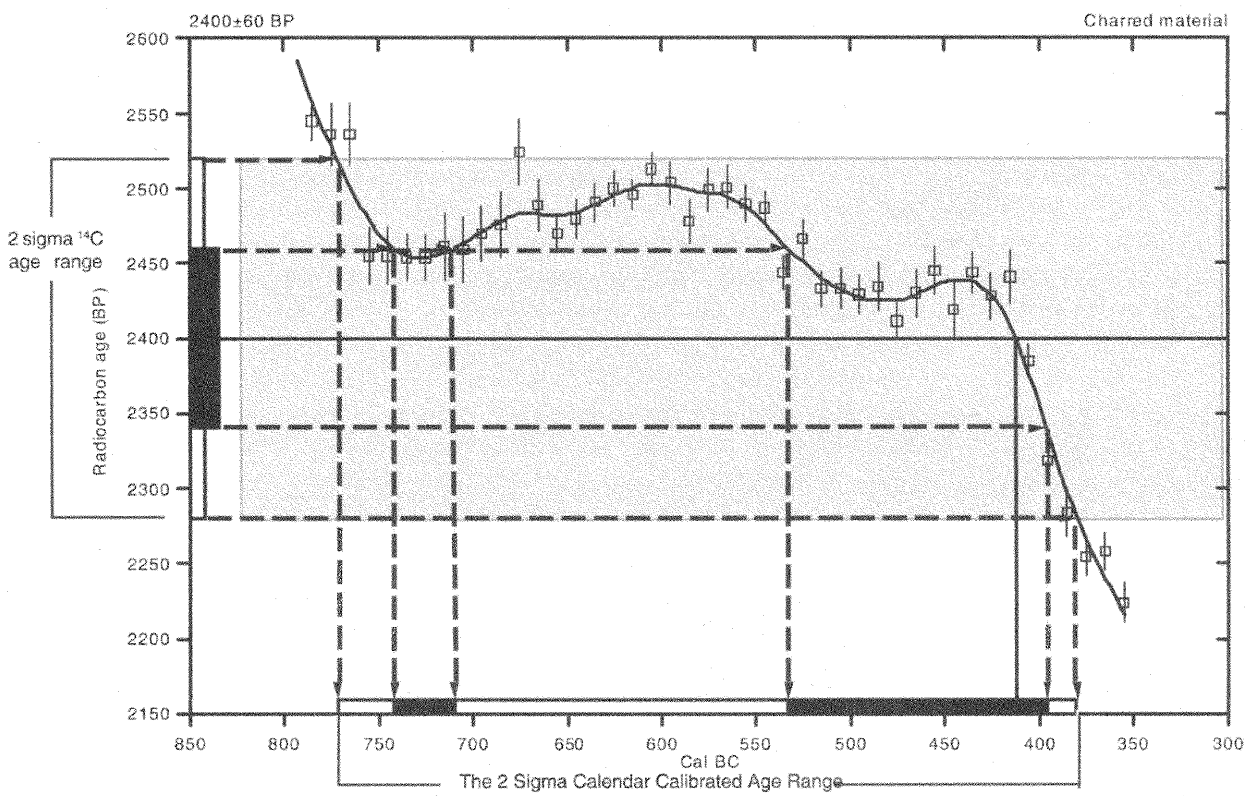
The calendar age range in both calendar years (AD or BC) and in Radiocarbon Years (BP) → **2 Sigma calibrated result: (95% probability)** **Cal BC 770 to 380 (Cal BP 2720 to 2330)**

[1] *C13/C12 ratio estimated*

Intercept data ← The intercept between the average radiocarbon age and the calibrated curve time scale. This value is illustrative and should not be used by itself.

Intercept of radiocarbon age with calibration curve: Cal BC 410 (Cal BP 2360)

→ 1 Sigma calibrated result: (68% probability) Cal BC 740 to 710 (Cal BP 2690 to 2660) and Cal BC 535 to 395 (Cal BP 2485 to 2345)



This range is determined by the portion of the curve that is in a "box" drawn from the 2 sigma limits on the radiocarbon age. If a section of the curve goes outside of the "box", multiple ranges will occur as shown by the two 1 sigma ranges which occur from sections going outside of a similar "box" which would be drawn at the 1 sigma limits.

References:

Database used
Intcal 98
Calibration Database
Editorial Comment
Stuiver, M., van der Plicht, H., 1998, Radiocarbon 40(3), pxii-xiii
INTCAL98 Radiocarbon Age Calibration
Stuiver, M., et. al., 1998, Radiocarbon 40(3), p1041-1083
Mathematics
A Simplified Approach to Calibrating C14 Dates
Talma, A. S., Vogel, J. C., 1993, Radiocarbon 35(2), p317-322

← References for the calibration data and the mathematics applied to the data. These references, as well as the Conventional Radiocarbon Age and the 13C/12C ratio used should be included in your papers.

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CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-9.5:lab. mult=1)

Laboratory number: **149342**

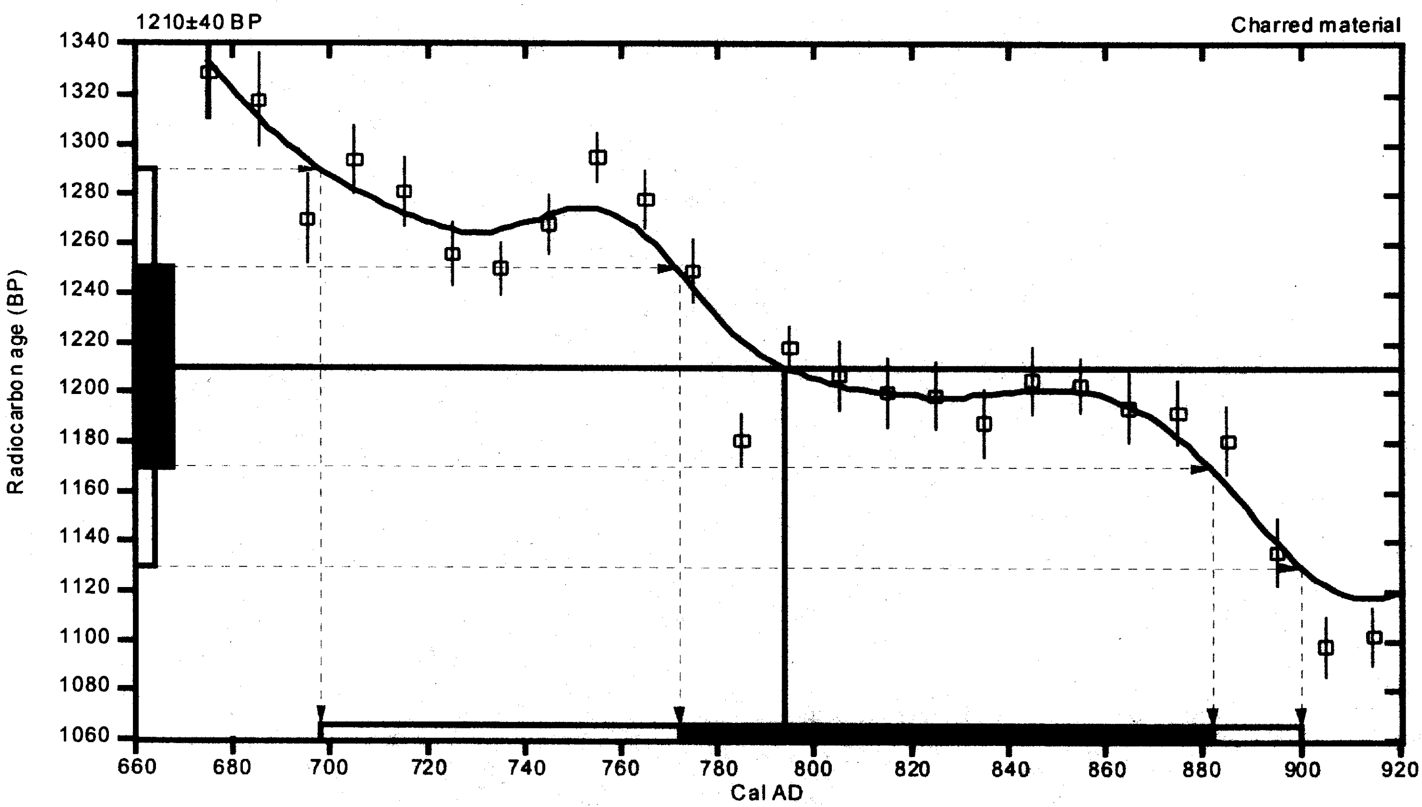
Conventional radiocarbon age: **1210±40 BP**

2 Sigma calibrated result: **Cal AD 700 to 900 (Cal BP 1250 to 1050)**
(95% probability)

Intercept data

Intercept of radiocarbon age with calibration curve: Cal AD 790 (Cal BP 1160)

1 Sigma calibrated result: Cal AD 770 to 880 (Cal BP 1180 to 1070)
(68% probability)



References:

Database used

Calibration Database
Editorial Comment
Stuiver, M., van der Plicht, H., 1998, Radiocarbon 40(3), pxii-xiii
INTCAL98 Radiocarbon Age Calibration
Stuiver, M., et. al., 1998, Radiocarbon 40(3), p1041-1083
Mathematics
A Simplified Approach to Calibrating C14 Dates
Talma, A. S., Vogel, J. C., 1993, Radiocarbon 35(2), p317-322

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CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-23.7:lab. mult=1)

Laboratory number: **149343**

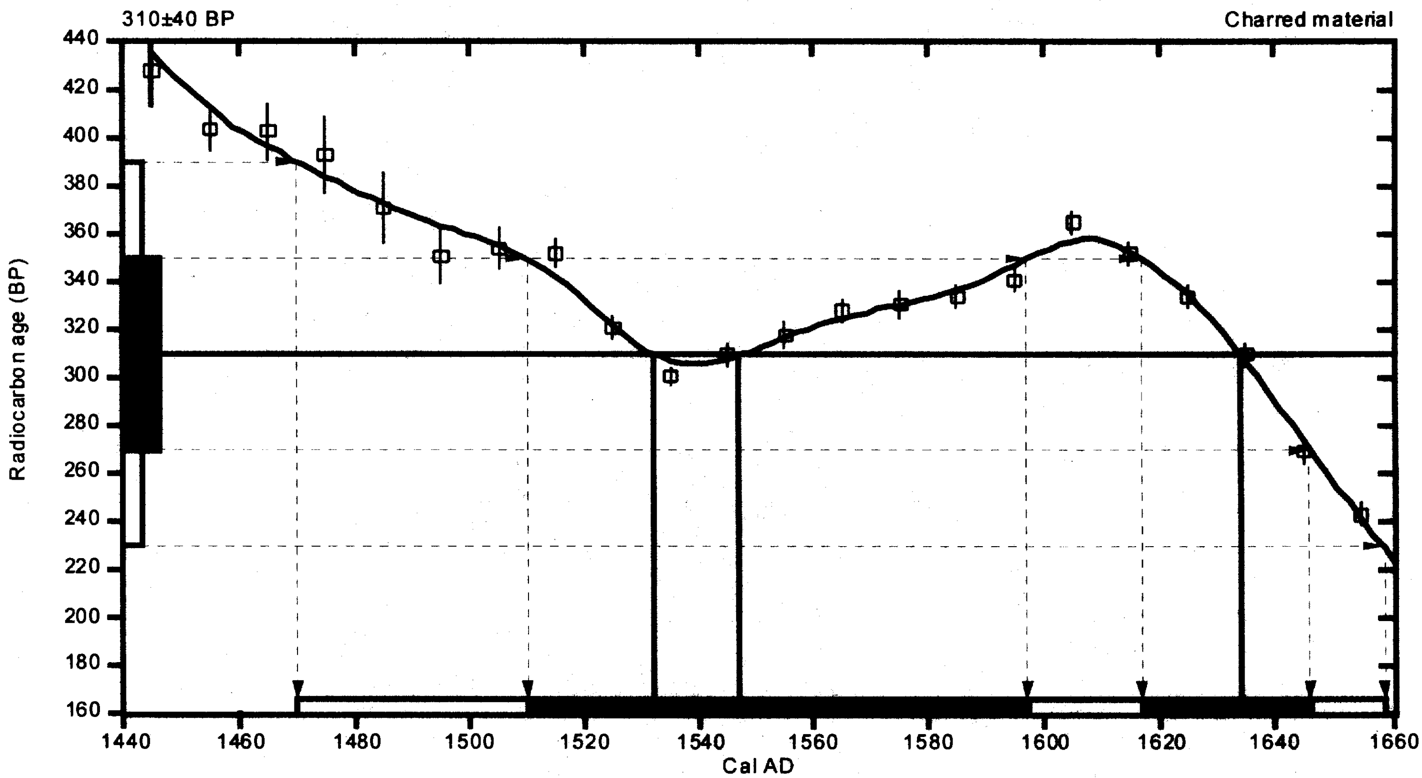
Conventional radiocarbon age: **310±40 BP**

2 Sigma calibrated result: (95% probability) **Cal AD 1470 to 1660 (Cal BP 480 to 290)**

Intercept data

Intercepts of radiocarbon age with calibration curve: Cal AD 1530 (Cal BP 420) and
Cal AD 1550 (Cal BP 400) and
Cal AD 1630 (Cal BP 320)

1 Sigma calibrated results: (68% probability) Cal AD 1510 to 1600 (Cal BP 440 to 350) and
Cal AD 1620 to 1650 (Cal BP 330 to 300)



References:

Database used

Calibration Database
Editorial Comment
Stuiver, M., van der Plicht, H., 1998, Radiocarbon 40(3), pxii-xiii
INTCAL98 Radiocarbon Age Calibration
Stuiver, M., et. al., 1998, Radiocarbon 40(3), p1041-1083
Mathematics
A Simplified Approach to Calibrating C14 Dates
Talma, A. S., Vogel, J. C., 1993, Radiocarbon 35(2), p317-322

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CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-12.1:lab. mult=1)

Laboratory number: **149344**

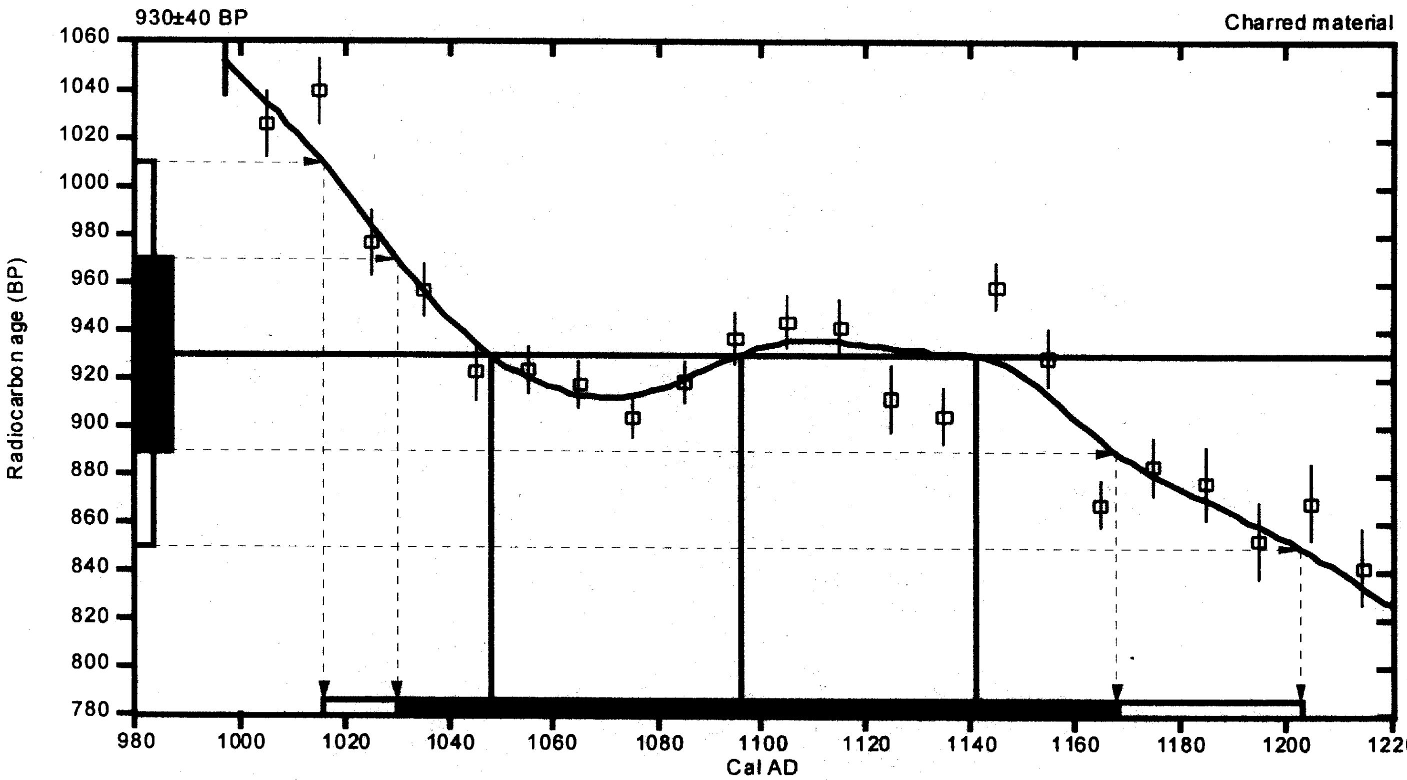
Conventional radiocarbon age: **930±40 BP**

2 Sigma calibrated result: (95% probability) **Cal AD 1020 to 1200 (Cal BP 930 to 750)**

Intercept data

Intercepts of radiocarbon age with calibration curve: Cal AD 1050 (Cal BP 900) and
Cal AD 1100 (Cal BP 850) and
Cal AD 1140 (Cal BP 810)

1 Sigma calibrated result: (68% probability) Cal AD 1030 to 1170 (Cal BP 920 to 780)



References:

Database used

Calibration Database
Editorial Comment
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Mathematics
A Simplified Approach to Calibrating C14 Dates
Talma, A. S., Vogel, J. C., 1993, Radiocarbon 35(2), p317-322

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CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-11:lab. mult=1)

Laboratory number: **149345**

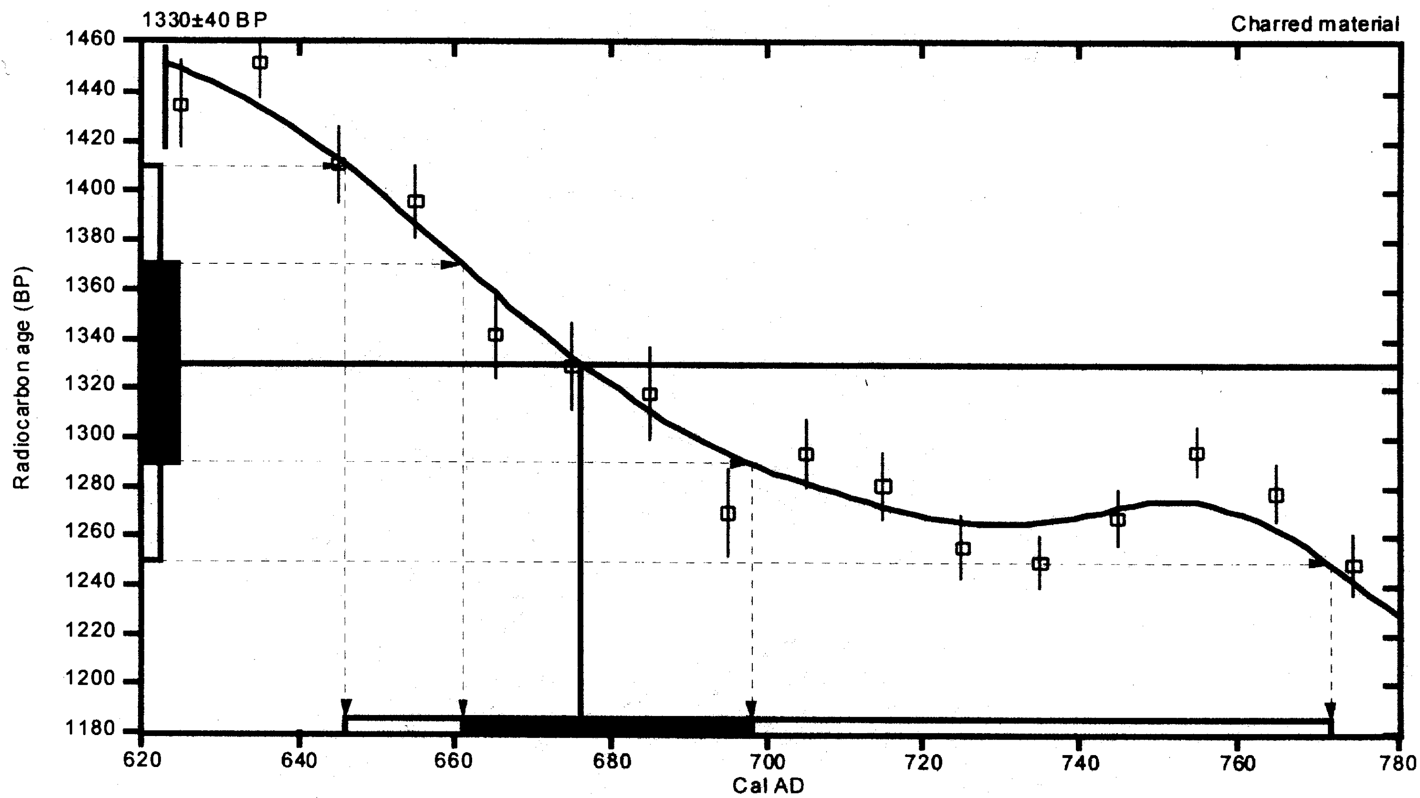
Conventional radiocarbon age: **1330±40 BP**

2 Sigma calibrated result: **Cal AD 650 to 770 (Cal BP 1300 to 1180)**
(95% probability)

Intercept data

Intercept of radiocarbon age with calibration curve: Cal AD 680 (Cal BP 1270)

1 Sigma calibrated result: Cal AD 660 to 700 (Cal BP 1290 to 1250)
(68% probability)



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CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-18.3:lab. mult=1)

Laboratory number: **149346**

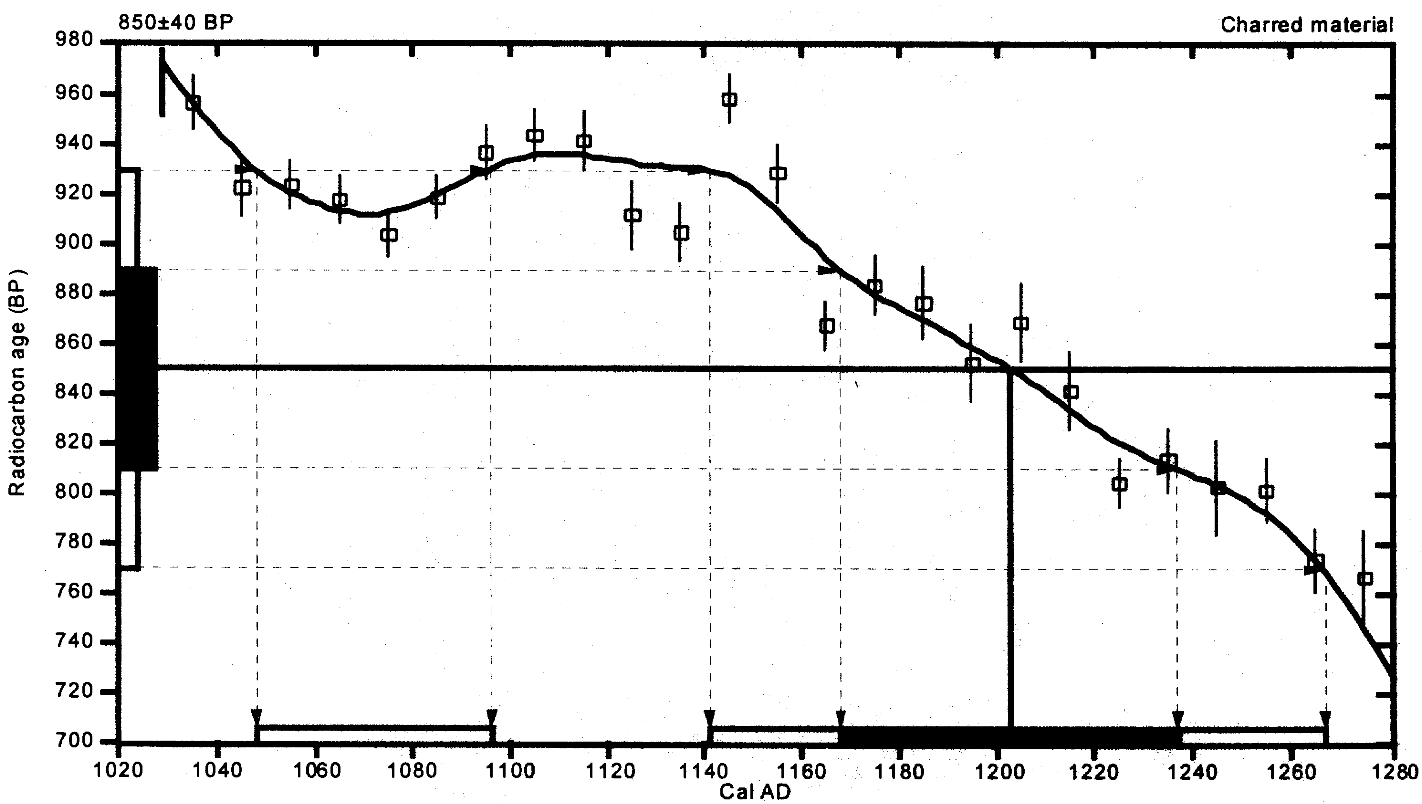
Conventional radiocarbon age: **850±40 BP**

2 Sigma calibrated results: **Cal AD 1050 to 1100 (Cal BP 900 to 850) and**
(95% probability) **Cal AD 1140 to 1270 (Cal BP 810 to 680)**

Intercept data

Intercept of radiocarbon age with calibration curve: Cal AD 1200 (Cal BP 750)

1 Sigma calibrated result: Cal AD 1170 to 1240 (Cal BP 780 to 710)
(68% probability)



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CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-12.9:lab. mult=1)

Laboratory number: **149347**

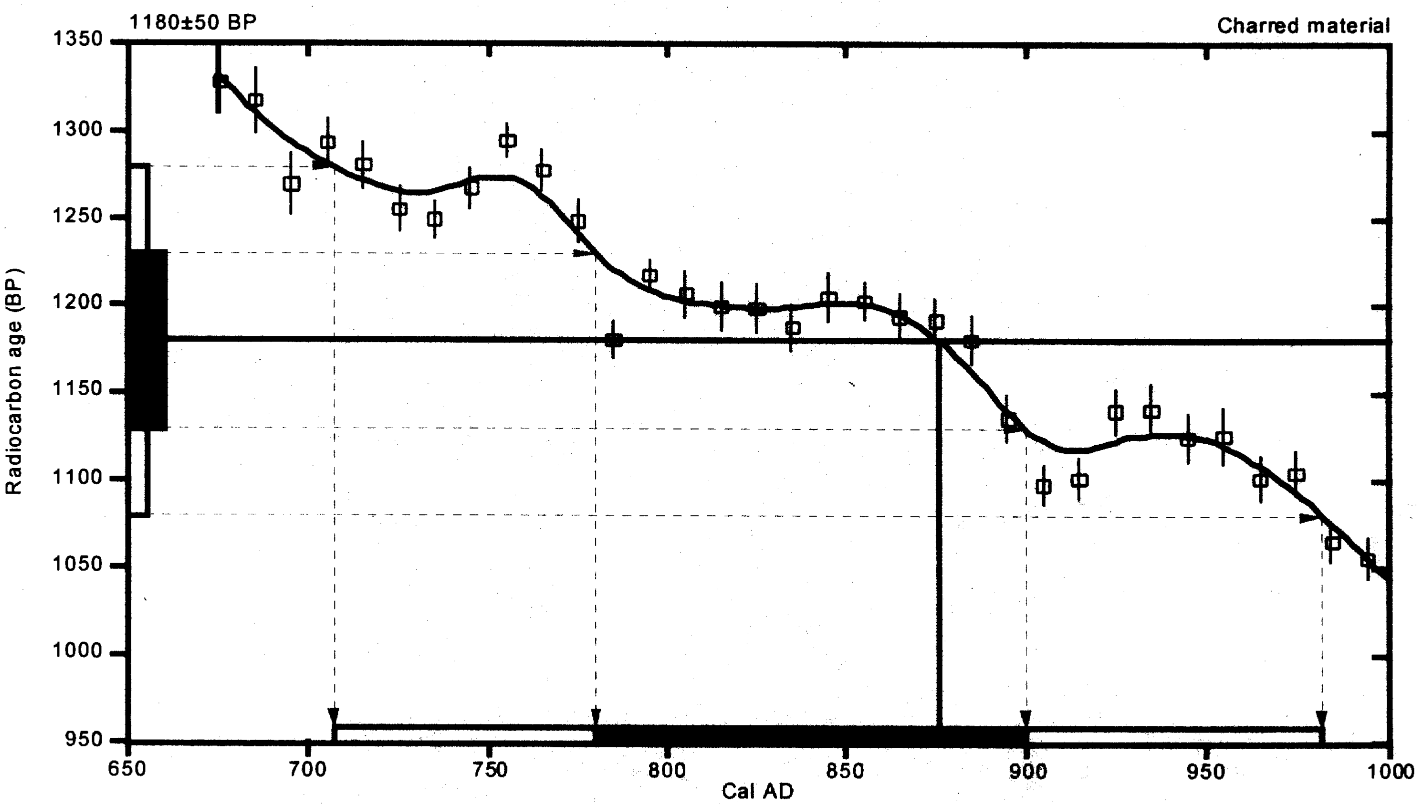
Conventional radiocarbon age: **1180±50 BP**

2 Sigma calibrated result: (95% probability) **Cal AD 710 to 980 (Cal BP 1240 to 970)**

Intercept data

Intercept of radiocarbon age with calibration curve: Cal AD 880 (Cal BP 1070)

1 Sigma calibrated result: (68% probability) Cal AD 780 to 900 (Cal BP 1170 to 1050)



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CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-23:lab. mult=1)

Laboratory number: **149348**

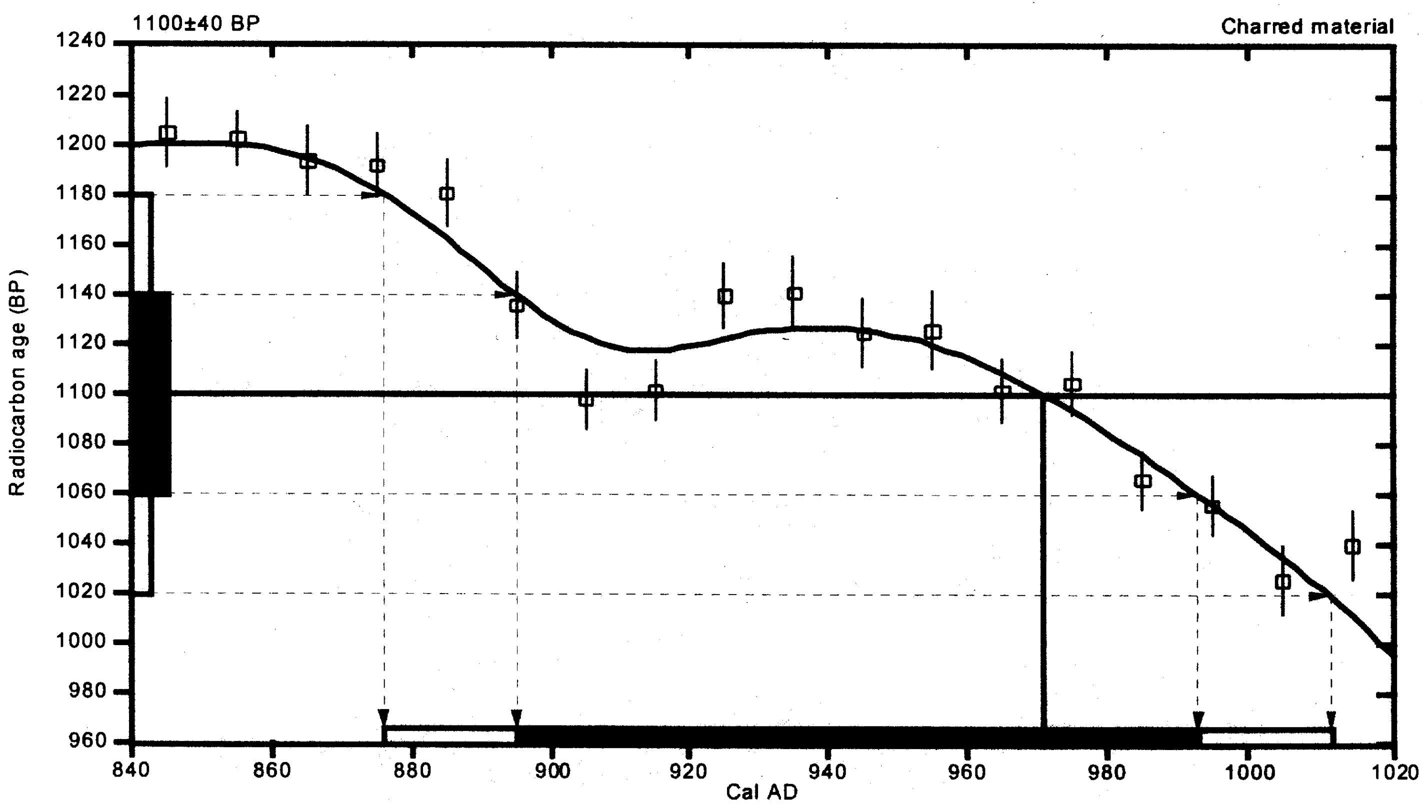
Conventional radiocarbon age: **1100±40 BP**

2 Sigma calibrated result: (95% probability) **Cal AD 880 to 1010 (Cal BP 1070 to 940)**

Intercept data

Intercept of radiocarbon age with calibration curve: Cal AD 970 (Cal BP 980)

1 Sigma calibrated result: (68% probability) Cal AD 900 to 990 (Cal BP 1060 to 960)



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CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-10.7:lab. mult=1)

Laboratory number: **149349**

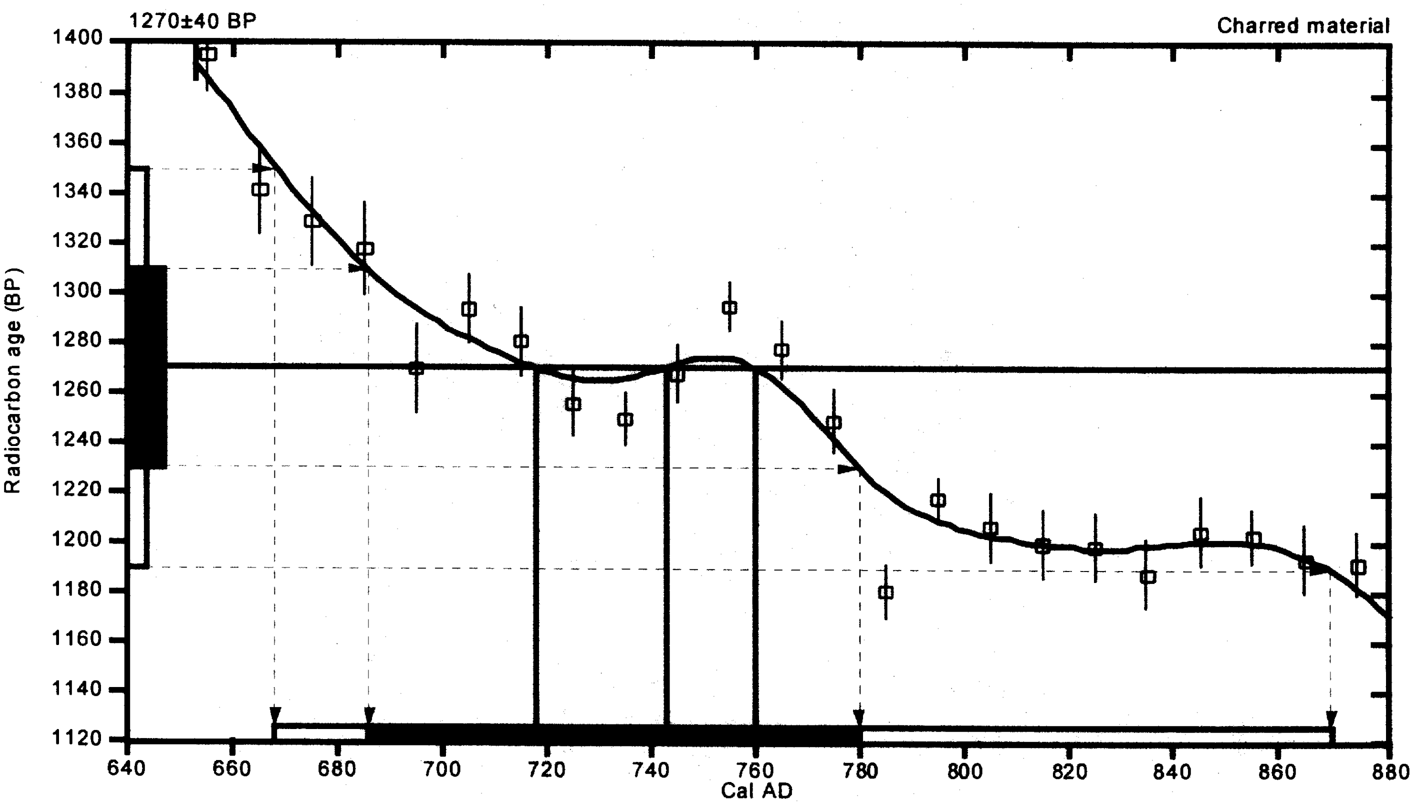
Conventional radiocarbon age: **1270±40 BP**

2 Sigma calibrated result: (95% probability) **Cal AD 670 to 870 (Cal BP 1280 to 1080)**

Intercept data

Intercepts of radiocarbon age with calibration curve: Cal AD 720 (Cal BP 1230) and Cal AD 740 (Cal BP 1210) and Cal AD 760 (Cal BP 1190)

1 Sigma calibrated result: (68% probability) Cal AD 690 to 780 (Cal BP 1260 to 1170)



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CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-24.9:lab. mult=1)

Laboratory number: **149350**

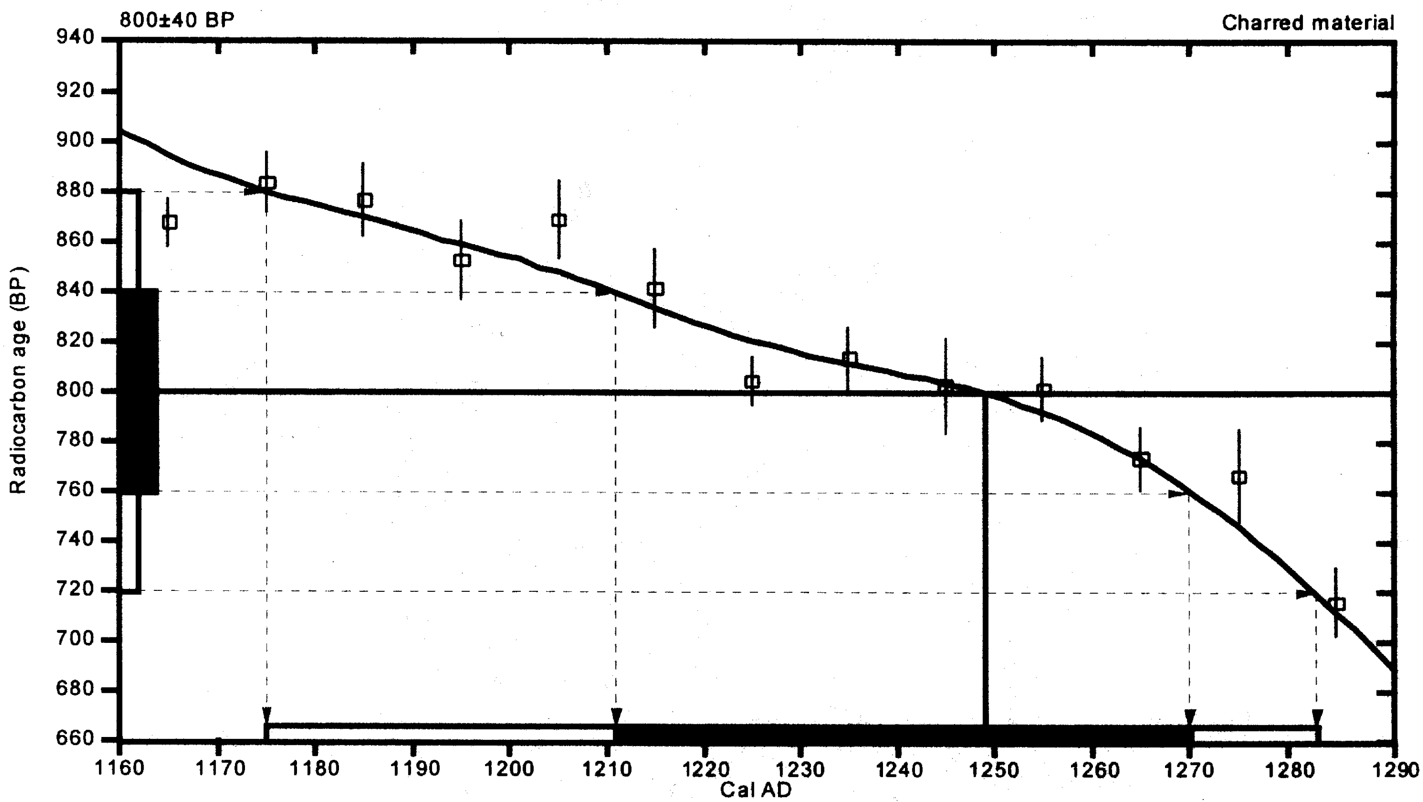
Conventional radiocarbon age: **800±40 BP**

2 Sigma calibrated result: (95% probability) **Cal AD 1180 to 1280 (Cal BP 780 to 670)**

Intercept data

Intercept of radiocarbon age with calibration curve: Cal AD 1250 (Cal BP 700)

1 Sigma calibrated result: (68% probability) Cal AD 1210 to 1270 (Cal BP 740 to 680)



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