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10,000 Years of Transient Occupation in the Jornada del Muerto:
Excavations at Eight Sites at the Spaceport America Facility, Sierra County, New Mexico

Volume II

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Research excavations at Spaceport America recovered 618 pieces of bone from five sites. Two of the site samples were procured entirely from flotation. The majority are from LA 155963 and consist of pieces of burned bone from small mammals found in the Jornada Mogollon area (Area C). This report begins with a description of the methods used, which is followed by a description of the site assemblages, the research objectives, and a section that places them in a regional context.

Methods

The fauna was identified and recorded using established OAS methods and a coding system. OAS comparative collections were used to identify this assemblage.

Provenience Related Variables. Field Specimen (FS) numbers are the primary link to more detailed proveniences within a site. Each line was also assigned a lot number, which identifies a specimen or group of specimens that fits the description recorded in that line.

Count. The count states how many specimens are described by that data line. Each bone (specimen) is counted only once, even when it was broken into a number of pieces by the archaeologist. If the break occurred prior to excavation, the pieces are counted separately and noted in a variable that identifies conjoinable pieces, parts that were articulated when found, and pieces that appear to be from the same individual.

Taxon. Taxonomic identifications are made as specific as possible. Specimens that cannot be identified as to the species, family, or order are assigned to a range of indeterminate categories based on the size of the animal and whether it is a mammal, bird, other animal, or cannot be determined. Unidentifiable fragments often constitute the bulk of a faunal assemblage. By identifying these as precisely as possible, the information can supplement that from the identified taxa. Small mammals are those up to and including those the size of a jackrabbit. When the size is more consistent with a rodent, they are called a range of sizes along with "rodent" (small rodent, medium-to-large rodent). Large mammals are the size of artiodactyls, while medium-to-large mammals are generally small pieces that were so eroded that they could be from a larger medium mammal or a large mammal. When an identification is less than certain, this is indicated in a certainty variable as "fairly certain" or "less certain but probable."

Element (Body Part). The skeletal element (e.g., cranium, mandible, humerus) is identified then described by side, age, and the portion recovered. Side is recorded for the element itself or for the portion recovered when it is axial, such as the left transverse process of a lumbar vertebra. Age is recorded at a general level: fetal or neonate, immature, young adult (near or full size with unfused epiphysis or young bone), and mature. Further refinements based on dental eruption or wear are noted as comments. The criterion used for assigning an age is also recorded. This is generally based on size for fetal, neonate, and immature elements, and epiphysis closure, bone texture, or dental development and wear for juvenile and mature elements. The portion of the skeletal element represented in a particular specimen is recorded in detail to aid in estimating how many individuals could be represented in an assemblage.

Completeness. Completeness refers to how much of that skeletal element is represented by the specimen (< 10%, 10–50%, 50–75%, 75–95%, analytically complete). The completeness variable provides information on whether a species is intrusive and on processing, environmental deterioration, animal activity, and thermal fragmentation.

Taphonomic Variables. Taphonomy is the study of preservation processes and how these affect the information obtained by identifying some of the non-human processes that affect the condition or frequencies found in an assemblage (Lyman 1994:1). Environmental alteration includes pitting or corrosion from soil conditions, sun bleaching from extended exposure, checking or exfoliation from exposure, root etching from the acids excreted by roots, and polish or rounding from sediment movement. Animal alteration was recorded by source or probable source, e.g., carnivore, rodent gnawing, and scat.

Burning. Burning can occur as part of the cooking process or part of the disposal process. Rather than recording the color or range of colors, the analyst makes a judgment as to the behavior that led to the state of burning, Choices include unburned, burned as part of the discard process, and roasting or partial burns. Discard burns are heavy burns ranging from black to calcine. Roasting burns can be no more than scorches, and need not be part of the cooking process. Scorching can occur when a bone is discarded but not completely burned, from burial beneath a thermal feature, or from roasting parts of an animal.

Butchering. Evidence of butchering is recorded as cuts, impacts, spiral breaks, defleshing, or snaps. The location of the butchering is also recorded. A conservative approach is taken to the recording of marks and fractures that could be indicative of processing animals for food, tools, or hides since many natural processes result in similar marks and fractures.

Modification. Deliberate modification not related to processing for consumption is indicted through this variable. Manufacturing debris and broad tool forms are recorded. Modified bone is subject to a separate analysis and coding form.

Comments. A coded comment column flags specimens recovered by flotation or indicates other common observations (e.g., whether measurements were taken, pigment staining), or indicates a verbal comment in the following variable. A second comment column is for verbal notations on that specimen.

Data Entering and Analysis. Data were entered directly into an Excel spreadsheet as a specimen was analyzed. These data were then converted into SPSS for data manipulation. Tables are generated by SPSS and copied into Excel.

Site Assemblages

Data at the site assemblage level is presented in Table 16.1 and the provenience breakdown for each site is in Table 16.2. Most (76.5 percent) of the bone was identified as small mammal with only a few pieces that could be identified as a particular animal or body part. Small fragments are typical of most site assemblages, with the complete and nearly complete elements coming mainly from rodents, lizards, snakes, and an occasional rabbit-foot bone. Nearly all are either environmentally modified or burned, sometimes both. Both burned and unburned bones are pitted and root-etched.

The large amount of highly fragmented bone is due in part to burning. Heavily burned bone is more friable than unburned bone and tends to break into small pieces or be reduced to powder by trampling and soil compaction (Stiner et al. 1995:229). A good amount of the Spaceport America unburned bone is relatively recent, and is often heavily pitted parts of small burrowing or burrow-dwelling animals, which suggests that preservation of fauna in these sites is poor. When organic material is not well preserved, burned bone survives better than unburned (Buikstra and Swegle 1989:248; Nicholson 1993:411).

If burning is an indication that an animal was eaten, or at least captured and discarded by humans, the only animals that were human discards are cottontail, jackrabbit, bobcat, a medium-sized bird, and box turtle (Table 16.3). Most of the small mammal fragments could be from the rabbits but some of the larger rodents could also fall within this taxon. The kangaroo rat, lizard, snake, and even some of the rabbit specimens are probably post-occupational.

LA 111422

Five cottontail specimens were recovered from two proveniences at this site. The first was a small burned fragment of a radius found in the first level of fill in Surface Strip Area 2. The other four were found in the same grid and level of the surface strip area around Feature 4, a deflated fire pit. Three are unburned fragments of a mandible and a femur, all in good condition. The final piece is much of a calcaneus that is burned. Ceramics and a radiocarbon date from Feature 4 indicate that these date to the Mesilla phase.

LA 111429

Little fauna was recovered from LA 111429. The first level of fill in Surface Investigation Area 5 produced a heavily etched complete snake vertebra that is probably not cultural. The other three specimens from this area are small mammal long-bone fragments that are unburned and heavily pitted. These could also be noncultural.

The 22 flotation samples from the large burned caliche-filled roasting pit (Feature 11) dating to the early Historic period (cal. AD 1620–1685; Boyer, Chapter 19 this report) produced three pieces of bone. Two unburned lizard long bones are undoubtedly noncultural, as may be a small fragment of a cottontail metatarsal. Only the cottontail specimen is pitted, but since all three specimens are from Level 5 of the feature and it is unburned, it too is most likely noncultural.

LA 111435

Two features at this site produced bone. Feature 8, the remains of what may have been a burned brush structure with a radiocarbon date of cal. AD 771-1014 (Boyer, Chapter 19, this report), had a complete caudal vertebra and a nearly complete tibia from a kangaroo rat. These and an unburned piece of small mammal long bone are probably noncultural. The final piece is a burned and pitted fragment of a small mammal long bone.

The Middle Archaic-period Feature 10 specimens were recovered from a flotation sample. Most of an unidentified element from a small reptile or amphibian [herp] was found in this heavily disturbed area of charcoal-stained soil. It is not pitted and probably from a relatively recent post-occupational burrower. The other piece is a small mammal long-bone fragment that is burned and etched.

LA 155963

This site produced much of the fauna from this project. With the exception of the Feature 6 and Feature 9 fauna, all are from surface strip areas or a feature in one of the strip areas and date to the Mesilla phase. A flotation sample from Feature 6, a badly disturbed thermal feature, contained an unburned vertebra from a lizard that is probably post-occupational. An unburned long-bone end fragment from a small animal was found in the Feature 9 stain flotation sample and it too is probably post-occupational.

Bone was recovered from surface collection and excavation in two surface-strip areas and Feature 141, which is in Surface Strip Area 2 (Table 16.4). Nearly all of the Surface Strip Area 2 bone is burned, including those from the cottontail, jackrabbit, bobcat, medium bird, and box turtle, indicating these were probably eaten or at least burned and discarded by humans. Over 60 percent of the Feature 141 bone is from flotation and all of it is identifiable only as small mammal (n = 37). More of it is burned (n = 21) than unburned (n = 15) or scorched/possibly roasted (n = 1). The bone recovered through excavation of Feature 141 (i.e., not from flotation) is all burned.

The smaller sample from Surface Strip Area 3 is largely burned. The unburned specimens are small mammal (n = 2) and cottontail (n = 1).

Rabbit body parts from this site are mainly hind limbs and feet (Table 16.5) but most elements are represented. Rather than suggesting preference for some elements, the counts for the more numerous parts are higher because these elements tend to be more identifiable than others. Nearly all are burned.

LA 155964

Feature 1, a large fire-cracked rock–filled roasting pit dating from between about 1800 and 1940 (Boyer, Chapter 19 this report), produced all of the fauna for this site. Feature 1.1 is a rock circle at the base of Feature 1. Most of the fauna (74.4 percent) was collected from the 25 flotation samples taken from this feature. None are burned but are from Levels 1 through 7 of the pit. Given that the pit fill is burned rock, ash, and charcoal, with sand-filled animal burrows, it is possible that all of the bone is post-occupational. Rodent and lizard burrowing definitely resulted in the redistribution of elements. What is probably the same jackrabbit hind-foot was recovered from Levels 3, 4, 6, and 7 of the same grid. Lizard, snake, and herp bones were found in three grids and from Levels 2 through 6. On the other hand, the only possible butchering for the project is on a piece of jackrabbit tibia from Level 4. It has a beveled edge and appears to have been cut through,

Table 16.1. Fauna recovered from the research-oriented excavations.

	LA 111422		LA 111429		LA 111435		LA 155963		LA155964		**Total**	
	Count	Col. %	Count	Col. %	Count	Col. %	Count	Col. %	Count	Col. %	Count	Col. %
Common name												
Unknown small	–	–	–	–	–	–	2	0.4	27	34.6	29	4.7
Small	–	–	–	–	–	–	2	0.4	–	–	2	0.3
Small mammal	–	–	3	42.9	3	50.0	464	88.9	3	3.8	473	76.5
Small–medium mammal	–	–	–	–	–	–	4	0.8	–	–	4	0.6
Medium-to-large mammal	–	–	–	–	–	–	2	0.4	–	–	2	0.3
Banner-tailed kangaroo rat	–	–	–	–	2	33.3	–	–	–	–	2	0.3
Small rodent	–	–	–	–	–	–	–	–	9	11.5	9	1.5
Medium-to-large rodent	–	–	–	–	–	–	–	–	7	9.0	7	1.1
Cottontails	5	100.0	1	14.3	–	–	22	4.2	3	3.8	31	5.0
Black-tailed jack rabbit	–	–	–	–	–	–	20	3.8	12	15.4	32	5.2
Bobcat	–	–	–	–	–	–	1	0.2	–	–	1	0.2
Medium bird	–	–	–	–	–	–	2	0.4	–	–	2	0.3
Ornate box turtle	–	–	–	–	–	–	2	0.4	–	–	2	0.3
Lizards	–	–	2	28.6	–	–	1	0.2	10	12.8	13	2.1
Whiptails	–	–	–	–	–	–	–	–	1	1.3	1	0.2
Snakes	–	–	1	14.3	–	–	–	–	3	3.8	4	0.6
Herp	–	–	–	–	1	16.7	–	–	3	3.8	4	0.6
Total	5	100.0	7	100.0	6	100.0	522	100.0	78	100.0	618	100.0
Total from flotation	–	–	3	42.9	2	33.3	38	7.3	58	74.4	101	16.3
Age												
Immature	–	–	–	–	–	–	–	–	3	3.8	3	0.5
Juvenile	–	–	–	–	1	16.7	14	2.7	6	7.7	21	3.4
Mature	5	100.0	7	100.0	5	83.3	508	97.3	69	88.5	594	96.1
Completeness												
< 10%	2	40.0	4	57.1	3	50.0	507	97.1	17	21.8	533	86.2
10–50%	2	40.0	2	28.6	–	–	10	1.9	21	26.9	35	5.7
50–75%	1	20.0	–	–	–	–	2	0.4	8	10.3	11	1.8
75–95%	–	–	–	–	2	33.3	2	0.4	16	20.5	20	3.2
Complete	–	–	1	14.3	1	16.7	1	0.2	16	20.5	19	3.1
Environmental alteration												
None	5	100.0	2	28.6	2	33.3	321	61.5	53	67.9	383	62.0
Pitting/corrosion	–	–	5	71.4	4	66.7	42	8.0	25	32.1	76	12.3
Sun bleached	–	–	–	–	–	–	1	0.2	–	–	1	0.2
Checked/ exfoliated	–	–	–	–	–	–	3	0.6	–	–	3	0.5
Root etched	–	–	–	–	–	–	15	2.9	–	–	15	2.4
Polished/rounded	–	–	–	–	–	–	140	26.8	–	–	140	22.7
Burning												
Unburned	3	60.0	7	100.0	4	66.7	24	4.6	78	100.0	116	18.8
Discard burn	2	40.0	–	–	2	33.3	494	94.6	–	–	498	80.6
Roasting burn	–	–	–	–	–	–	4	0.8	–	–	4	0.6

Table 16.2. Provenience information for fauna.

Provenience	Count	From Flotation	% From Flotation
LA 111422			
Surface Strip Area 2	1	–	0.0
Feature 4 surface strip	4	–	0.0
LA 111429			
Surface Investigation Area 5	4	–	0.0
Feature 11 excavation	3	3	100.0
LA 111435			
Feature 8 excavation	4	–	0.0
Feature 10 excavation	2	2	100.0
LA 155963			
Surface Strip Area 2 surface	134	–	0.0
Surface Strip Area 2 surface strip	261	–	0.0
Surface Strip Area 3 surface	7	–	0.0
Surface Strip Area 3 excavation	61	–	0.0
Feature 6 excavation	1	1	100.0
Feature 9 excavation	1	–	0.0
Feature 141 excavation	57	37	64.9
LA 155964			
Feature 1 excavation	76	56	73.7
Feature 1.1 excavation	2	2	100.0
Total	618	101	20.3

Table 16.3. Percent of unburned and discard or roasting burn by site and taxon.

	LA 111422		LA 111429	LA 111435		LA 155963			LA 155964	All Sites			**Total**
	% Not Burned	% Discard Burn	% Not Burned	% Not Burned	% Discard Burn	% Not Burned	% Discard Burn	% Roasting Burn	% Not Burned	% Not Burned	% Discard Burn	% Roasting Burn	Count
Unknown small	–	–	–	–	–	50.0	50.0	–	100.0	96.6	3.4	–	29
Small mammal/ bird	–	–	–	–	–	–	100.0	–	–	–	100.0	–	2
Small mammal	–	–	100.0	33.3	66.7	4.3	94.8	0.9	100.0	5.7	93.4	0.8	473
Small–medium mammal	–	–	–	–	–	–	100.0	–	–	–	100.0	–	4
Medium-to-large mammal	–	–	–	–	–	–	100.0	–	–	–	100.0	–	2
Banner-tailed kangaroo rat	–	–	–	100.0	–	–	–	–	–	100.0	–	–	2
Small rodent	–	–	–	–	–	–	–	–	100.0	100.0	–	–	9
Medium-to-large rodent	–	–	–	–	–	–	–	–	100.0	100.0	–	–	7
Cottontails	60.0	40.0	100.0	–	–	4.5	95.5	–	100.0	25.8	74.2	–	31
Black-tailed jack rabbit	–	–	–	–	–	5.0	95.0	–	100.0	40.6	59.4	–	32
Bobcat	–	–	–	–	–	–	100.0	–	–	–	100.0	–	1
Medium bird	–	–	–	–	–	–	100.0	–	–	–	100.0	–	2
Ornate box turtle	–	–	–	–	–	–	100.0	–	–	–	100.0	–	2
Lizards	–	–	100.0	–	–	100.0	–	–	100.0	100.0	–	–	13
Whiptails	–	–	–	–	–	–	–	–	100.0	100.0	–	–	1
Snakes	–	–	100.0	–	–	–	–	–	100.0	100.0	–	–	4
Herp	–	–	–	100.0	–	–	–	–	100.0	100.0	–	–	4
Total	60.0	40.0	100.0	66.7	33.3	4.6	94.6	0.8	100.0	18.8	80.6	0.6	618

Table 16.4. LA 155963, surface strip taxa and burning.

	Surface Strip Area 2				Feature 141				Surface Strip Area 3				**Total**	
	Surface Collection		Surface Stripping		Stripping Above Feature		Feature Fill		Surface Collection		Level			
Common Name	Count	Col. %	Count	Col. %	Count	Col. %	Count	Col. %	Count	Col. %	Count	Col. %	Count	Col. %
Unknown small	–	–	1	0.4	–	–	–	–	–	–	–	–	1	0.2
Small mammal/ bird	2	1.5	–	–	–	–	–	–	–	–	–	–	2	0.4
Small mammal	118	88.1	235	90.0	5	83.3	47	92.2	7	100.0	52	85.2	464	89.2
Small–medium mammal	–	–	3	1.1	–	–	1	2.0	–	–	–	–	4	0.8
Medium-to-large mammal	1	0.7	1	0.4	–	–	–	–	–	–	–	–	2	0.4
Cottontails	2	1.5	13	5.0	1	16.7	1	2.0	–	–	5	8.2	22	4.2
Black-tailed jack rabbit	8	6.0	6	2.3	–	–	2	3.9	–	–	4	6.6	20	3.8
Bobcat	1	0.7	–	–	–	–	–	–	–	–	–	–	1	0.2
Medium bird	2	1.5	–	–	–	–	–	–	–	–	–	–	2	0.4
Ornate box turtle	–	–	2	0.8	–	–	–	–	–	–	–	–	2	0.4
Total	134	100.0	261	100.0	6	100.0	51	100.0	7	100.0	61	100.0	520	100.0
Burning														
Unburned	1	0.7	2	0.8	–	–	15	29.4	–	–	4	6.6	22	4.2
Discard burn	133	99.3	256	98.1	6	100.0	35	68.6	7	100	57	93.4	494	95.0
Roasting burn	–	–	3	1.1	–	–	1	2.0	–	–	–	–	4	0.8

Does not include Features 6 and 9 specimens.

Table 16.5. LA 155963, rabbit elements and burning.

	Cottontail		Jack Rabbit		Total		% Burned
Element	Count	Col. %	Count	Col %	Count	Col %	Row %
Cranium	1	4.5	2	10.0	3	7.1	100.0
Mandible	2	9.1	1	5.0	3	7.1	100.0
Tooth	1	4.5	1	5.0	2	4.8	50.0
Lumbar vertebra	1	4.5	–	–	1	2.4	100.0
Scapula	2	9.1	1	5.0	3	7.1	100.0
Innominate	–	–	1	5.0	1	2.4	100.0
Radius	4	18.2	1	5.0	5	11.9	100.0
Ulna	1	4.5	–	–	1	2.4	100.0
Metacarpal	–	–	1	5.0	1	2.4	100.0
Metacarpal 3	1	4.5	–	–	1	2.4	100.0
Femur	2	9.1	2	10.0	4	9.5	75.0
Tibia	2	9.1	3	15.0	5	11.9	100.0
Calcaneous	1	4.5	1	5.0	2	4.8	100.0
Metatarsal	1	4.5	2	10.0	3	7.1	100.0
Metatarsal 2	–	–	1	5.0	1	2.4	100.0
Metatarsal 3	1	4.5	1	5.0	2	4.8	100.0
Metatarsal 4	1	4.5	–	–	1	2.4	100.0
First phalanx (pes)	1	4.5	1	5.0	2	4.8	100.0
Third phalanx	–	–	1	5.0	1	2.4	100.0
Total	22	100.0	20	100.0	42	100.0	95.2

suggesting that some of the pit bone could be cultural, but it could also have found its way into the pit through non-cultural means (rodents).

Discussion

The faunal assemblage from Spaceport America provides some information on animal use during the Mesilla phase and the early Historic period. Large animal remains are absent from the Spaceport site assemblages, however this does not necessarily indicate that deer, pronghorn, and even bison were not pursued, only that if large animals were captured and consumed, the remains have not been preserved. We can say that groups who used the area probably captured small animals, mainly rabbits, on an encounter basis. We cannot say for sure whether most were procured during a particular season of the year. Only one cottontail and two jackrabbit specimens have unfused epiphyses, which suggests that the animals were not fully grown; only the cottontail specimen (a phalange from LA 155963) is burned. This could suggest procurement almost any time of the year except, possibly, winter or very early spring. Burned turtle remains from the same site and area suggests deposition between spring and fall. Ethnobotanical remains also suggest occupation in midsummer through fall.

Under the Ecological Landscape research orientation of this project, the prime objective is to understand how human groups utilize different strategies and techniques to address changes in ecological parameters of the landscape. While we presume that environmental factors underlay changes in subsistence practices, the lack of detailed information on prehistoric climate and resource distribution limit our ability to address this objective (Moore and Dello-Russo 2010:63–64). It is further limited by the results of the research excavations, where virtually all of the fauna was recovered from contexts dating to the Mesilla phase and few species were found. As a result, we can best address how the Jornada del Muerto was used during the Formative period, consider who might have been using the area, and whether animal use during the Mesilla phase would have differed from earlier and later time periods.

The Formative was a period of rapid changes in settlement, subsistence, and technology. With an increasing dependence and specialization in agriculture, mobility for at least some groups decreased considerably (Miller and Kenmotsu 2004:236–237). Results of regional excavations suggest that by the end of the Archaic period, upland and lowland sites had distinctive faunal assemblages. Lowland faunal assemblages indicate a focus on small mammals with significant amounts of rabbit bone, and a diet that was more plant based. This contrasts with highland sites, where the assemblages show an emphasis on artiodactyl procurement (Miller and Kenmotsu 2004:250; Moore et al. 2010a:157). Formative-period assemblages continue the upland-lowland pattern with the addition of residential sites in areas suitable for agriculture. The early part of the period was characterized by a dispersed settlement system, exploitation of several environmental zones, and ephemeral house structures. As use of alluvial fans, presumably associated with early farming, increased, mobility decreased and houses became more substantial. As a result of the decreased mobility, use of the central basin areas, such as the Jornada del Muerto, decreased and sites in those locations tend to be more like logistic bases (Miller and Kenmotsu 2004:244–246). Thus, the challenge for the Spaceport sites is to evaluate whether the area was used seasonally by mobile foragers, by groups from more permanent habitations who collected resources from the basin, or by both contemporaneously or sequentially—and whether use of the interior basin corresponds with how wet or dry periods affected strategies in upland and riverine situations. While the faunal assemblages are insufficient to answer these questions, they can contribute information on the overall subsistence strategies employed by these groups.

Researchers in southwestern and south–central New Mexico and the lower Rio Grande portion of Texas generally approach subsistence from a forager-collector theoretical perspective (e.g., Bury et al. 2009; Church and Sales 2003; Walker et al. 2005) and invariably conclude that groups inhabiting Northern Chihuahuan desert environments relied mainly on a plant diet and that hunting tended to focus primarily on rabbits. Most also agree that jackrabbit densities tend to be greater (Church and Sale 2003:146: jackrabbit 43–80 and cottontail 3–18 per sq km; Nelson et al. 2003:83: jackrabbit 23.17 and cottontail 13.90 per sq km). They also go on to describe rabbit hunts in areas throughout the world as either individual hunts that utilized projectiles, rabbit sticks, and snares, or as communal hunts (Church and Sale 2003:146-149; Walker et al. 2005:59-63). Unfortunately most, as with this project, recovered fairly small samples of bone that are largely burned and represent few species. Rabbits generally comprise the bulk of the identified specimens (Church and Sale 2003:166–167; Condon et al. 2010:310–311) but the assemblages do not answer the more substantive issues posed by the research designs.

Table 16.6 summarizes some of the larger and better-documented regional faunal data from upland, drainage, and lowland sites dating from the Late Archaic through the Doña Ana phase for the Jornada Mogollon sequence and the Pithouse period for the Mimbres sequence. Some adjustments were made, such as converting percentages to counts and accounting for differences in definitions of the various body-size definitions (e.g., small mammal and large mammal) to make the data more compatible. However, analytic differences still remain a factor. Sample sizes vary tremendously with residential sites having the larger sample sizes. Relatively few camp sites are included because most have very small assemblages that contribute little to the comparisons.

In general (Table 16.7), the results are consistent with trends described by Miller and Kenmotsu (2004:250). Upland site assemblages have more artiodactyl and large animal remains with only the latest site (Beargrass) having more small animal specimens. The few riverine sites also have considerable artiodactyl proportions, at least compared to lowland sites, and large amounts of small animal remains. Lowland assemblages contain little or no bone from large forms. Preference for cottontail over jackrabbit (indices over 0.50 indicate a preference for cottontail and less than that for jackrabbit) varies in all three areas.

When the same data are evaluated by time, the earlier sites tend to have more large forms with the exceptions all being lowland sites. Large remains are rare in almost all sites dating from the Formative period forward, with the few exceptions found in riverine or drainage locales. Again, the lagomorph indices are mixed.

Research Questions

Faunal data are better suited to address some of research questions than others. As expected, the fauna provides no information on Research Questions 1 and 2, which deal with chronology. No remains of Pleistocene fauna or domestic animals that could aid in dating the deposits were encountered in the research excavations.

How Do Our Sites Fit the Regional Culture Historical Framework?

The only site with an adequate sample, LA 155963, has a faunal assemblage that is similar to other sites from that period (Mesilla phase). Large body forms are absent or near absent and all have predominately small forms, presumably rabbits (Table 16.7). Preference for cottontail or jackrabbit varies with some lagomorph indices larger and others smaller than that for LA 155963. Thus, animal subsistence in the Jornada del Muerto during the Mesilla phase is similar to that found in other basin locales.

How Do Site Location and the Availability of Water Vary Through Time?

No taxa that would suggest more mesic climatic conditions were recovered. All of the species found are present or theoretically present today and do not suggest changes in surface water availability. Sites do tend to cluster at the edges of the two large draws where more moisture might support larger plant and animal populations. Human populations would have had to either transport water or rely on the moisture content of plants and animals.

How Were Sites Located in Relation to Other Critical Resources?

Faunal data do not help answer this question.

What Evidence Is There for Either Continuity or Changes in Land-Use Patterns Through Time?

Four sites have burned rabbit bones. Two date to the Mesilla phase (LA 111422 Feature 4 and LA 155963 Area B) and two to the Protohistoric or early Historic (LA 111429 and LA 155964). The absence of large body forms and presence of rabbit in these assemblages could suggest similar uses of the landscape in the Early Formative and early Historic periods, however, the samples are so small that it

Table 16.6. Summary of major faunal groups for Late Archaic through Pueblo period sites.

Site	Area	Locale	Type	Period	Sample Size	Rodent	Small Mammal*	Total Rabbit	Jack	Cotton-tail	Ided. Carnivore	Artio-dactyl	Large Mammal	Medium-large Mammal	% Burned	Source
LA 7809 (Forest Home)	Big Burro Mts.	upland	seasonal residential	Archaic & Early Pithouse	907	12	65	37	19	13	13	60	140	315	?	Duncan, 2000:488–507
LA 99631 (Wood Canyon)	Big Burro Mts.	upland	residential; farming	Late Archaic	2820	18	541	191	50	51	15	115	347	484	12.8	Duncan, 2000:488–507
LA 121158 (Beargras	Big Burro Mts.	upland	large residential	Pithouse	984	26	339	447	71	28	1	47	53	45	20.7	Duncan, 2000:488–507
LA 50548	Cuchillo Negro	drainage	residential	pre-AD 550	207	2	134	67	32	31	0	1	2	1	8.7	Daniel, 1994:146–152
LA 50548	Cuchillo Negro	drainage	residential; farming	post-AD 550	571	8	304	172	115	29	0	34	38	4	?	Daniel, 1994:146–152
LA 50548	Cuchillo Negro	drainage	residential	AD 900-1000	197	0	90	84	37	39	0	9	12	1	?	Daniel, 1994:146–152
LA 50547	Cuchillo Negro	drainage	short-term residential?	post-AD 550	155	2	125	1	9	0	0	2	6	0	42.6	Daniel, 1994:185, 188–189
LA 75797	Cuchillo Negro	drainage	residential	pre-AD 550	**777	2	428	29	5	8	0	7	38	6	23.3	Daniel, 1994: 301–304
LA 129562	West of Deming	lowland	residential	Early Pithouse	1072	89	727	149	41	24	56	3	15	0	20.6	Ch. 98 McClure, Cannon, & Moreland: 2009:1429–1430
LA 59652	West of Deming	lowland	residential	Pithouse	14395	175	10654	3183	1352	197	9	34	118	0	26.1	Ch. 95 Jones, 2009:1277–1279
LA 144921	West of Deming	lowland	residential	Archaic & Early Pithouse	15502	362	13141	1615	671	462	5	3	3	56	28.7	Ch 96 Kearns, 2009:1306– 1358
LA 155963	Jornada del Muerto	lowland/ interior basin	camp?	Mesilla	522	0	466	42	20	22	1	0	0	2	94.6	this report
LA 145343	Deming area	lowland	structure	Late Archaic/Early	155	0	130	19	4	0	0	0	0	0	96	Ch. 85 Smith & McVickar, 2009:1012, 1018
LA 37027	Fort Bliss	lowland	structure	Late Mesilla/ Dona Ana	331	2	243	65	45	11	1	1	2	3	57.5	Condon et al., 2010:309–310, O'Laughlin
LA 156414	Fort Bliss	lowland	stain	Late Mesilla/ Dona Ana	159	0	96	44	35	7	0	0	1	3	71.7	Condon et al. 2010:310, O'Laughlin, 2010 D–11–D–12
LA 156418	Fort Bliss	lowland	scatters	Mesilla-El Paso	150	2	91	56	27	28	0	0	0	0	44	Condon et al., 2010:310, O'Laughlin 2010, D–12–D–13

(Table 16.6, continued)

Site	Area	Locale	Type	Period	Sample Size	Rodent	Small Mammal*	Total Rabbit	Jack	Cotton-tail	Ided. Carnivore	Artio-dactyl	Large Mammal	Medium-large Mammal	% Burned	Source
Sandy Bone	El Paso	lowland Rio floodplain	trash deposit	Mesilla	1510	4	1015	361	318	43	0	1	0	0	33% of ided.	O'Laughlin, 1977:25–36
41EP1602	El Paso	lowland	residential and camp	El Paso	340	1	294	41	8	3	0	0	0	0	56.5	Presley and Shaffer, 2001:411–412
41EP1664	El Paso	lowland	residential midden	El Paso	268	2	200	55	36	0	0	0	0	5	15.3	Presley and Shaffer. 2001:409
41EP2724	El Paso	lowland	residential and camp	El Paso	5834	15	3411	24	11	7	0	22	1	84	18.2	Presley and Shaffer, 2001:414–418
41EP2757	El Paso	lowland	camp	Mesilla	816	2	724	80	5	19	0	0	0	0	69.6	Presley and Shaffer, 2001:414,419

* Definitions vary; can include small mammal/bird, medium mammal, and small vertebrate.

**Adjusted 84 bones from the same rabbit are considered 1 count here.

Table 16.7. Summary of body sizes and lagomorph indices for regional sites.

Site	Locale	Type	Period	Sample Size	% Artiodactyl	% Artiodactyl + Large Mammal	% Artiodactyl + Large Mammal + Medium–large Mammal	% Rabbit	% Rabbit + Small Mammal	Lagomorph Index Cottontail/ Jackrabbit + Cottontail
LA 7809 (Forest Home)	upland	seasonal residential	Archaic & Early Pithouse	907	6.6	22.1	56.8	4.1	11.2	0.42
LA 99631 (Wood Canyon)	upland	residential; farming	Late Archaic	2820	4.1	16.4	33.5	6.8	26.0	0.51
LA 121158	upland	large residential	Pithouse	984	4.8	10.2	14.7	45.4	79.9	0.28
LA 50548	drainage	residential	pre AD 550	207	0.5	1.5	1.9	32.4	97.1	0.49
LA 50548	drainage	residential; farming	post AD 550	571	6.0	12.6	13.3	30.1	83.4	0.20
LA 50548	drainage	residential	AD 900-1000	197	4.6	10.6	11.2	42.6	88.3	0.51
LA 50547	drainage	short-term residential	post AD 550	155	1.3	5.2	5.2	0.6	81.3	0.00
LA 75797	drainage	residential	pre AD 550	**777	0.9	5.8	6.6	3.7	58.8	0.62
LA 129562	lowland	residential	Early Pithouse	1072	0.3	1.7	1.7	13.9	81.7	0.37
LA 59652	lowland	residential	Pithouse	14395	0.2	1.1	1.1	22.1	96.1	0.87
LA 144921	lowland	residential	Archaic & Early Pithouse	15502	0.02	0.04	0.4	10.4	95.2	0.41
LA 155963	lowland/ interior basin	camp?	Mesilla	522	0	0	0.4	8.1	97.3	0.52
LA 135343	lowland	structure	Late Archaic/ Early Formative	155	0	0	0	12.2	96.1	0.00
LA 37027	lowland	structure	Late Mesilla/ Dona Ana	331	0.3	0.9	1.8	19.6	97.3	0.55
LA 156414	lowland	stain	Late Mesilla/ Dona Ana	159	0	0.6	2.5	27.7	96.2	0.17
LA 156418	lowland	scatters	Mesilla-El Paso	150	0	0	0	41.3	98.0	0.51
Sandy Bone	lowland Rio floodplai	trash deposit	Mesilla	1510	0.07	0.07	0.07	23.9	91.1	0.12
41EP1602	lowland	features	El Paso	340	0	0	0	12.1	98.5	0.27
41EP1664	lowland	midden	El Paso	268	0	0	1.7	20.5	95.2	0.00
41EP2724	lowland	features	El Paso	5834	0.4	0.4	1.8	0.4	58.9	0.39
41EP2757	lowland	camp	Mesilla	816	0	0	0	9.8	98.5	0.79

can hardly be taken as representative of the later period.

Is There Evidence for an Apache Presence in the Project Area that Can Be Tied to Concurrent Military Activities?

The presence of a possible knife cut on a rabbit bone is suggestive but cannot be seen as conclusive evidence of either Apache presence or a relation to military activities.

With What Areas Did the Residents of the Study Area Interact During Various Periods of Occupation?

All of the fauna recovered are currently present at the Spaceport (FAA 2008:3–70) and do not provide evidence for movement or interaction with other areas.

Conclusions

It is unlikely that the Spaceport America area could have supported groups who came specifically to hunt rabbits. Instead, those who utilized the area probably collected and processed plant material so that the occasional rabbit, rodent, or other animal was procured to support groups who were there for another purpose. Considerable effort was directed toward constructing and gathering the fuel wood for the large roasting pits associated with the Late Archaic-Mesilla–phase transition, the Mesilla phase, and the early Historic period. Yet none of these features have evidence of a camp or of extended use of the area around the feature. Rather, the only evidence of even a moderately extended stay or repeated occupation of a particular location is the Mesilla phase Area B occupation at LA 155963, where our investigations did not locate either storage or roasting features near those deposits.

The presence of both large isolated roasting pits for processing a good quantity of resources and repeated occupation of a particular location during the Mesilla phase may be more characteristic of collectors who acquire and process resources that are returned to a home base. Located about equidistance (under 30 km) from the foothills of the San Andres Mountains and the Rio Grande, the Spaceport area lies within the potential range utilized by tactically sedentary horticulturalists in either location. These collectors, who mainly exploit plants, move an average of 3.22±3.61 times a year—an average of 10.71±4.84 km per move (Binford 2001:278).

Given that what little information we have on seasonality indicates that the Spaceport area was visited during the warm season (spring to fall), this could have conflicted with horticultural activities. Reviewing the most accurate and most precise radiocarbon dates for the project (Boyer, Table 19.17, this report) tentatively suggests that the area was used during periods of regional drought, with none of the features dating to the wettest period in the sequence (AD 1040–1125, AD 1140–1210), while several correspond with periods of long-term droughts (AD 940–1040, AD 1125-1140, AD 1210–1305) followed by less variability after AD 1300, (Grissino-Mayer et al. 1997:19–21).

As a result, what we might be seeing is increased or greater use of interior basin resources during drier times when horticulturalists extended their ranges. Processing storable quantities of desert succulents, yucca, and mesquite beans may have been the primary objective. Animals, especially rabbits, but including turtles, rodents, artiodactyls, birds, and small carnivores, may have been actively hunted by these horticulturalists when they were not engaged in gathering and processing plants. Traps and snares may have been used to procure dispersed and low-density animals, especially when there was no division of labor and when labor was in short supply (Binford 2001:394–395).

17 | Ethnobotanical Analysis

Pamela J. McBride

Introduction

This chapter reports on analysis results of flotation and macrobotanical samples from seven sites at the Spaceport America facility. Thermal features ranged from small pits to large rock-filled roasting pits. The range of dates for features offers the possibility of looking at subsistence adaptations in the arid Jornada del Muerto over a long time period, beginning in the Middle Archaic and ending in the Protohistoric. Comparisons can be made to sites of comparable age in the Mesilla Bolson, Tularosa Basin, and the Hueco Bolson.

The sites are in an area that can generally be characterized as Chihuahuan Desertscrub (Brown 1994) where honey mesquite (*Prosopis glandulosa*) is the primary shrub species, particularly on dune ridges. Other shrubs that provide edible fruits and that have more limited distribution in the area include little-leaf sumac (*Rhus microphylla*), lotebush (*Ziziphus obtusifolia var. canescens*), and wolfberry (*Lycium pallidum*). Four-wing saltbush (*Atriplex canescens*), creosotebush (*Larrea tridentata*), and tarbush (*Flourensia cernua*) also occur and could have provided firewood or, in the case of four-wing saltbush, edible seeds. Several dropseeds (alkali, spike, and mesa dropseed; *Sporobolus airoides, S. cantractus, and S. flexuosus*) are among the grasses identified at the Spaceport with documented economic uses. Soaptree yucca (*Yucca elata*), groundcherry (*Physalis* spp.), and scattered prickly pear (*Opuntia* spp.) and cholla (*Cylindropuntia* spp.) are examples of other plants with edible or manufacturing uses found on the Spaceport property (see vegetation survey results, this volume, for more detailed information).

Archaeobotanical analysis included flotation processing and identification of plant material encompassing reproductive and non-reproductive parts and charcoal. The methods used are described, followed by a description of analysis results and a discussion of possible interpretations of the data.

Methods

Plant remains from the Spaceport America facility were recovered in one of two ways. One recovery method involved collecting a sample of sediment that was later submerged in water to extract plant remains, commonly referred to as flotation (Pearsall 1989). The second method involved collecting easily recognizable vegetal material during the excavation process, called macrobotanical samples.

Flotation

Flotation Processing

The 108 soil samples collected during excavation were processed at the Museum of New Mexico's Office of Archaeological Studies using the simplified "bucket" version of flotation (Bohrer and Adams 1977). The volume of flotation soil samples ranged from .15 to 4.67 liters. Each sample was immersed in a bucket of water, and a 30–40 second interval allowed for the settling-out of heavy particles. The solution was then poured through a colander lined with a square of "chiffon" fabric, which would catch organic materials floating or in suspension. The squares of fabric were lifted out and laid on coarse mesh screen trays until the recovered material had dried. Flotation sample summary information, including the presence of roots, insects, bone fragments, and insect or rodent scats is reported along with sample volumes (before flotation) in Table 17.1.

Full-Sort Analysis

Each of the 108 samples was sorted using a series of nested geological screens (4.0, 2.0, 1.0, and 0.5 mm mesh), and then reviewed under a binocular microscope at 7–45x. Charred and uncharred reproductive plant parts (seeds and fruits) were identified, counted, and placed in labeled polypropylene capsules. Flotation data are reported as a standardized count of seeds per liter of soil, rather than an actual number of seeds recovered. Relative abundance of non-reproductive plant parts, such as yucca basal caudex fragments, was estimated per sample.

To aid the reader in sorting out botanical occurrences of cultural significance from the considerable noise of post-occupational intrusion, data in tables are sorted into categories of "Cultural" (all carbonized remains), "Possibly Cultural" (unusual unburned remains that have known economic uses), and "Noncultural" (unburned materials or burned introduced species, especially when of taxa not economically useful, and when found in disturbed contexts together with modern roots, insect parts, scats, or other signs of recent biological activity).

Charcoal Identification

From each flotation sample that contained a minimum of 20 pieces of wood charcoal, a sample of 10 pieces was identified from the 4 mm screen and 10 pieces from the 2 mm screen. In smaller samples, all charcoal from the 4 mm and 2 mm screens was analyzed. Each piece was snapped to expose a fresh transverse section, and then examined at 45x. Identified charcoal from each taxon was weighed on a top-loading digital balance to the nearest tenth of a gram and placed in labeled plastic bags or polyethylene capsules labeled with the corresponding taxon. Low-power, incident-light identification of wood specimens does not often allow species—or even genus-level—precision, but can provide reliable information useful for distinguishing broader patterns in the utilization of resources derived from different environmental settings (i.e., dunes, riparian, woodland).

Macrobotanical Sample Analysis

Macrobotanical samples consist of specimens systematically collected in the field during excavation. Special emphasis was placed on collecting small-diameter shrub wood and non-wood taxa for radiocarbon dating, resulting in a macrobotanical assemblage consisting largely of wood charcoal and yucca stems and basal caudex, but yucca leaf fragments and a prickly pear cactus pad were also present. Specimens were identified as to taxon and plant part by comparison with modern reference specimens and weighed on a digital, top-loading balance with .01g accuracy. When necessary, fragile specimens were wrapped in acid-free tissue or polyester fiber and placed in rigid containers to protect them from any further breakage. Table 17.2 lists all carbonized plant taxa encountered in the Spaceport samples by scientific and common names along with the anatomical parts recovered. As Derring (2002, Fig. F-4) illustrates in his report of carbonized plant remains from Otero Mesa, tuberculate or "verrucose elevations" are typical of the base of leaf succulents. The leaves attach to the ventral side of the leaf succulent bases and the roots on the dorsal side. The basal portion of leaf succulents are difficult to distinguish (agave, sotol, yucca), but in the case of the Spaceport specimens, have been designated as yucca because of the absence of sotol and agave in the area today.

Results

LA 111422

The dark fill of a Mesilla-phase charcoal stain (Feature 1), which was all that remained of a deflated feature, contained burned yucca basal caudex fragments and unburned spurge and wild buckwheat seeds as well as mesquite leaves and grass florets (Table 17.3). The small rock-filled fire pit (Feature 2) produced only unburned annual and yucca seeds and mesquite leaves. Burned cheno-am seeds and yucca basal caudex were recovered from the deflated fire pit that dates to the Mesilla phase (Feature 4). A similar array of noncultural plant material that was recovered elsewhere was found in Feature 4. The small number of wood charcoal fragments encountered in the LA 111422 flotation samples was entirely saltbush (Table 17.4).

LA 111429

Dating to the Mesilla phase, the first of two large roasting pits excavated at LA 111429 (Feature 3) was

Table 17.1. Flotation sample summary information.

Site	FS No.	Feature No.	Volume (l)	Roots	Insects	Bone	Feces
LA 111422	68	4	1.76	+	+	–	–
	71	2	3.51	+	+	–	+
	74 (2 bags)	1	4.71	+	+	–	+
	75	1	0.30	+	–	–	+
	76	4	2.66	+	+	–	+
LA 111429	24	11	1.19	+	+	–	+
	136	11	1.47	+	+	+	++
	138	11	1.98	+	+	–	++
	269	11	1.79	+	+	–	+
	272	11	1.55	+	+	–	+
	273	11	0.77	+	+	–	+
	274	11	2.80	+	+	–	++
	275	11	2.65	+	+	–	++
	276	11	1.35	+	+	–	+
	277	11	2.05	+	+	+	+
	278	11	2.43	+	+	–	+
	279	11	2.38	+	+	–	+
	297	11	2.27	+	+	–	+
	300	3	3.00	+	+	–	+
	301	3	3.85	+	+	–	+
	302	3	1.60	+	+	–	+
	304	3	2.12	+	+	–	+
	305	3	3.25	+	+	–	+
	306	3	3.45	+	+	–	+
	310	11	1.22	+	+	–	+
	311	11	1.21	+	+	–	+
	312	11	2.88	+	+	–	+
	315	11	1.78	+	+	–	+
	318	11	2.89	+	+	+	+
	319	11	1.48	+	+	–	+
	321	11	1.70	+	+	–	+
	322	11	1.91	+	+	–	+
	323	11	2.14	+	+	–	+
LA 111435	1	3	1.50	+	+	–	+
	22	3	0.77	+	+	–	+
	29	10	2.13	+	+	+	+
	30 (3 bags)	10	9.09	+	+	+	+
	38	6	1.59	+	+	–	–
	40	6	1.59	+	+	–	–
	41 (2 bags)	4	2.38	+	+	–	+
	44	5 area	1.01	+	+	–	++
	48	4	2.32	+	+	–	+++
	53	5	1.60	+	+	–	+
	98	8	1.47	+	+	–	–
	102	8	2.85	+	+	–	+
LA 155963	17	133	0.15	+	–	–	+
	19	125	1.50	+	+	–	+
	25 (2 bags)	125	1.36	+	+	–	+
	405	1	2.14	+	+	–	+
	406	1	1.85	+	+	–	+

(Table 17.1, continued)

Site	FS No.	Feature No.	Volume (l)	Roots	Insects	Bone	Feces
	407	1	1.35	+	+	–	+
	440	18	0.94	+	+	–	+
	485 (2 bags)	8	5.23	+	+	–	+
	511 (2 bags)	9	1.95	+	+	+	+
	578	14	0.45	+	+	–	+
	579	14	1.62	+	+	–	+
	581	14	2.65	+	+	–	+
	582	14	1.50	+	+	–	+
	584	15	3.23	+	+	–	+
	585	15	2.22	+	+	–	+
	586	15	3.31	+	+	–	+
	618	141	2.75	+	+	+	+
	619	141	4.67	+	+	+	+
	621	6	3.50	+	+	+	+
LA 155964	8	1	0.69	+	+	–	+
	15	1	1.77	+	+	–	+
	17	1	0.62	+	+	–	+
	19	1	1.62	+	+	+	+
	22	1	2.48	+	+	+	+
	23	1	2.32	+	+	+	+
	24	1	1.65	+	+	+	+
	25	2	4.53	+	+	–	+
	27	1	1.27	+	+	+	+
	28	1	2.17	+	+	+	+
	29	1	0.90	+	+	+	+
	30	1	1.92	+	+	+	+
	31	1	2.17	+	+	+	+
	32	1	1.92	+	–	+	+
	34	1	1.30	+	+	–	+
	35	1	1.93	+	+	–	+
	36	1	2.35	+	+	+	+
	37	1	1.40	+	+	–	+
	38	1	3.48	+	+	+	+
	40	1	1.48	+	+	–	+
	42	1	0.72	+	+	+	+
	43	1	2.25	+	+	+	+
	44	1	3.33	+	+	+	+
	45	1	2.00	+	+	–	+
	46	1.1	1.35	+	+	–	+
	47	1.1	1.69	+	+	+	+
LA 155968	468	1.1	0.20	+	+	–	+
	470	1.1	0.19	+	–	–	–
	473	1	2.05	+	+	–	+
	474 (3 bags)	1	10.42	+	+	–	+
	476	1	2.52	+	+	–	+
	478	1	2.36	+	+	–	–
	480	1	3.00	+	+	–	+
	508	1.2	1.80	+	+	–	+
LA 156877	100	5	1.29	+	+	–	+

Table 17.2. Charred plant taxa from flotation and macrobotanical samples.

Taxon	Common Name	Plant Part
	Annuals	
Amaranthus	Amaranth	seed
Cheno-Am	Goosefoot/ Amaranth	seed
Chenopodium	Goosefoot	seed
Corispermum	Bugseed	seed
Euphorbia	Spurge	seed
Kallstroemia	Caltrop	seed
Portulaca	Purslane	seed
Talinum	Flameflower	seed
Trianthema	False purslane	seed
	Grasses	
Poaceae	Grass family	caryopsis, glume, stem
Sporobolus	Dropseed grass	caryopsis
	Other	
Asteraceae	Aster family	seed
Cactaceae	Cactus family	aereole, epidermis, pad
Fabaceae	Bean family	seed
Monocotyledonae	Monocot	stem
–	Unidentifiable	seed
–	Unknown	fruit, plant part
	Perennials	
Atriplex canescens	Four-wing saltbush	twig, wood
Cylindropuntia	Cholla	wood
Echinocereus	Hedgehog cactus	seed
Flourensia	Tarbush	wood
Opuntia	Prickly pear cactus	embryo, possible fruit, pad
Prosopis	Mesquite	endocarp, seed, wood
Yucca	Yucca	caudex, fiber, fruit, leaf, stem

Table 17.3. LA 111422, flotation sample plant remains.

Feature		1 Stain		2 Small Rock-filled Firepit	4 Deflated Firepit	
FS No.		74	75	71	68 Strat. 1, level 1	76 Strat. 2, level 1
Cultural						
Annuals	Cheno-am	–	–	–	–	0.8
Perennials	Yucca	+ ca	–	–	+ ca	+ ca
Noncultural						
Annuals	Amaranth	–	–	0.3	–	0.4
	Caltrop	–	–	–	0.6	0.4
	Goosefoot	–	–	1.4	1.7	0.4
	Purslane	–	–	0.3	1.1	–
	Spectacle pod	–	–	0.6	–	–
	Spurge	0.6	–	–	0.6	0.8
Grasses	Dropseed grass	–	–	–	1.1	0.4
	Grass family	–	6.6 floret	–	0.6 floret	–
Other	Groundcherry	–	–	–	1.1	–
	Wild buckwheat	0.2	6.6	–	–	1.1
Perennials	Mesquite	+ l	+ l	+ l	+ l	+ l
	Twinleaf senna	–	–	–	–	0.4
	Yucca	–	–	0.3	–	–

Plant parts are seeds unless indicated otherwise.
Cultural plant material is charred, noncultural material is uncharred.
Reproductive plant parts are reported as a standardized count of seeds per liter of soil, rather than an actual number of seeds recovered.
+ = 1–10/sample, ca = caudex, l = leaf

Table 17.4. LA 111422, flotation sample wood taxa by count and weight in grams.

Feature	1 Stain	4 Deflated Fire Pit	
FS No.	74	68 Strat. 1, level 1	76 Strat. 2, level 1
Nonconifer			
Saltbush	7/.08	2/.01g	1/.01

filled with darkly stained soil. Yucca basal caudex fragments, found in every level excavated, were the only identifiable carbonized plant remains recovered (Table 17.5). Flotation wood charcoal from all levels consisted of saltbush (Table 17.6). The density and size of charcoal increased with depth of the feature (Chapter 7), but taxa diversity did not change. Every macrobotanical wood sample collected from Stratum 9 of Feature 3 was also saltbush (Table 17.7).

The second, roasting pit (Feature 11) dates to the Early Historic period. This pit was filled with tightly packed rock, primarily burned caliche. Feature 11 produced evidence for cactus pad and/or fruit processing, consisting of cactus areoles (Fig. 17.1), a prickly pear embryo, a possible prickly pear fruit fragment, and epidermis with persistent areoles (Fig. 17.2). Areoles are small well-defined areas, usually circular or oval in shape, from which the glochids and/or spines emerge. Yucca basal caudex and leaf fragments were also abundant (Table 17.8 a–d). Level 11 from grid 7542N/9463E had the greatest diversity of other carbonized plant material including cheno-am, spurge, dropseed grass, and grass family seeds. Grass family seeds were recovered from two other samples and cheno-am from one additional sample, while monocot stems were found in a single sample. The wood assemblage from Feature 11, unlike Feature 3, was predominately mesquite (77 percent by weight). Only 23 percent of the flotation wood was saltbush; one sample yielded one fragment of cholla wood and 19 of saltbush (Table 17.9). The macrobotanical wood taxa mirror those of flotation in that mesquite comprises the majority of the assemblage. However, cholla wood was present in a number of macrobotanical samples, particularly in the Level 11 sample from grid 7542N/9463E, where 76 fragments from a large piece of cholla were identified, weighing slightly over 10 grams (Table 17.10). Yucca basal caudex and/or stem and leaf fragments were present in all of the macrobotanical samples except one.

LA 111435

Three distinct occupations are represented at

Figure 17.1. LA 111429, Feature 11, cactus areoles.

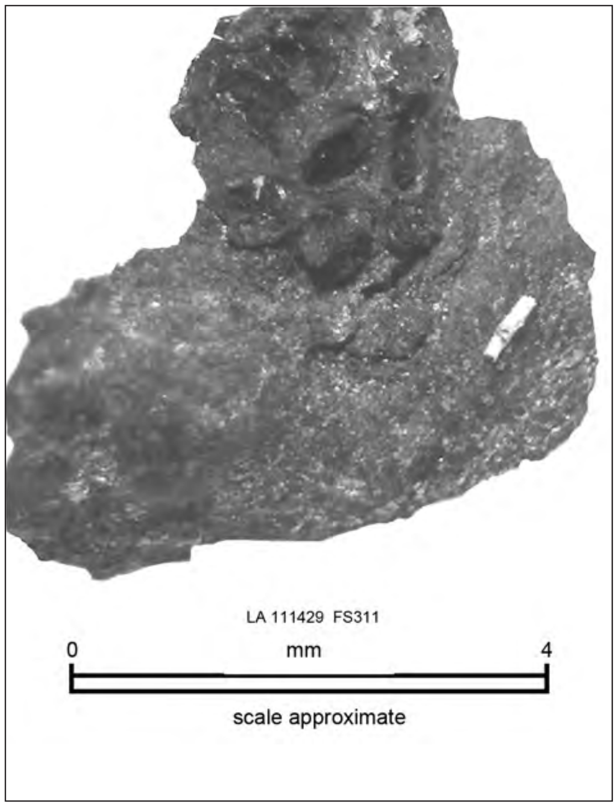

Figure 17.2. LA 111429, Feature 11, prickly pear embryo, possible fruit fragment, and epidermis with persistent aureoles.

Table 17.5. LA 111429, Feature 3 (large roasting pit), Grid Unit 3725N/9362E, Stratum 9, flotation sample plant remains.

FS No.	Taxon	300	304	301	305	302	306
Level		Level 2		Level 3		Level 4	
Cultural							
Other	Unknown taxon	–	–	–	0.9 pp	–	–
Perennials	Yucca	+ ca		+ ca	+ ca	+ ca	–
Noncultural							
Annuals	Spurge	0.7	0.9	–	–	–	–
Grasses	Grass family	0.3	–	0.3	–	–	–
Other	Vervain	–	–	–	–	–	0.9
Perennials	Flame flower	–	–	–	–	–	0.9
	Hedgehog cactus	–	–	0.5	–	–	–

Plant parts are seeds unless indicated otherwise.
Cultural plant material is charred, noncultural material is uncharred.
Reproductive plant parts are reported as a standardized count of seeds per liter of soil, rather than an actual number of seeds recovered
+ = 1–10/sample, ca = caudex, pp = plant part

Table 17.6. LA 111429, Feature 3 (large roasting pit), Grid Unit 3725N/9362E, Stratum 9, flotation sample wood taxa by count and weight in grams.

FS No.	300	304	301	305	302	306
Level	Level 2		Level 3		Level 4	
Nonconifer						
Saltbush	20/.80	20/.90	20/1.0	20/2.0	20/.60	20/1.8

Table 17.7. LA 111429, Feature 3 (large roasting pit), Stratum 9, wood sample taxa by count and weight in grams.

Grid	East Side			West Side		
Level	Level 1	Level 2	Level 3	Level 2	Level 3	Level 4
FS	299	300	301	304	305	306
Wood	116/5.5	151/20.48	84/20.64	191/15.56	94/20.79	78/20.27

Table 17.8a. LA 111429, Feature 11 (large rock-filled roasting pit), Grid Unit 7542N/9462E, Stratum 4, flotation sample plant remains.

FS No.	Taxon	273	312	315	318	323	322
Level		Level 2	Level 3	Level 4	Level 5	Level 6	Level 7
Cultural							
Annuals	Cheno-am	–	0.3	–	–	–	–
Other	Unknown taxon	2.6 pp	0.3	–	1.0 pp	0.5 pp	0.5 pp
Perennials	Cactus family	–	1.0 ar	1.7 ar	0.3 ar	0.9 ar	–
	Prickly pear	–	0.3 e	–	–	–	–
	Yucca	+ ca	+ ca, + cf l	+ ca, + cf l	+ ca	+ ca, + cf l	+ ca, + cf l
Noncultural							
Annuals	Amaranth	–	–	–	0.3	–	0.5
	Caltrop	1.3	0.7	0.6	2.4	4.2	2.1
	Goosefoot	–	–	–	0.3	–	–
	Spectacle pod	–	–	1.1	0.7	–	–
	Spurge	2.6	2.1	14.6	16.6	15.0	17.8
Grasses	Dropseed grass	–	0.3	0.6	0.3	–	–
	Grass family	6.5	2.1	6.2	3.5	2.3	–
Other	Aster family	1.3	–	–	0.3	–	0.5
	Bean family	–	–	–	0.3	–	–
	Crownbeard	–	–	–		–	1.0
	Hiddenflower	1.3	0.3	–	1.0	0.5	–
	Nightshade	7.8	14.2	20.2	14.9	7.9	16.2
	Unidentifiable seed	–	0.3	–	0.3	–	–
	Unknown taxon	–	–	–	–	–	0.5 fruit
	Wild buckwheat	151.9	0.3	9.0	1.7	–	0.5
Perennials	Cholla	–	–	–	0.3	–	–
	Flame flower	1.3	0.3	1.1	1.7	0.5	0.5
	Globemallow	–	–	–	–	–	0.5
	Mesquite	+ l	+ l	+ l	0.7 end, + l	2.3 end, 0.9	2.1 end, 6.8
	Prickly pear	–	–	0.6	0.7	–	0.5
	Sumac	–	–	0.6	–	0.5	–
	Twinleaf senna	1.3	0.3	1.1	0.3	–	–

Plant parts are seeds unless indicated otherwise.
Cultural plant material is charred, noncultural material is uncharred.
Reproductive plant parts are reported as a standardized count of seeds per liter of soil, rather than an actual number of seeds recovered.
+ = 1–10/sample, * = charred, ar = areole, ca = caudex, cf. = resembles taxon, e = embryo, end = endocarp, l = leaf, pp = plant part, s = stem

Table 17.8b. LA 111429, Feature 11 (large rock-filled roasting pit), Grid Unit 7542N/9463E, Strata 1 and 4, flotation sample plant remains.

FS No.	Taxon	136	138	269	272	276	310
Stratum/ Level		Strat. 1, Level 1	Strat. 4, Level 2	Level 4	Level 5	Level 6	Level 7
Cultural							
Grasses	Grass family	–	0.5	–	–	–	–
Other	Monocot	–	+ s	–	–	–	–
	Unknown taxon	–	1.5 pp	1.1 pp	3.9 pp	0.7 pp	–
Perennials	Cactus family	–	–	0.6 ar	6.5 ar	2.2 ar	0.8 ar
	cf Prickly pear	–	0.5 e	–	–	–	–
	Yucca	+ ca	+ ca, + cf l	+ ca, + cf l	+ ca, + cf l	+ ca, + cf l	+ ca, + cf l
Possibly Cultural							
Annuals	Caltrop	–	–	–	–	0.7 *	–
Noncultural							
Annuals	Caltrop	1.4	–	–	0.6	0.7	–
	Purslane	–	–	0.6	–	–	–
	Spectacle pod	–	–	1.7	–	–	–
	Spurge	8.2	2.0	1.1	3.2	1.5	0.8
Grasses	Dropseed grass	1.4	–	–	–	–	–
	Grass family	1.4	2.5	7.3	5.8	11.9	–
Other	Aster family	0.7	–	0.6	–	–	–
	Bean family	–	–	–	–	0.7	–
	Hiddenflower	4.1	–	3.9	7.7	3.0	1.6
	Nightshade	6.8	0.5	1.7	1.9	1.5	–
	Unidentifiable seed	–	–	1.1	–	–	–
	Wild buckwheat	140.8	–	26.8	19.4	5.2	120.5
Perennials	Creosotebush	–	–	–	–	–	–
	Flame flower	–	–	–	–	0.7	4.1
	Mesquite	1.4 end, + l	+ l	+ l	+ l, 0.6	+ l	+ l
	Twinleaf senna	1.4	0.5	–	–	–	–

Plant parts are seeds unless indicated otherwise.
Cultural plant material is charred, noncultural material is uncharred.
Reproductive plant parts are reported as a standardized count of seeds per liter of soil, rather than an actual number of seeds recovered.
+ = 1–10/sample, * = charred, ar = areole, ca = caudex, cf. = resembles taxon, e = embryo, end = endocarp, l = leaf, pp = plant part, s = stem

Table 17.8c. LA 111429, Feature 11 (large rock-filled roasting pit), Grid Unit 7542N/9463E and 7542N/9464E, Stratum 4, flotation sample plant remains.

Grid		7542N/9463E			7542N/9464E		
FS No.	Taxon	311	319	321	24	274	275
Level		Level 8	Level 10	Level 11	Level 1	Level 3	Level 4
Cultural							
Annuals	Cheno-Am	–	–	0.6	–	–	–
	Spurge	–	–	0.6	–	–	–
Grasses	Dropseed grass	–	–	0.6	–	–	–
	Grass family	–	–	1.2	–	–	–
Other	Unknown taxon	–	–	2.9	–	2.1	0.4 fruit, 2.6 pp
Perennials	Cactus family	0.8 epidermis W/ ar	0.7 ar	5.3 ar	–	–	–
	Yucca	+ ca, + cf l	+ ca, + cf l	+ ca, + l	+ ca	+ ca, + s	+ ca, + cf l
Noncultural							
Annuals	Amaranth	–	–	–	–	1.1	0.4
	Caltrop	–	5.4	1.2	2.5	3.6	4.5
	Spectacle pod	0.8	–	–	–	0.7	–
	Spurge	3.3	23.6	12.9	13.4	3.2	3.0
Grasses	Grass family	16.5	2	0.6	2.5	8.9	0.8
Other	Aster family	–	2	0.6	0.8	1.4	0.4
	Bean family	–	0.7	–	–	–	–
	Groundcherry	–	–	–	0.8	–	–
	Hiddenflower	1.7	0.7	–	13.4	1.4	4.9
	Nightshade	8.3	52	1.8	12.6	5.7	6.0
	Unidentifiable seed	–	0.7	–	–	–	0.4
	Unknown taxon	–	–	–	–	0.7 fruit	–
	Vervain	–	0.7	–	–	–	0.4
	Wild buckwheat	83.5	7.4	–	280.7	67.1	12.8
Perennials	Cholla	–	–	–	–	–	0.4
	Creosotebush	–	–	–	+ l	–	–
	Flame flower	0.8	0.7	0.6	0.8	3.6	0.4
	Hedgehog cactus					.	.
	Mesquite	0.8 end, + l	1.4 end, + l, 3.4	2.4 end	+ l	1.8 end, + l	+ l, 0.4
	Prickly pear	–	–	0.6	–	0.4	0.8
	Sumac	–	0.7	–	–	0.7	0.8
	Twinleaf senna	–	–	–	1.7	–	0.4

Plant parts are seeds unless indicated otherwise.
Cultural plant material is charred, noncultural material is uncharred.
Reproductive plant parts are reported as a standardized count of seeds per liter of soil, rather than an actual number of seeds recovered.
+ = 1–10/sample, * = charred, ar = areole, ca = caudex, cf. = resembles taxon, e = embryo, end = endocarp, l = leaf, pp = plant part, s = stem

Table 17.8d. LA 111429, Feature 11 (large rock-filled roasting pit), Grid Unit 7542N/9464E, Stratum 4, flotation sample plant remains.

FS No.	Taxon	277	278	279	297
Level		Level 5	Level 6	Level 7	
Cultural					
Grasses	Grass family	–	–	0.4	–
Perennials	Cactus family	–	–	–	0.4 ar
	poss. Prickly pear	–	–	–	0.4 fruit frag.
	Yucca	+ ca	+ ca	+ ca, + l	+ ca, + l
Noncultural					
Annuals	Caltrop	0.5	1.6	3.4	0.9
	Spectacle pod	0.5	–	–	–
	Spurge	–	10.7	11.3	4.4
Grasses	Grass family	–	2.5	1.7	4.0
Other	Aster family	–	–	0.4	2.6
	Bean family	0.5	–	–	–
	Hidden flower	11.2	279.4	173.5	12.3
	Nightshade	2.9	10.7	10.5	3.5
	Unidentifiable seed	–	–	0.4	–
	Wild buckwheat	120.5	146.5	311.3	17.6
Perennials	Cholla	–	–	1.7	–
	Flame flower	2.0	3.7	–	–
	Mesquite	0.5 end, + l, 0.5	5.8 end, + l, 0.4	8.4 end	0.4 end, + l
	Prickly pear	1.0	1.2	2.1	–
	Sumac	–	1.2	2.5	–
	Twinleaf senna	0.5	–	–	–

Plant parts are seeds unless indicated otherwise.

Cultural plant material is charred, noncultural material is uncharred.

Reproductive plant parts are reported as a standardized count of seeds per liter of soil, rather than an actual number of seeds recovered.

+ = 1–10/sample, * = charred, ar = areole, ca = caudex, e = embryo,
end = endocarp, l = leaf, pp = plant part, s = stem

Table 17.9. LA 111429, Feature 11 (large rock-filled roasting pit), Grid Unit 7542N/9462–9463E, Stratum 4, flotation sample wood taxa by count and weight in grams.

Grid	7542N/9462E					
Stratum	4					
Level	2	3	4	5	6	7
FS No.	273	312	315	318	323	322
Cholla	–	–	–	–	–	–
Mesquite	19/.72	10/.45	8/2.57	15/.87	14/.73	3/.22
Saltbush	1/.01	10/.22	12/.38	5/.09	6/.14	17/1.20
Total	20/.73	20/.67	20/2.95	20/.96	20/.87	20/1.42

Grid	7542N/9463E												
Stratum	1	4											
Level	1	2	4	5		6		7	8	10	11	–	–
FS No.	136	138	269	272	277	276	278	310	311	319	321	279	297
Cholla	–	–	–	–	–	–	–	–	–	–	1/.02	–	–
Mesquite	12/.13	19/.71	15/.55	15/.78	18/2.6	18/2.50	11/.80	15/1.21	16/1.35	3/.24	–	12/.50	17/1.1
Saltbush	3/.01	1/.01	5/.11	5/.15	2/.04	2/.20	9/.80	5/.20	4/.06	17/1.31	19/1.62	8/.50	3/.10
Total	15/.14	20/.72	20/.66	20/.93	20/2.64	20/2.70	20/1.60	20/1.41	20/1.41	20/1.55	20/1.64	20/1.0	20/1.20

Grid	7542N/9464E		
Stratum			
Level	1	3	4
FS No.	24	274	275
Cholla	–	–	–
Mesquite	20/.88	15/3.56	19/1.61
Saltbush	–	5/.07	1/.01
Total	20/.88	20/3.63	20/1.62

Grid	**Table Total**	
Stratum	Weight	%
Level		
FS No.		
Cholla	0.02	<1%
Mesquite	24.08	77%
Saltbush	7.23	23%
Total	31.33	100%

Table 17.10. LA 111429, Feature 11 (large rock-filled roasting pit), Stratum 4, wood sample taxa by count and weight in grams.

Category	Grid	7542N/9462E						7542N/9463E							7542N/9463E				7542N/9464E					**Table Total**	
	Level	2	3	4	5	6	7	1	3	4		5	6	7	9	10	11		1	3	4	6	7	Weight	%
	FS	298	312	315	318	323	322	136	138	269	310	272	276	297	311	319	320	321	24	274	275	278	279		
Wood	Cholla	–	1/.04	–	–	–	1/.34	–	1/.07	–	–	–	–	–	–	7/ .55	73/ 9.96	3/ .13	–	–	–	–	–	11.09	3%
	Mesquite	6/ 2.04	3/ .77	25/ 9.6	34/ 5.83	24/ 14.69	14/ 4.58	29/ 2.49	26/ 3.15	40/ 5.39	41/ 11.29	37/ 5.64	25/ 4.5	46/ 38.09	41/ 19.69	21/ 3.56	–	8/ 4.05	56/ 11.05	52/ 28.6	34/ 26.27	3/ .44	2/ .16	201.88	64%
	Saltbush	2/ .04	11/ 1.4	83/ 8.95	20/ 2.28	42/ 11.04	31/ 6.35	2/ .12	3/ .18	3/ .35	9/ 1.27	10/ .72	6/ .90	–	6/ .72	44/ 7.4	2/ .83	57/ 12.8	2/ .11	2/ .07	1/ .28	–	–	55.81	18%
Other	Cholla bark	–	–	–	–	–	–	–	–	–	–	–	–	–	–	12/ .24	–	–	–	–	–	–	–	0.24	<1%
	Yucca caudex	5/ .22	9/ .47	12/ 2.0	3/ .18	21/ 2.83	15/ 1.51	13/ .47	10/ .33	6/ .37	2/ .12	15/ .70	–	10/ 1.88	–	22/ 1.65	–	19/ 2.83	1/ .01	8/ 3.07	3/ 5.98	17/ 1.94	5/ .51	27.07	9%
	Yucca leaf	–	–	–	–	–	–	–	–	–	–	6/ .40	–	–	7/ .87	2/ .11	–	–	–	–	–	5/ .64	–	2.02	1%
	Yucca stem	–	11/ 3.86	5/ .33	–	1/ .06	–	–	–	1/ .07	–	–	–	–	3/ .97	5/ .53	–	7/ 8.0	–	–	–	–	–	13.82	4%
	Unknown plant part	–	–	–	1/ .32	–	1/.31	–	–	–	–	–	–	–	–	–	15/ 1.1	–	–	–	–	–	–	1.73	1%
	Unknown twig	–	–	–	–	–	1/.08	–	–	–	–	–	–	–	–	2/ .21	–	–	–	–	–	–	–	0.29	<1%
Total		13/ 2.3	35/ 6.54	125/ 20.88	58/ 8.61	88/ 28.62	63/ 13.1	44/ 3.08	40/ 3.73	50/ 6.18	52/ 12.68	68/ 7.46	31/ 5.4	56/ 39.97	57/ 22.25	115/ 14.25	90/ 11.89	94/ 27.81	59/ 11.17	62/ 31.74	38/ 32.53	25/ 3.02	7/ .67	313.95	100%

LA 111435—Middle Archaic, Late Archaic, and Mesilla phase—but the Late Archaic feature was not sampled for flotation, so that component is not discussed in this chapter. Surprisingly, Feature 10, a fire-cracked rock scatter with a stain that dates to the Middle Archaic use of the site, produced the most diverse array of taxa. Charred goosefoot, dropseed grass, aster family, and bean family seeds were identified along with a prickly pear cactus embryo. Feature 3 was a small, Middle Archaic rock-lined fire pit located on the edge of a mesquite-stabilized coppice dune. Fire-cracked rock surrounds the feature, giving it the appearance of a ring midden, but the rocks probably represent repeated cleaning and reuse, rather than the remains of activities associated with a true ring midden (Chapter 8, this report). The two samples collected from Levels 1 and 2 produced burned yucca basal caudex and modern seeds of annuals, the aster family, twinleaf senna, and wild buckwheat, as well as mesquite leaves (Table 17.11).

Feature 6 was a large Mesilla-phase roasting pit with only a few small fire-cracked rock spalls (Chapter 8, this report). Yucca basal caudex, leaf fragments, and fiber were identified, along with a plant part that resembles a spine. Carbonized grass stems, false purslane, hedgehog cactus seeds, and yucca basal caudex and leaf fragments were recovered from the possible shallow structure (Feature 8).

Radiocarbon dates were not obtained for Features 4 and 5. Only uncharred seeds and mesquite duff were recovered from the highly rodent-disturbed Feature 4 fire pit. Feature 5, another probable thermal pit surrounded with discarded fire-cracked rock, contained yucca basal caudex both in the fill and surface strip around the feature; unburned taxa from both samples was similar as well, consisting of spurge, dropseed grass, and wild buckwheat seeds and mesquite leaves. Unburned bean and goosefoot family seeds were restricted to the surface strip sample.

Flotation wood taxa from the site consisted entirely of saltbush with the exception of one fragment of mesquite from the large Mesilla-phase roasting pit (Feature 6; Table 17.12), which is probably the earliest project feature to have mesquite. Like flotation wood, macrobotanical wood was predominately saltbush; one fragment of wood that resembled tarbush was recovered from the small Middle Archaic fire pit (Feature 3; Table 17.13). Yucca basal caudex was identified in the roasting pit and the possible shallow structure (Feature 8). In addition, leaf and stem fragments were recovered from the possible structure. The sample of wood taken from charcoal-stained soil in the rodent burrow (Feature 7) was entirely saltbush.

LA 155963

Features from LA 155963 date to the Late Archaic-Mesilla–phase transition, the Mesilla phase, and the Protohistoric and Historic periods. Only one of the samples from the Late Archaic-Mesilla–phase feature (Feature 15) produced carbonized floral material, consisting of yucca basal caudex (Table 17.14). The samples were collected from one of the more clearly defined stains in the central portion of a fire-cracked rock scatter. The stain was not excavated except to collect flotation and macrobotanical samples from the fill. Twelve pieces of saltbush wood were recovered from the same flotation sample that produced the yucca basal caudex (Table 17.15).

Three features dating to the Mesilla-phase use of the site were examined for floral remains; these were all thermal features with fire-cracked rock. Only unburned purslane, spurge, and wild buckwheat seeds, creosotebush fruit, and mesquite leaves were recovered from Feature 14, a rock-filled roasting pit (Table 17.16). Yucca basal caudex was identified in one of the samples from Feature 125. Feature 141 was the most productive where burned amaranth, cheno-am, hedgehog cactus, purslane, and mesquite seeds were found, along with grass stems. One feature dates to either the Doña Ana or El Paso phase of the Formative (Feature 8) and produced carbonized goosefoot seeds and yucca basal caudex. Wood was present in two of the Mesilla-phase features and consisted of mesquite, saltbush, and unknown non-conifer (Table 17.15). One fragment of saltbush was collected from Feature 14 and macrobotanical wood samples from Features 125 and 141 are similar to wood recovered from flotation (Table 17.17). Four more mesquite seeds (Fig. 17.3) were recovered in the macrobotanical sample from Feature 141 and most fortuitous of all, a sumac seed (Figs. 17.4, 17.5).

Protohistoric and Historic features consisted of a stain and two thermal features with rocks. Evidence for plant exploitation was meager; charred goosefoot seeds from Early Historic–period Feature 9 were the only cultural plant materials recovered (Table 17.18). The balance of the Protohistoric and

Table 17.11. LA 111435, flotation sample plant remains.

Category	Feature	3 Small TF w/ FCR		4 Pit w/ FCR		5 Surface Strip	5 Small TF w/ FCR	6 Large Roasting Pit		8 Possible Shallow Structure		10 FCR w/ Stain	
	FS No/ Level	1 L 1	22 L 2	48 L 1	41 L 2	44	53	38	40	98	102	29 L 1	30 L 2
Cultural													
Annuals	False purslane	–	–	–	–	–	–	–	–	0.7	–	–	–
	Goosefoot	–	–	–	–	–	–	–	–	–	–	–	0.1
Grasses	Dropseed grass	–	–	–	–	–	–	–	–	–	–	–	2.3
	cf. Grass family	–	–	–	–	–	–	–	–	+ stem	–	–	–
Other	Aster family	–	–	–	–	–	–	–	–	–	–	–	0.6
	Bean family	–	–	–	–	–	–	–	–	–	–	–	0.3
	Unidenti-fiable seed	–	–	–	–	–	–	–	–	–	–	–	0.6
	unknown taxon	–	–	–	–	–	–	–	0.6 cf. sp	–	–	–	0.3 pp
Perennials	Hedgehog cactus	–	–	–	–	–	–	–	–	0.7	–	–	–
	Prickly pear	–	–	–	–	–	–	–	–	–	–	–	0.1 e
	Yucca	+ ca	+ ca	–	–	+ ca	+ ca	+ ca, + fiber	+++ ca, + l	++ ca	+ ca, + cf. l	–	–
Noncultural													
Annuals	Amaranth	–	–	–	–	–	–	–	–	0.7	0.4	–	–
	Caltrop	4.0	3.9	–	–	–	–	–	–	–	–	0.5	0.3
	False purslane	–	–	–	–	–	–	–	–	0.7	0.4	–	–
	Goosefoot	–	–	–	–	–	–	–	–	–	–	–	0.2
	Purslane	–	–	–	–	–	–	–	–	–	–	–	0.2
	Scorpion-weed	–	–	–	–	–	–	–	–	–	–	–	0.1
	Spectacle pot	–	–	–	–	–	–	0.6	–	–	–	–	–
	Spurge	–	–	1.3	0.4	11.9	5.0	0.6	–	2.0	0.7	6.6	3.7
	Tansy mustard	–	–	–	–	–	–	–	–	–	0.4	–	–
	Tumble-weed	–	–	–	–	–	–	–	–	–	+ bract	–	–
Grasses	Dropseed grass	–	–	–	–	1.0	0.6	0.6	–	2.0	0.7	6.6	3.7
	Grass family	–	–	–	–	–	–	–	–	–	0.4	–	–
Other	Aster family	0.7	7.8	3.0	–	–	–	–	–	–	–	5.2	–
	Bean family	–	1.3	–	–	1.0	–	–	–	0.7	–	–	–
	Goosefoot family	–	–	–	–	2.0	–	–	–	–	–	–	–
	Unidenti-fiable seed	–	–	–	–	–	–	0.6	–	–	0.4	–	–
	Wild buckwheat	0.7	–	1.3	9.7	1.0	1.3	0.6	–	–	3.5	0.5	0.4
Perennials	Globe-mallow	–	–	–	–	–	–	–	–	0.7	0.4	–	–
	Hedgehog cactus	–	–	–	–	–	–	–	–	1.4	–	–	–

(Table 17.11, continued)

Category	Feature	3 Small TF w/ FCR		4 Pit w/ FCR		5 Surface Strip	5 Small TF w/ FCR	6 Large Roasting Pit		8 Possible Shallow Structure		10 FCR w/ Stain	
	FS No/ Level	1 L 1	22 L 2	48 L 1	41 L 2	44	53	38	40	98	102	29 L 1	30 L 2
	Mesquite	+ l	+ l	+ l, + cf. sp	+ l	+ l	+ l	+ l	–	–	+ l	+ l	+ l
	Twinleaf senna	0.7	1.3	–	0.4	–	–	–	–	–	–	–	–
	Yucca	–	–	–	–	–	–	–	–	–	+ ca	–	–

Plant parts are seeds unless indicater otherwise. Cultural plant material is charred, noncultural material is uncharred. Reproductive plant parts are reported as a standardized count of seeds per liter of soil, rather than an actual number of seeds recovered.
+ = 1–10/sample, ++ = 11–25/sample, +++ = 25–100/sample, ca = caudex, cf. = resembles taxon, l = leaf, pp = plant part, sp = spine, TF = thermal feature, FCR = fire-cracked rock

Table 17.12. LA 111435, flotation sample wood taxa, by count and weight in grams.

Feature	3 Rock-filled Firepit	6 Large Roasting Pit		8 Possible Shallow Structure		10 FCR Scatter w/ Stain
FS No.	22	38	40	98	102	30
Nonconifers						
Mesquite	–	–	1/.10	–	–	–
Saltbush	4/.01	20/.19	19/.32	20/.29	20/.31	1/.01

FCR = fire-cracked rock

Table 17.13. LA 111435, wood sample taxa by count and weight in grams.

Feature	3 Rock-filled Fire Pit	6 Large Roasting Pit		7 Rodent Burrow	8 Possible Shallow Structure			10 FCR Scatter w/ Stain
	W Edge	Upper Fill, L. 2, Strat. 5	Lower Fill, L. 2, Strat. 5	L. 1, Strat. 1	Upper Fill, L. 1, Strat. 1	Lower Fill, L. 1, Strat. 1	SW 1/4, L. 2, Strat. 9	W 1/2, L. 2, Strat. 3
FS	23	38	39	50	49	56	102	30
Wood: Saltbush	1/.01	47/5.47	76/16.54	13/.34	8/.63	6/.12	47/3.11	5/.35
cf. Tarbush	1/.22	–	–	–	–	–	–	–
Other: Yucca caudex	–	2/.10	14/1.24	–	4/.32	7/.09	7/.16	–
leaf	–	–	–	–	–	1/.01	2/.03	–
stem	–	–	–	–	–	–	2/.06	–
Total	2/.23	49/5.57	90/17.78	13/.34	12/.95	14/.22	58/3.36	5/.35

FCR = fire-cracked rock
cf. = resembles taxon

Table 17.14. LA 155963, Feature 15, Late Archaic-Mesilla phase, flotation plant remains.

Feature		15 Stain or Small Fire Pit		
FS No.		584	585	586
Cultural				
Perennials	Yucca	–	–	+ caudex
Noncultural				
Annuals	Bugseed	0.3	0.5	–
	Goosefoot	0.6	–	–
	Purslane	0.6	–	0.3
	Spurge	–	0.5	1.5
Other	Nightshade	–	0.5	0.3
	Wild buckwheat	0.6	–	1.5
Perennials	Creosotebush	0.3 fruit	–	0.3 fruit
	Globemallow	–	–	0.6
	Mesquite	–	+ leaf	–

Plant parts are seeds unless indicated otherwise.
Cultural plant material is charred, noncultural material is uncharred.
Reproductive plant parts are reported as a standardized count of seeds per liter of soil, rather than the actual number of seeds recovered.
+ = 1–10/sample

Table 17.15. LA 155963, flotation sample wood taxa by count and weight in grams.

Time Period	Late Archaic	Mesilla Phase				Protohistoric			
Feature	15 Stain or Small Fire Pit	125 Small Fire Pit w/ FCR		141 Fire Pit w/ FCR		1 Large Fire Pit w/Rock			9 Stain
FS No.	586	19	25	618	619	405	406	407	511
Mesquite	–	4/.10	13/.30	3/.10	8/.10	15/.90	–	3/.10	31/.80
Saltbush	12/.10	–	19/.20	17/.20	2/.01	5/.20	20/1.1	17/.50	9/.20
Unknown nonconifer	–	–	–	–	3/.01	–	–	–	–

FCR = fire-cracked rock

Table 17.16. LA 155963, Formative-period flotation plant remains.

Time Period		Mesilla							Doña Ana/ El Paso
Feature		14 Rock-filled Roasting Pit			125 Small Fire Pit w/ FCR		141 Fire Pit w/ FCR		8 Small Fire Pit w/ FCR
FS No.		579	581	582	19	25	618	619	485
Cultural									
Annuals	Amaranth	–	–	–	–	–	0.4	–	–
	Cheno-Am	–	–	–	–	–	0.4	–	–
	Goosefoot	–	–	–	–	–	–	–	1.0
	Purslane	–	–	–	–	–	–	0.2	–
Grasses	Grass family	–	–	–	–	–	+ stem	–	–
Other	Unidentifiable seed	–	–	–	–	–	0.4	–	–
	Unknown taxon	–	–	–	–	–	0.7 pp	–	–
Perennials	Yucca	–	–	–	+ ca	–	–	–	–
	Hedgehog cactus	–	–	–	–	–	0.8	0.2	–
	Mesquite	–	–	–	–	–	4.0	2.6	–
	Yucca	–	–	–	–	–	–	–	+ ca
Noncultural									
Annuals	Caltrop	–	–	–	0.7	–	–	–	–
	Purslane	1.2	–	0.7	2.0	3.7	0.4	0.6	–
	Spurge	0.6	0.4	–	4.7	2.2	–	0.3	–
	Tansy mustard	–	1.5	–	1.3	2.9	–	–	–
	Bugseed	–	–	–	–	–	–	–	0.2
	Goosefoot	–	–	–	–	–	2.9	1.5	–
	Spectacle pod	–	–	–	–	–	–	0.3	–
Grasses	Dropseed grass	–	0.4	–	0.7	–	–	2.4	1.1
Other	Bean family	–		–	0.7	5.9	–	0.9	0.6
	Wild buckwheat	1.2	153.2	28.0	–	–	–	–	–
	Aster family	–	–	–	–	–	–	–	0.4
	Nightshade	–	–	–	–	–	–	–	0.2
Perennials	Creosotebush	3.7 fruit	17.7 fruit, + l	+ l	–	–	–	–	–
	Globemallow	–	0.8	–	–	–	–	–	0.2
	Flame flower	–	–	–	–	–	–	3.0	–
	Mesquite	+ l	–	+ l	+ l	–	–	–	–

Plant parts are seeds unless indicated otherwise.
Cultural plant material is charred, noncultural material is uncharred.
Reproductive plant parts are reported as a standardized count of seeds per liter of soil, rather than an actual number of seeds recovered.
+ = 1–10/sample, ca = caudex, FCR = fire-cracked rock, l = leaf, pp = plant part

Table 17.17. LA 155963, wood sample taxa by count and weight in grams.

Time Period	Mesilla				Protohistoric				
Feature	14 Rock-filled RP	125 Small Fire Pit w/FCR	141 Fire Pit w/ FCR		1 Large Fire Pit w/Rock		9 Stain		
Location, Level, Stratum		W 1/2	N 1/2	S 1/2	E 1/2	W 1/2	2640N/4268E, Level 1, Strat. 10	2640N/4269E, Level 1, Strat. 10	2640N/4269E, Level 1, Strat. 19
FS No.	574	25	618	619	404	406	509	510	511
Mesquite	–	–	20/1.62	19/1.1	68/7.4	8/.43	10/.51	21/1.83	24/3.26
Saltbush	1/.04	87/7.67	12/.93	10/.46	33/2.74	15/1.08	–	–	4/.06
Total	1/.04	87/7.67	32/2.55	29/1.56	101/10.14	23/1.51	10/.51	21/1.83	28/3.32

FCR = fire-cracked rock
RP = roasting pit

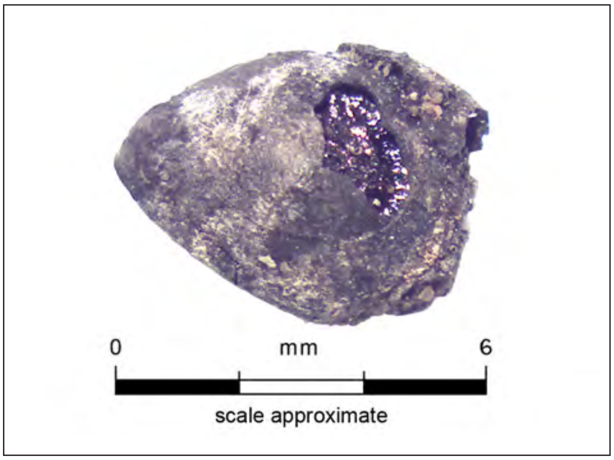

Figure 17.3. LA 155963, Feature 141, mesquite seed.

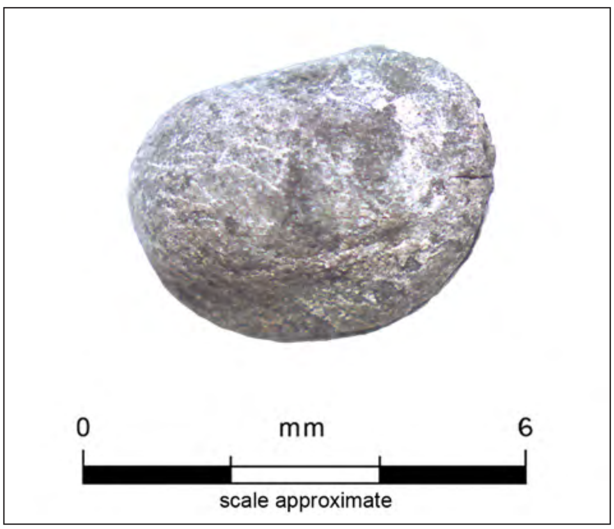

Figure 17.4. LA 155963, Feature 141, sumac seed.

Figure. 17.5. LA 155963, Feature 141, sumac seed.

Table 17.18. LA 155963, Protohistoric- and Historic-period flotation plant remains.

Time Period		Protohistoric			Historic		Modern?	No Date
Feature		1 Large Fire Pit w/Rock			9 Stain	6 Disturbed Fire Pit w/ Rocks	18 Sandstone Slab Circle	133 Stain
FS No.		405	406	407	511	621	440	17
Cultural								
Annuals	Goosefoot	–	–	–	0.3	–	–	–
Other	Monocot	–	–	–	–	+ stem	–	–
	Unidenifiable seed	–	–	–	–	–	–	26.7
	Unknown taxon	–	–	–	–	–	–	+ bark, 6.7 pp
Perennials	Flame flower	–	–	–	–	–	–	6.7
	Prickly pear	–	–	–	–	–	–	40.0 e*
	Yucca	–	–	–	–	–	–	+ca, + l
Noncultural								
Annuals	Bugseed	–	–	–	0.3	–	–	–
	Caltrop	–	–	–	–	–	3.2	–
	Goosefoot	–	–	–	2.1	–	–	–
	Purslane	2.3	–	–	–	–	4.3	–
	Spurge	3.7	–	0.7	3.3	0.3	29.8	6.7
	Tansy mustard	1.4	–	–	–	–	1.1	–
Grasses	Dropseed grass	–	–	–	0.3	–	4.3	–
	Grass family	–	–	–	–	4.6	4.3	–
Other	Aster family	0.5	–	–	–	–	645.7	13.3
	Bean family	1.4	–	–	–	–	–	–
	Hidden flower	–	–	–	–	0.6 fruit	–	–
	Nightshade	–	0.5	–	0.3	0.3	3.2	–
	Unknown taxon	–	–	–	–	–	–	+ bark
	Wild buckwheat	0.5	–	–	–	–	24.5	–
Perennials	Creosotebush	0.9 fruit	0.5 fruit	–	0.3 fruit	194.3 fruit, + l	4.3 fruit	–
	Four-wing saltbush	–	–	–	–	–	1.1 fruit	–
	Globemallow	–	–	–	0.9	0.3	–	–
	Mesquite	0.5 end, + l	+l	–	+ l	0.9 end, + l, + sp	2.1 end, + l	–
	Yucca	–	–	–	+ l, 0.6	–	–	–

Plant parts are seeds unless indicated otherwise.
Cultural plant material is charred, noncultural material is uncharred.
Reproductive plant parts are reported as a standardized count of seeds per liter of soil, rather than an actual number of seeds recovered.
+ = 1–10/sample, * immature, ca = caudex, end = endocarp, l = leaf, pp = plant part, sp = spine

Historic assemblage was noncultural, including uncharred annual, dropseed grass, aster family, bean family, nightshade, globemallow, yucca, and wild buckwheat seeds, creosotebush fruits, yucca leaf fragments, and mesquite leaves, all plants that are present in the immediate area today. Flotation wood from the Protohistoric (Feature 1) and Early Historic (Feature 9) features consists of mesquite and saltbush wood (Table 17.15); macrobotanical wood paralleled this assemblage (Table 17.17).

What was probably another small thermal feature with fire-cracked rock (Feature 6) is associated with historic use of the site area during the eighteenth or early twentieth centuries. Monocot stems were the only possible culturally affiliated plant materials recovered (Table 17.18). Between the initial inventory of the feature and when it was excavated eight months later, a rabbit probably nested in the feature, scattering rock in a circular formation; the flotation sample contained hundreds of rabbit pellets, indicating that the high level of disturbance impacted the integrity and contents of the feature.

A stain investigated as Feature 133 was charcoal-stained fill preserved in a rodent burrow; the fill was not dated (Chapter 9, this report). Burned plant material in the stain includes a considerable number of unidentifiable seeds and prickly-pear cactus embryos, most of which were immature; yucca basal caudex and leaf fragments were also present. The final feature at LA 155963 from which a flotation sample was collected was a small circle of sandstone slabs. In the center were a dead aster-family plant and a desiccated prickly pear cactus; they were not collected. Hundreds of unburned aster family achenes or seeds, displaying a profuse bristle-like pappus at the apex of each, were recovered in the flotation sample along with nine other unburned seed taxa, creosotebush, globemallow fruit, and mesquite leaves. A small "collector's pile" of chipped stone and a slab metate were found near the feature.

LA 155964

Three features were sampled for plant remains at LA 155964, but the primary focus of data recovery was Feature 1, a large, rock-filled roasting pit with an oval-shaped arrangement of very large cobbles at the base (Feature 1.1). Radiocarbon samples consisting of cf. tarbush, mesquite, a cactus pad, yucca basal caudex, and yucca stems (Fig. 17.6) are estimated to date between 1800 and 1940 (Chapter 19, this report). However, considering the contents of the feature, which included charred amaranth and bugseed seeds, yucca basal caudex in every layer (some with leaf and fiber fragments), grass stems, and lots of cactus areoles, epidermis, and stem tissue (Table 17.19 a–b), together with other attributes (Chapter 10, this report), this date seems late. Charred aster family seeds were also identified from the base of Feature 1 and microscopic pieces of seed epidermis from the same family were found in the phytolith fraction from Level 2 examined by Yost (Appendix 2, this report). Yost notes that seeds of annual sunflowers were roasted in pits before consumption (Thoms 2008) and these specimens might be evidence for processing aster family seeds in a similar fashion. A macrobotanical sample, collected from Level 5 in grid 699N/4999E, was a flat-stemmed cactus-pad fragment, complete with areoles and glochids (Figs. 17.7, 17.8; Table 17.20). Wood collected as macrobotanical samples (Table 17.21) was primarily mesquite, although six pieces of saltbush were identified in the Level 7 sample from grid 699N/4998E. Mesquite comprised 93 percent of the flotation wood assemblage by weight, saltbush 4 percent, and tarbush 3 percent. The percentage of mesquite in macrobotanical samples was even higher at 98 percent, saltbush was less than 1 percent, and cf. tarbush was

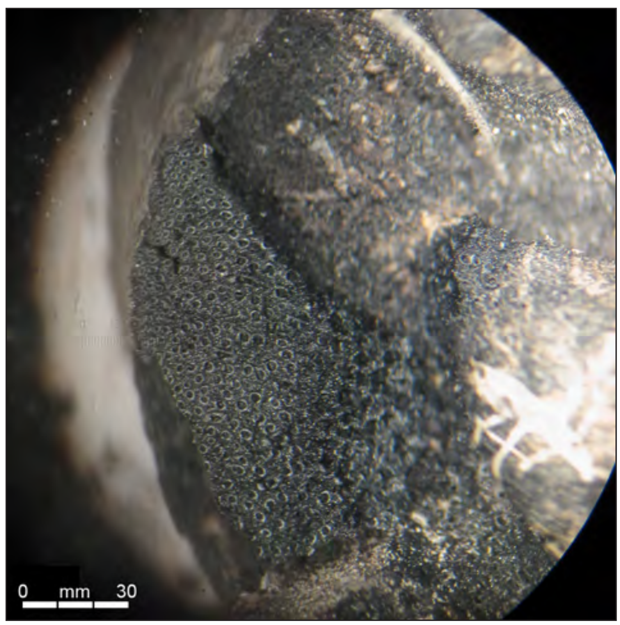

Figure 17.6. LA 155963, Feature 1, yucca basal caudex and stems.

Table 17.19a. LA 155964, Feature 1, flotation sample plant remains.

Feature		1 Large Rock-filled Roasting Pit											
Grid		699N/ 4998E	699N/ 4999E	699N/ 5000E	700N/ 5000E	699N/ 4998E	699N/ 4999E	699N/ 5000E	700N/ 5000E	699N/ 4998E	699N/ 4999E	699N/ 5000E	700N/ 5000E
Stratum/Level		Stratum 2, L 2				Stratum 2, L 3				Stratum 2, L 4			
FS No.		17	8	15	19	27	24	23	22	29	30	31	28
Cultural													
Annuals	Amaranth	1.6	–	–	–	–	–	–	–	1.1	0.5	–	–
	Bugseed	–	–	–	–	–	–	–	–	–	–	0.5	–
Grasses	cf. Grass family	–	–	–	–	–	–	–	–	–	+ s	–	–
Other	Unknown taxon	–	2.9 pp	–	–	–	0.6 pp	0.4 pp	0.4 pp	2.2 pp	0.5 pp	–	0.5 pp
Perennials	Cactus family	–	–	–	–	–	–	–	–	–	–	poss. 1.4 ar	–
	Yucca	+ ca	+ ca	+ ca	+ ca	+ ca	+ ca	+ ca	+ ca	+ ca	+ ca	+ ca	+ ca
Possibly Cultural													
Annuals	Spurge	–	–	–	–	–	–	0.9	–	–	–	–	–
Noncultural													
Annuals	Amaranth	–	–	–	–	–	0.6	–	–	–	–	–	–
	Caltrop	1.6	1.4	0.6	0.6	1.6	2.4	2.6	–	–	1.6	–	–
	Purslane	–	–	–	–	–	–	0.9	–	–	–	–	–
	Scorpionweed	–	–	–	0.6	–	–	–	–	–	–	–	–
	Spurge	1.6	–	7.3	2.5	2.4	4.2	–	0.8	2.2	51.6	2.3	2.8
Grasses	Dropseed grass	–	–	–	–	–	–	–	–	1.1	–	–	–
	Grass family	–	–	1.1	1.2	–	–	0.9	0.4	–	–	0.9	0.9
Other	Aster family	–	–	–	–	–	–	–	–	1.1	–	1.4	0.5
	Bean family	–	–	1.1	–	–	–	1.3	–	–	–	0.5	0.9
	Nightshade	–	–	–	1.2	–	–	–	–	–	–	–	–
	Wild buckwheat	–	1.4	5.1	–	–	1.2	2.6	2.4	–	–	12.0	1.8
Perennials	Flame flower	–	–	–	0.6	–	–	0.4	–	–	1.6	–	–
	Four-wing saltbush	–	–	–	0.6 fruit	–	–	–	–	–	–	–	–
	Globemallow	–	4.3	–	–	–	0.6	–	–	1.1	0.5	–	–
	Hedgehog cactus	–	–	–	–	–	0.6	–	–	–	0.5	0.5	–
	Mesquite	+ l	+ l	+ l	+ l	+ l	–	+ l	+ l	–	–	+ l	0.5 end, + l
	Twinleaf senna	–	–	–	–	1.6	–	–	–	–	–	–	–

Plant remains are seeds unless indicated otherwise.
+ = 1–10/sample, ar = areole, ca = caudex, cf. = resembles taxon, ep = epidermis, l = leaf, pp = plant part, s = stem

Table 17.19b. LA 155964, Features 1 and 2, flotation sample plant remains.

Feature		1 Large Rock-filled Roasting Pit											1.1 Oval of Cobbles at Base of Feature 1		2, Small Fire Pit
Grid		699N/ 4998E	699N/ 4999E	699N/ 5000E	700N/ 5000E	699N/ 4998E	699N/ 4999E	699N/ 5000E	700N/ 5000E	699N/ 4999E	699N/ 5000E	700N/ 5000E	699N/ 4998E	699N/ 4999E	720N/ 4967E
Stratum/Level		Stratum 2, L 5				Stratum 2, L 6		Stratum 2, L 6		Stratum 2, L 7					–
FS No.		34	32	35	36	42	40	38	37	45	44	43	46	47	25
Cultural															
Annuals	Bugseed	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	Goosefoot	–	–	–	0.4	2.8	–	–	–	–	–	–	–	–	–
Other	Aster family	–	–	–	–	–	–	–	–	–	–	–	0.7	–	–
	Monocot	–	–	–	–	–	–	–	–	–	–	cf. + s	–	+ s	+ s
	Unidentifiable	–	–	–	–	–	–	–	–	–	0.3	–	–	–	–
	Unknown taxon	–	7.3 pp	–	–	2.8 pp	1.4 pp	0.6 pp	–	0.5 pp	–	0.4 pp	–	–	–
Perennials	Cactus family	–	cf. 0.5 ar	–	–	cf. 4.2 ar	1.4 ar, + ep, + stem tissue frags.	–	cf. 0.7 ar, + cf. ep	+ ep, cf. + stem tissue frags.	0.9 ar, cf. + stem tissue frags.	–	–	–	–
	Mesquite	–	0.5 end	–	–	–	–	–	–	–	–	–	–	–	–
	Yucca	+ ca	+ ca, + l	+ ca	+ ca	+ ca, + l	+ ca, + l	+ ca	+ ca	+ ca	+ ca	+ ca, + fiber	+ ca	+ ca, + fiber	poss. 0.4 fruit frag.
Noncultural															
Annuals	Amaranth	–	–	–	–	–	0.7	0.3	–	–	–	0.4	–	–	–
	Caltrop	0.8	0.5	0.5	–	–	–	0.3	–	–	0.3	–	–	–	–
	Goosefoot	–	0.5	–	–	–	–	–	–	–	–	–	–	–	–
	Purslane	–	–	–	–	–	–	–	–	–	–	0.4	0.4	–	–
	Spurge	3.8	1.0	18.7	8.9	5.6	3.4	1.1	11.4	15.0	3.0	46.2	46.2	–	–
	Stickleaf	–	–	–	–	–	–	–	–	–	–	–	–	–	0.2
	Tansy mustard	0.8	–	–	–	–	–	–	–	–	–	–	–	–	–
Grasses	Dropseed grass	–	–	–	–	–	–	2.9	–	–	–	–	–	5.9	–
	Grass family	–	1.0	–	–	–	0.7	0.3	–	0.5	0.9	0.4	–	–	–
Other	Aster family	0.8	0.5	–	–	–	–	–	–	–	0.6	–	–	–	0.4
	Bean family	0.8	–	–	0.4	–	–	–	0.7	0.5	–	0.4	–	–	0.2
	Hiddenflower	–	–	–	–	–	–	–	–	–	–	1.3	–	–	–
	Nightshade	–	–	–	–	–	–	0.3	–	–	–	–	–	–	–
	Unknown taxon	–	–	–	–	–	–		–	0.5 pp	–	–	–	–	–
	Wild buckwheat	6.2	3.1	2.6	3.8	1.4	0.7	1.4	3.6	–	–	1.8	–	–	2.9
Perennials	Cactus family	–	0.5	–	–	–	–	–	–	–	–	–	–	–	–
	Flame flower	0.8	1.0	–	0.4	1.4	–	–	1.4	–	0.6	–	–	–	–
	Globemallow	–	–	–	0.4	–	–	–	–	–	0.3	0.4	–	0.6	–
	Hedgehog cactus	–	–	0.5	–	–	0.7	0.3	–	–	–	–	0.7	–	–
	Mesquite	+ l	+ l	–	+ l	–	–	+ l	+ l	+ l	+ l	+ l	–	+ l	+ l
	Prickly pear	–	–	–	–	–	–	–	–	–	–	–	–	–	0.2

Plant remains are seeds unless indicated otherwise.
+ = 1–10/sample, ar = areole, ca = caudex, cf. = resembles taxon, ep = epidermis, l = leaf, pp = plant part, s = stem

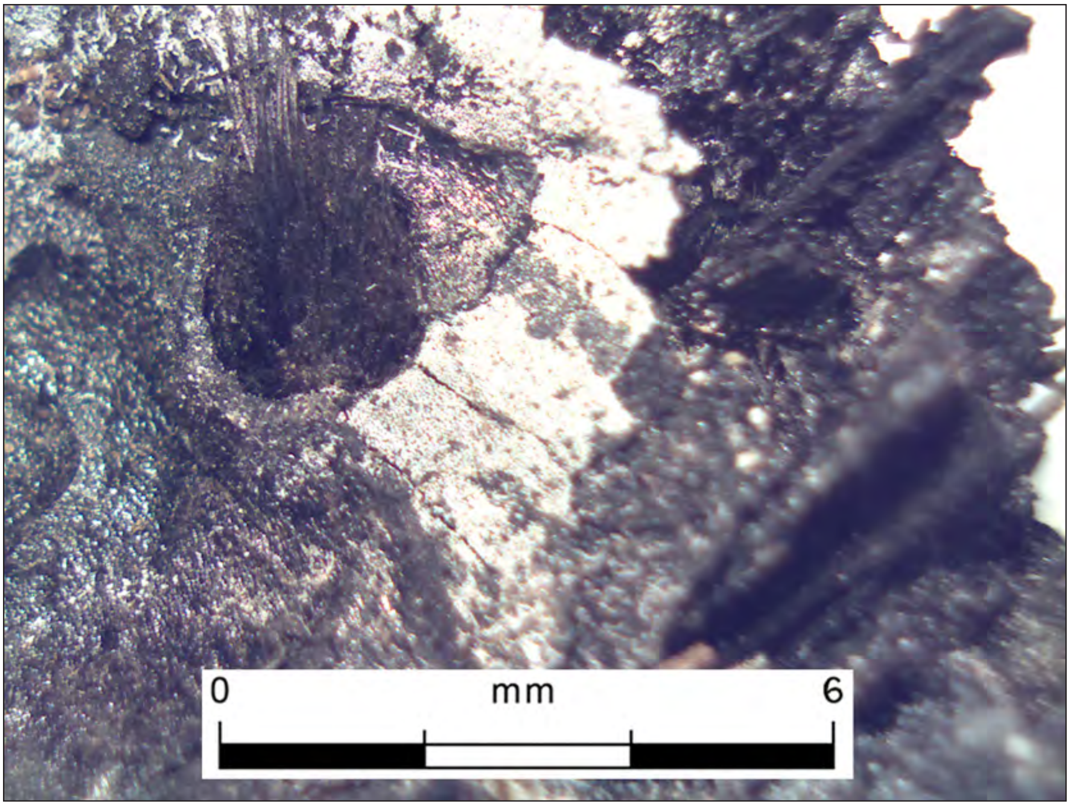

Figure 17.7. LA 155964, Feature 1, cactus pad fragment with aureoles and glochids.

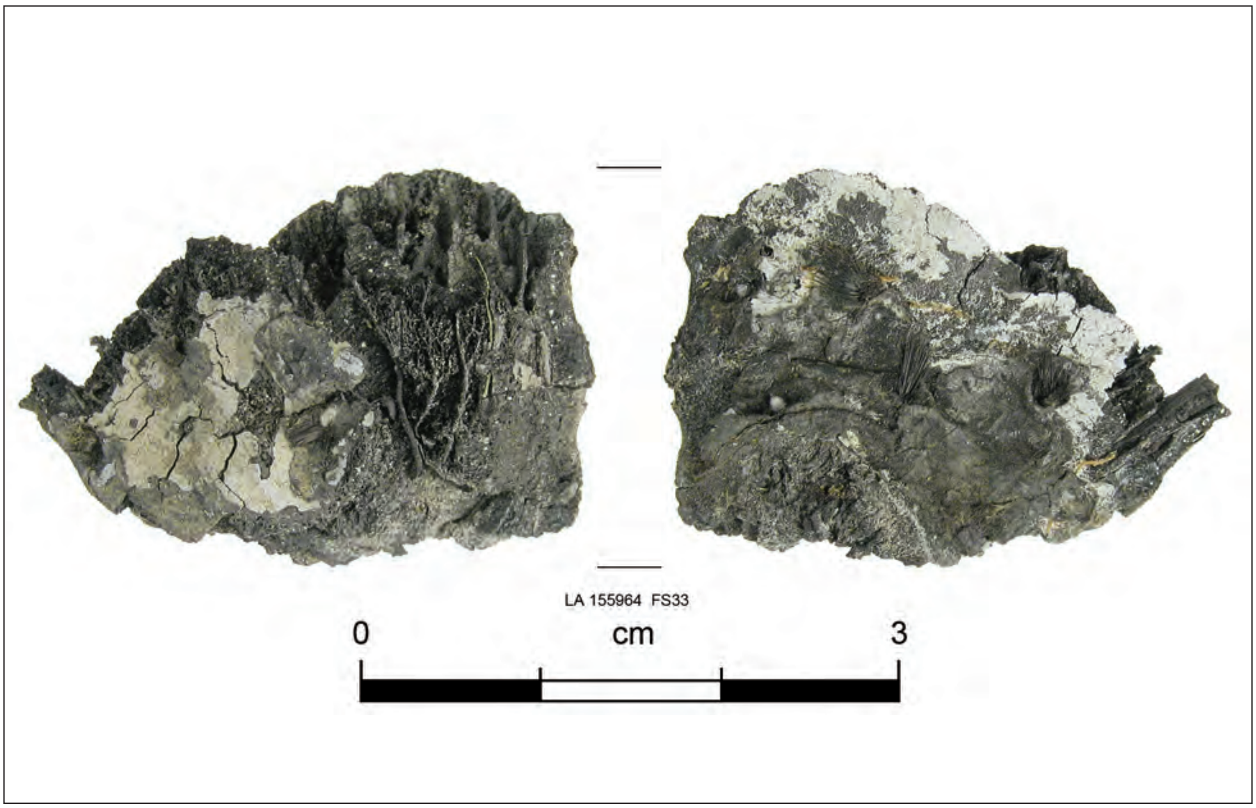

Figure 17.8. LA 155964, Feature 1, cactus pad fragment with aureoles and glochids.

Table 17.20. LA 155964, Feature 1 (large rock-filled roasting pit), macrobotanical sample taxa.

Grid	699N/4998E	699N/4999E		700N/5000E	
Level	7	5	7	6	7
FS No.	46	33	45	37	43
Wood: Mesquite	8/27.10 g	–	3/163.10 g	1/41.20 g	3/195.30 g
Saltbush	6/0.60 g	–	–	–	–
Other: Prickly pear cactus	–	1 pad frag./1.1 g	–	–	–

2 percent (Table 17.22). Yucca basal caudex and stem fragments also comprised a small part of the macrobotanical sample assemblage. Burned aster family seeds, grass stems, and yucca basal caudex and fiber were recovered from the oval of large cobbles at the base of Feature 1.

Feature 2 was a small, deflated fire pit. A flotation sample was taken from charcoal-stained fill underneath the rock concentration in the feature. This contained burned monocot stems, unknown plant parts that looked somewhat like cactus-pad tissue, and a few very small pieces of material that could be fragments of yucca fruit, but are much too small to identify with any certainty (Table 17.19 a–b). Flotation wood consisted of five pieces of mesquite and 15 of saltbush (Table 17.21).

LA 155968

The primary feature at LA 155968 was a large roasting pit with relatively few fire-cracked rocks; it dates to the Mesilla phase. Five flotation samples were collected and yucca basal caudex was identified in all five, while yucca leaf fragments were found in three (Table 17.23). A burned caltrop seed was recovered in Level 5 of the feature and could be cultural; the leaves and roots were used medicinally (Robbins et al. 1916). Flotation wood was predominantly saltbush with trace amounts of cholla (Table 17.24). Macrobotanical wood sample taxa distribution is similar with the exception of one piece of mesquite in a Level 2 sample and three of cf. tarbush in another Level 2 sample; yucca stems were found in the same sample (Table 17.25). Features 1.1 and 1.2 were depressions with darkly stained fill that may have originated in Feature 1. Both contained yucca basal caudex and Feature 1.2 also yielded yucca fiber. Other plant material recovered included burned unknown plant parts from Feature 1.1 and unburned annual, grass, yucca, twinleaf senna, mesquite, and seeds of other weedy taxa in addition to mesquite leaves.

LA 156877

A flotation sample was analyzed from a feature exposed in the road cut on the southwest edge of the site. Most of the feature was removed during road construction, obscuring its edges but it could have been a structure or large roasting pit. Carbonized plant material consisted of yucca basal caudex, one fragment of mesquite wood, and two of saltbush (Table 17.26).

Discussion

All but two of the features that yielded cultural floral remains from the Spaceport project produced yucca, so depth and size of a feature does not seem to be a determinant (Table 17.27), nor does the presence or absence of fire-cracked rock. It would appear, then, that yucca was being used as fuel or processed for food during all occupations of the project area in a variety of feature types. However, it is only in the large roasting pits (Early Mesilla-phase Feature 6, at LA 111435; Mesilla-phase Feature 1, at LA 155968; Early Historic-period Feature 1, at LA 111429, Historic-period Feature 1, at LA 155964), in the possible Mesilla-phase structure (Feature 8) at LA 111435, and in an undated stain at LA 155963 (Feature 133) where

Table 17.21. LA 155964, flotation wood taxa by count and weight in grams.

Feature	1 Large Roasting Pit w/ FCR															
Grid	699N/ 4998E	699N/ 4999E	699N/ 5000E	700N/ 5000E	699N/ 4998E	699N/ 4999E	699N/ 5000E	700N/ 5000E	699N/ 4998E	699N/ 4999E	699N/ 5000E	700N/ 5000E	699N/ 4998E	699N/ 4999E	699N/ 5000E	700N/ 5000E
Stratum/ Level	Stratum 2, L 2				Stratum 2, L 3				Stratum 2, L 4				Stratum 2, L 5			
FS No.	17	8	15	19	27	24	23	22	29	30	31	28	34	32	35	36
Mesquite	13/.29	15/.44	20/.61	14/.33	20/.38	13/.36	20/4.51	15/.47	17/.63	19/.54	20/2.29	14/.55	20/2.29	15/2.08	19/2.57	19/2.74
Saltbush	–	1/.01	–	–	–	1/.01	–	5/.17	3/.07	1/.01	–	6/.24	–	5/.12	1/.01	1/.04
Tarbush	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Total	13/.29	16/.45	20/.61	14/.33	20/.38	14/.37	20/4.51	20/.64	20/.70	20/.55	20/2.29	20/.79	20/2.29	20/2.20	20/2.58	20/2.78

Feature	1 Large Roasting Pit w/ FCR								1.1 Oval of Cobbles at Base of Feature 1	2 Small Fire Pit	**Table Total**	
Grid	699N/ 4998E	699N/ 4999E	699N/ 5000E	700N/ 5000E	699N/ 4998E	699N/ 4999E	699N/ 5000E	700N/ 5000E	699N/ 4999E	720N/ 4967E		
Stratum/ Level	Stratum 2, L 6				Stratum 2, L 7				Stratum 2, L 7	–	Weight (g)	Percent
FS No.	42	40	38	37	46	45	44	43	47	25		
Mesquite	14/3.16	17/.89	17/2.12	19/2.15	16/3.54	19/6.36	14/2.2	19/4.83	14/2.7	5/.16	49.19	93%
Saltbush	6/.23	3/.08	–	1/.01	4/.16	1/.06	1/.01	1/.01	6/.40	15/.72	2.36	4%
Tarbush	–	–	cf. 3/.71	–	–	–	5/1.0	–	–	–	1.71	3%
Total	20/3.39	20/.97	20/2.83	20/2.16	20/3.70	20/6.42	3.21	20/4.84	20/3.1	20/.88	53.26	100%

FCR = fire-cracked rock, TF = thermal feature

Table 17.22. LA 155964, Feature 1 (large rock-filled roasting pit), Stratum 2, wood sample taxa by count and weight in grams.

Grid	699N/4998E					699N/4999E	
Level	Level 2	Level 3	Level 4	Level 5	Level 6	Level 2	Level 3
FS	17	27	29	34	42	8	24
Wood:Mesquite	35/2.01	37/8.68	31/7.27	24/22.12	20/33.52	70/6.36	150/19.57
Saltbush	–	–	–	–	–	–	–
Saltbush twig	–	–	–	6/.43	–	–	–
cf. Tarbush	–	–	–	–	–	–	–
wood	–	–	2/.30	–	–	1/.01	7/.31
Other: Yucca caudex	–	–	–	–	–	1/.02	3/.37
Other: Yucca stem	–	–	–	–	–	–	–
stem	–	–	–	–	–	1/.04	1/.04
Total	35/2.01	37/8.68	33/7.57	30/22.55	20/33.52	73/6.43	161/20.29

Grid	699N/4999E				699N/5000E		
Level	Level 4	Level 5	Level 6	Level 7	Level 2	Level 3	Level 4
FS	30	32	40	45	15	23	31
Wood:Mesquite	49/19.85	46/14.24	39/38.90	13/67.42	19/1.66	79/45.99	33/43.65
Saltbush	2/.14	2/.11	1/.40	–	–	–	1/.32
cf. Tarbush	–	1/.15	1/.36	–	–	–	–
Other: Yucca stem	1/.09	–	–	–	–	–	–
Total	52/20.08	49/14.50	41/39.66	13/67.42	19/1.66	79/45.99	34/43.97

Grid	699N/5000E			699N/5001E	700N/5000E		
Level/strat.	Level 5	Level 6	Level 7	Level 2, Strat. 1	Level 2	Level 3	Level 4
FS	35	38	44	5	19	22	28
Wood:Mesquite	67/29.72	27/40.57	7/55.89	8/1.22	107/15.05	55/17.8	33/24.17
Saltbush	–	–	–	–	1/.06	1/.05	1/.74
cf. Tarbush	8/2.82	3/1.70	3/6.41	–	–	–	–
Other: Yucca caudex	1/.10	2/.29	–	–	2/.07	4/1.15	–
Total	76/32.64	32/42.56	10/62.30	8/1.22	110/15.18	60/19.0	34/24.91

Grid	700N/5000E			**Table Total**	
Level	Level 5	Level 6	Level 7	Weight	%
FS	36	37	43		
Wood:Mesquite	26/46.28	16/58.54	13/67.4	687.88	98%
Saltbush twig	–	–	–	0.43	<1%
wood	–	–	–	2.44	<1%
cf. Tarbush	–	–	–	11.44	2%
Other: Yucca caudex	–	–	–	2	<1%
stem	–	–	–	0.17	<1%
Total	26/46.28	16/58.54	13/67.4	704.36	100%

FCR = fire-cracked rock

Table 17.23. LA 155968, flotation plant remains.

Feature		1 Large Roasting Pit					1.1 Pit		1.2 Indeterminate Noncultural Feature
Stratum/Level		Strat. 1, Level 1	Strat. 2, Level 2	Strat. 2, Level 3	Strat. 2, Level 5	Strat. 3, Level 7	Strat. 1, Level 1		Strat. 2, Level 2
FS No.		473	474	476	478	480	468	470	508
Cultural									
Other	Unknown taxon	–	–	–	–	–	–	5.3 pp	–
Perennials	Yucca	+ ca	+ ca, + cf. l	+ ca	+ ca, + l	+ ca, + cf. l	+ ca	+ ca	+ ca, + fiber
Possibly Cultural									
Annuals	Caltrop	–	–	–	0.4	–	–	–	–
Noncultural									
Annuals	Caltrop	0.5	0.2	–	–	–	5.0	–	–
	False purslane	0.5	–	–	–	–	–	–	–
	Purslane	–	0.1	–	–	–	–	–	–
	Spurge	4.9	1.1	0.8	0.8	–	–	–	1.7
	Tansy mustard	0.5	–	–	–	–	–	–	–
Grasses	Dropseed grass	–	0.2	–	–	–	–	–	–
	Grass family	1.5	–	–	–	–	–	–	–
Other	Aster family	9.3	0.1	–	1.3	0.7	–	–	–
	Bean family	1.0	–	–	0.4	–	–	–	–
	Hidden flower	–	–	0.4	–	–	–	–	–
	Unidentifiable seed	1.0	–	–	–	–	–	–	–
	Wild buckwheat	504.9	–	0.8	28.4	1.3	–	5.3	–
Perennials	Mesquite	1.0 end, + l	0.1 end, + l	+ l	+ l	+ l	+ l	–	–
	Twinleaf senna	0.5	–	–	–	–	–	–	–
	Yucca	–	–	–	0.4	–	–	–	–

Plant parts are seeds unless indicated otherwise.
Cultural plant material is charred, noncultural material is uncharred.
Reproductive plant parts are reported as a standardized count of seeds per liter of soil, rather than an actual number of seeds recovered.
+ = 1–10/sample, ca = caudex, cf. = resembles taxon, end = endocarp, l = leaf, pp = plant part

Table 17.24. LA 155968, flotation sample wood taxa by count and weight in grams.

Feature	1 Large Roasting Pit				1.2 Indeterminate Noncultural Feature
Stratum/ Level	Strat. 2, Level 2	Strat. 2, Level 3	Strat. 2, Level 5	Strat. 3, Level 7	Strat. 2, Level 2
FS No.	474	476	478	480	508
Cholla	2/.01	2/.01	–	–	–
Saltbush	13/.14	18/.26	20/1.27	20/2.10	2/.02

Table 17.25. LA 155968, Feature 1 (large roasting pit), wood sample taxa by count and weight in grams.

Grid	657N/497E				657N/498E	**Total**	
Level/ Stratum	Level 2, Strat. 2	Level 4, Strat. 4	Level 5, Strat. 2	Level 6, Strat. 3	Level 2, Strat. 2	Weight	Percent
FS	475	477	478	479	493		
Wood: Cholla	1/.07	–	–	–	–	0.07	<1%
Mesquite	–	–	–	–	1/.02	0.02	<1%
Saltbush	18/1.3	18/.80	46/5.7	42/11.4	32/5.8	25	99%
cf. Tarbush	3/.30	–	–	–	–	0.3	1%
Other: Yucca caudex	–	–	–	–	1/.02	0.02	<1%
stem	2/.08	–	–	–	–	0.08	<1%
Total	24/1.75	18/.80	46/5.7	42/11.4	34/5.84	25.49	100%

Table 17.26. LA 156877, Feature 5 (possible structure or large roasting pit), flotation plant remains.

FS No.	100	
Cultural		
Perennials	Yucca	+ caudex
Wood	Mesquite	1/<0.1 g
Nonconifers	Saltbush	2/<0.1 g
Noncultural		
Annuals	Amaranth	0.8
Perennials	Mesquite	0.8 endocarp

Plant parts are seeds unless indicated otherwise.
Cultural plant material is charred, noncultural material is uncharred.
Reproductive plant parts are reported as a standardized count of seeds per liter of soil, rather than an actual number of seeds recovered.

Table 17.27. Feature comparison by period and earliest to latest.

Site	Fea. No.	Type	Size (m)	Depth (m)	FCR	Macro	Wood	Period
LA 111435	10	FCR w/ stain	1.5 x.80	0.2	<50	goosefoot, dropseed , aster family, bean family, pr pear embryo	saltbush	Middle Archaic
LA 111435	3	rock-filled FP	.42 x .38	0.31	~ 100	yucca Ca	saltbush, tarbush	Middle Archaic
LA 111429	3	large RP	1.7 x 1.9	0.52	0	yucca Ca	saltbush	Late Archaic/ Early Mesilla
LA 155963	15	Stain or small FP	.20 x .30	0.10	<50	yucca Ca	saltbush	Late Archaic/ Early Mesilla
LA 111435	6	large RP	1.06 x 1.10	0.39	0	yucca Ca, fiber, & l, unk. cf. spine	saltbush, mesquite (1)	Mesilla
LA 155963	14	rock-filled RP	.70x .70	0.10	160	0	saltbush	Mesilla
LA 111422	1	Stain	.15 x .15	~ .20	~20	yucca Ca	saltbush	Mesilla
LA 111422	4	deflated FP	.90 x .60	0.08	5	Ch-Am, yucca Ca	saltbush (3)	Mesilla
LA 155968	1	large RP	1.9 x 1.86	0.56	~ 200	yucca Ca, l	mostly saltbush, cholla, tarbush	Mesilla
LA 155963	141	FP w/ FCR	.82 x. 67	0.19	<20	Am, Ch-Am, Purs, grass stems, hedgehog, mesquite	mesquite, saltbush	Mesilla
LA 155963	125	small FP w/FCR	.59 x. 50	0.06	15–20	yucca Ca	mesquite, saltbush	Mesilla
LA 111435	8	poss. Structure	1.5 x 1.6	0.10	<30	false purslane, grass stems, hedgehog, yucca Ca, l, & s	saltbush	Mesilla
LA 155963	8	small FP w/FCR	.60 x .40	0.08	<20	goosefoot, yucca Ca	-	Doña Ana/ El Paso
LA 155963	1	large FP w/ rock	.76 x .74	.09-.10	90	0	mesquite, saltbush	Protohistoric
LA 111429	11	large rock-filled RP	2.16 e-w	0.63	>2000 in layers, mostly caliche	Ch-Am, yucca basal Ca, l, & s, dropseed, grass, monocot s, caltrop, spurge, cactus ar& ep, prpear embryo, poss. fruit frag.	77% mesquite, <1% cholla, 23% saltbush	Early Historic
LA 155963	9	Stain	unknown	unknown	50–100	Goosefoot	mesquite, saltbush	Early Historic
LA 155964	1	large rock-filled RP	2.76 x 2.0	0.46	1000's, excavated in layers	Am, bug, yucca Ca, fiber, & l, grass stems, cactus ar, ep, pad frag., & stem tissue frags., mesquite end	93% mesquite, 4% saltbush, 3% tarbush	Historic

Am = amaranth, ar = areole, bug = bugseed, Ca = caudex, Ch-Am = cheno-am, cf. = resembles taxon, end = endocarp, ep = epidermis, FCR = fire-cracked rock, FP = firepit, l = leaf, prpear = prickly pear, Purs = purslane, RP = roasting pit, s = stem not just the base of the caudex was recovered, but fiber, stems, and/or leaf fragments as well, suggesting that at least in the deeper roasting pits, yucca crowns were the plant parts that were processed in the features. This is not the case with all deep roasting pits, as plant material from the Middle Archaic-period or Mesilla-phase Feature 3 at LA 111429 consisted solely of yucca basal caudex and saltbush wood. The bark-like material at the base of the caudex and flower stalks could have been used as fuel and the large flowers, young flower stalks, and crowns for food. The Apache would gather the young flower stalks, roast them on a bed of embers, scrape away the charred portions, and eat the exposed white section of the stalk (Bell and Castetter 1941). Thicker stalks were often cooked in stone-lined baking pits and the finished product could be stored for up to a year, and then soaked to soften them before eating (Haley 1981:90). The crowns were gathered in early spring through the end of summer and baked in pits like the process used for agave hearts, while the flowers were boiled and eaten (Bell and Castetter 1941). Stalks, leaves, and caudex could also be the remains of ephemeral brush structures that burned after abandonment, especially those recovered from the possible structure at LA 111435. Figure 17.9 illustrates how a structure of this type could have been constructed. The structure pictured here was built by field-crew member Lynette Etsitty as a demonstration model, as well as to provide shade for crew members on the project.

In the two large rock-filled Historic roasting pits (Feature 11 at LA 111429 and Feature 1 at LA 155964) grass or monocot stems were recovered along with yucca leaf, fiber, and stem fragments. If, as Bell and Castetter indicate, the yucca crowns were roasted in the same manner as those of agave, pits would have been lined with relatively flat stones, then rocks piled on top, and finally oak and juniper wood (in this case mesquite and saltbush) placed over the rocks and set on fire, heating the rocks below. Moist grass was placed over the hot rocks, then the crowns, then more grass and a final covering of dirt and the whole left to bake for at least 48 hours (Castetter et al. 1938).The grass or monocot stems could be further evidence of pit baking of yucca crowns. Both phytolith and starch-grain analysis

Figure 17.9. Modern brush structure showing its ephemeral nature.

from Stratum 4, Level 3, of Feature 11, and from Stratum 2, Level 2, of Feature 1, produced evidence for use of panicoid and cloridoid grasses either for buffering or as a steam-retention layer in the pit (see Yost, Appendix 2, this report). Yost also notes that *Panicum obtusum,* one of the panicoid grasses that might have been growing in the area when the site was in use, has documented ethnographic uses—including grinding the seeds and mixing them with meat prior to roasting (Moerman 1998). Grass seeds recovered from Feature 11 at LA 111429 were from the same sample that was examined for phytolith and starch grains as well as lower levels from Stratum 4 and may represent use of the seeds in this manner. Seeds were not found in Feature 1 at LA 155964, but grass and monocot stems were identified in Levels 4 and 7.

Cactus areoles, prickly pear pad fragments and tissue, a prickly pear embryo and possible fruit fragment were also recovered from one or both Historic features (Feature 11 at LA 111429 and Feature 1 at LA 155964). The spines of the fruits (*tunas)* were removed by rolling the fruit in sand or burning it; it could be either boiled or eaten raw (Castetter 1935). The pads were eaten in spring when food was in short supply (Hough 1897); the spines were burned off and the pads were roasted or boiled with dried sweet corn by the Acoma, Laguna, and San Felipe Pueblo peoples (Castetter 1935). Burned hedgehog cactus seeds were found in two Mesilla-phase features, Feature 141 at LA 155963 and Feature 8 at LA 111435, indicating consumption of the fruits, although the fruits were generally eaten fresh (Castetter and Opler 1936; Rea 1997; Jones 1931), there are references to the fruit being baked or made into a conserve (Castetter 1935; Jones 1931).

Mesquite endocarp (the indurate inner layer of the fruit wall encapsulating the seed) fragments were recovered from Historic Feature 1 at LA 155964 and seeds were found in Mesilla-phase Feature 141 at LA 155963. This may indicate the pods and/or seeds were processed and used for food, or the pods could have been persistent on branches gathered for firewood and are merely an artifact of fuel use. Although there are a few accounts of indigenous groups utilizing mesquite seeds, for the most part the pods were ground into meal and the seeds winnowed out before storage or cooking. The meal was often made into cakes, eaten raw or baked, or dried for easy transportation (Bell and Castetter 1937). If the beans were to be stored whole, they were dried, and then either placed in baskets, sealed pots, on platforms, or on roofs. Despite the presence of scattered little-leaf sumac bushes at LA 111429, LA 155963, and LA 155964, evidence for sumac fruit use was only found at LA 155963 and was minimal, consisting of one charred seed in a macrobotanical sample from Mesilla-phase Feature 141. The sour, somewhat citrus-flavored fruits were used for seasoning, eaten raw, or as an appetizer (Jones 1931; Castetter 1935).

Annual seeds (amaranth, bugseed, cheno-ams, false purslane, goosefoot, and purslane) occurred in Mesilla-phase features at LA 111422 (Feature 4), LA 111435 (Feature 8), and LA 155963 (Feature 141), the later Formative feature at LA 155963 (Feature 8), and Historic features at LA 111429 (Feature 11), LA 115963 (Feature 9), and LA 155964 (Feature 1). Amaranth, goosefoot, and purslane are weedy taxa that are part of a wide variety of plants defined as agrestals and/or ruderals. Agrestals are plants that are adapted to agricultural pursuits and are often associated with a particular crop. Ruderals are plants that occur in areas of irregular or inadvertent disturbance such as roadsides (Stuckey and Barkley 2000). These taxa are found in virtually any disturbance situation and are widespread throughout the Southwest. A single amaranth or goosefoot plant can produce thousands of seeds, so it is not surprising that seeds from these disturbance-loving plants show up in archaeological assemblages from virtually all time periods. The seeds were parched, ground into meal, and often made into a thick gruel (Castetter 1935:16, 23, 30) or mixed with cornmeal and made into balls or cakes and steamed (Stevenson 1993:33). The seeds of false purslane were probably used in much the same way as purslane and, as with purslane, the leaves were gathered and eaten as greens (Curtin 1949:64). There are no documented ethnographic uses of bugseed. However, charred bugseed has been recovered from southeast Utah (Reed 1981), the Bis sa'ani community area of Chaco (Donaldson and Toll 1982), Tsaya Wash (Minnis 1978), at a Pueblo II site (AZ-O-38-45) in Dilkon, Arizona (McBride 2007), and from Lizard Man Village near Flagstaff, Arizona (Hunter 1997). These data, along with bugseed found in coprolites at Cowboy Cave (Hogan 1980) provide convincing evidence that bugseed was a relatively consistent source of food for prehistoric populations.

Wood use in the Archaic and early Mesilla

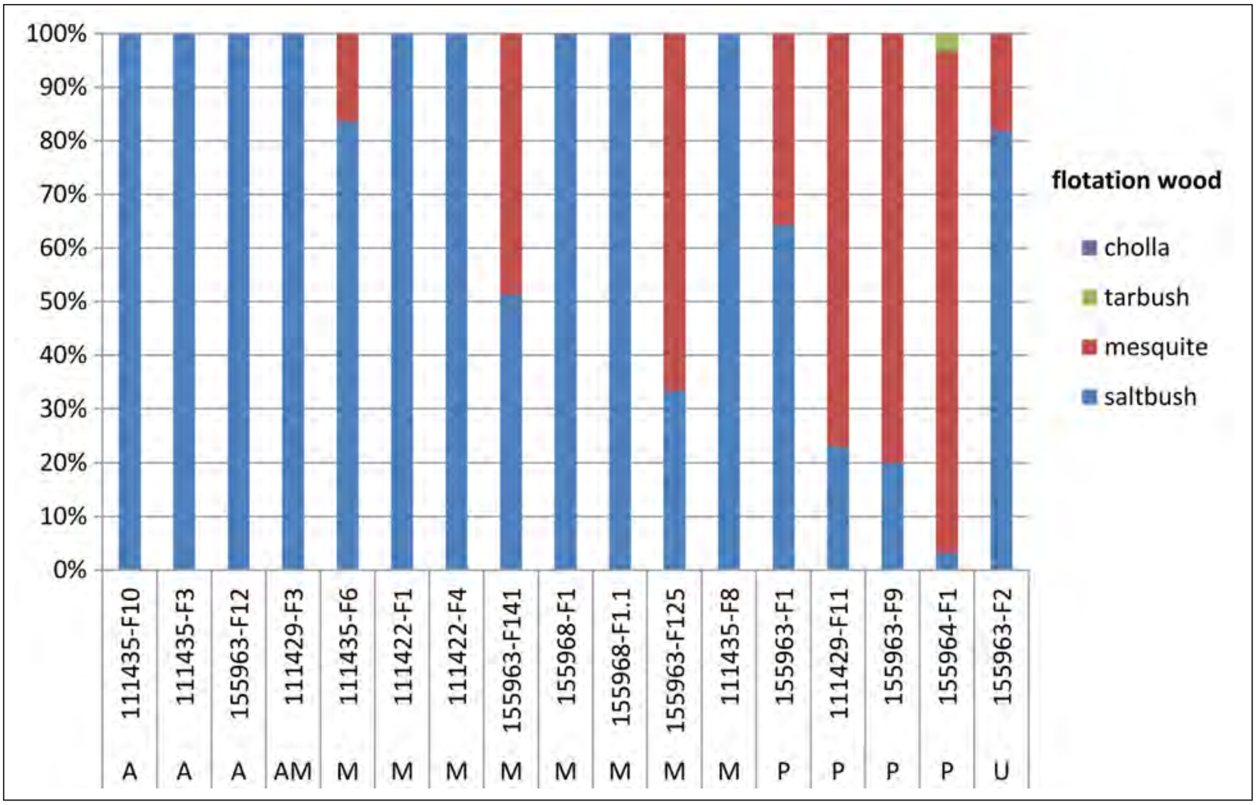

Figure 17.10. Flotation wood percent, presence by weight in grams.

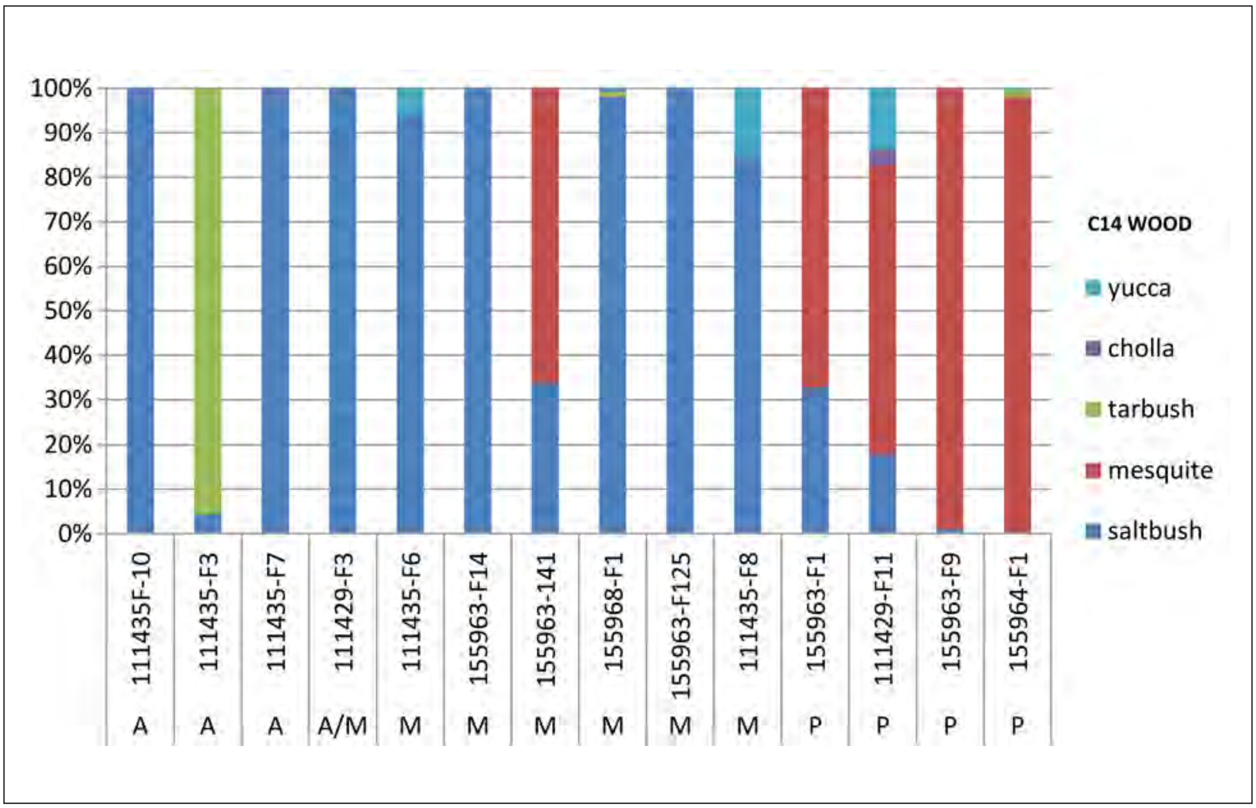

Figure 17.11. Wood sample percent, presence by weight in grams.

seems to be focused primarily on saltbush, but three features (the Feature 6 roasting pit and the possible structure at LA 111435 and the Feature 1 roasting pit at LA 155968) in use later in the Mesilla phase also contained mostly saltbush (Figs. 17.10, 17.11). The majority of wood from Protohistoric and Historic features was mesquite. Wood selection may be somewhat time sensitive, rather than functionally sensitive. The modern shrub distribution differs somewhat from taxa dominance in the archaeobotanical wood assemblage. Saltbush is rare today at LA 111429, growing in the middle of mesquite shrubs acting as nurse trees, but was the only taxon encountered in several levels from Feature 3 at LA 111435, in use during the Late Archaic/Early Mesilla phase. Yet mesquite was dominant in the Protohistoric and Historic samples as it is on the landscape today. Currently, saltbush is the predominant shrub found growing in the southern part of LA 155963 and is co-dominant with creosotebush in the northern section of the site. While the Late Archaic/Early Mesilla wood assemblage from the site is dominated by saltbush, the Mesilla assemblage is primarily mesquite. The Historic roasting pit at LA 155964 contained 93 percent mesquite, corresponding with the abundance of mesquite found at the site today. These discrepancies may be partially explained by microclimatic differences, changes in precipitation patterns (more moisture favors grass dominance, while decreases favor shrub dominance [Wondzell et al. 1996]), changes in fire regime (Humphrey 1958), and the possible influence on mesquite distribution by prehistoric foragers. Based on 1858 land surveys, distribution of mesquite on the Jornada del Muerto was primarily restricted to areas of indigenous settlement (York and Dick-Peddie 1969), suggesting that after processing the bean pods, the seeds were discarded and subsequently germinated near the sites, creating pockets of mesquite.

Spaceport Plant Utilization in a Regional Perspective

Plant remains recovered from the Spaceport sites are compared in Table 17.28 with other sites associated with the Archaic, Formative, Protohistoric, and Historic periods in the El Paso region, the Tularosa Basin, and Otero Mesa. Sites with the most diverse plant assemblages are those which have surface brush structures (Site 33, Zone 4, LA 126395, and LA 126396) that may have helped to preserve fragile plant parts. The presence of houses also indicates a longer duration of occupation or seasonal reuse of the site, resulting in more opportunities for preservation of carbonized plant parts from cooking accidents. In general, plant remains reflect the geographic locations of the sites. For instance sotol grows on Otero Mesa and Dering (2002) found plant parts that compare favorably to sotol basal caudex fragments and Keystone Dam is situated on an alluvial terrace east of the Rio Grande and west of the Franklin Mountains, offering site occupants access to riverine, bajada, and montane plant resources within easy walking distance. LA 97943 is located on an alluvial fan of the Organ Mountains where access to juniper would have been close at hand (one charred juniper seed was recovered, Holloway 2008). Other sites are located in arid dunal basins where resources are more limited, primarily consisting of grasses, weedy annuals, mesquite, and yucca.

Amaranth, cheno-ams, and purslane are the most common seed taxa that occur in Archaic, Mesilla phase, and Protohistoric contexts. Prehistoric utilization of purslane is substantiated by an unusual recovery of a significant quantity of these tiny seeds in a Chupadera Black-on-white jar (Phelps 1968). Exploitation of leaf succulents is documented by O'Laughlin (1988) at Unit 45SE and Unit 48NW from the Distributional Survey (Camilli et al. 1988) in the El Paso area, at Spaceport sites, at LA 97943, on Otero Mesa (Dering 2002), and from ring middens at LA 156101 and LA 157662 (Dering 2009). In fact, leaf succulents, either in the form of seeds or non-reproductive parts, are the most common plant taxa recovered, found at 82 percent of the components compared. Cacti are found at seven of the sites and include hedgehog, prickly pear, and Turk's cap (*Echinocactus horizonthalonius*), all with documented economic uses.

The earliest evidence for domesticates comes from the Late Archaic/Early Mesilla site LA 97533 where a single maize cupule was identified in Feature 16B (Holloway 2009), one of three probable hearths that were exposed in, or just south of, a backhoe trench. Maize cupules were also identified from two extramural hearths dating to the Late Mesilla phase at LA 97943 (Holloway 2008). Finally, maize was recovered from four of a cluster of six thermal features at LA 37027 associated with the

Doña Ana phase in the southern Tularosa Basin (Holloway 2010). Why domesticates appear at these sites and none of the others cannot be determined; sites where maize occurs are all in the Tularosa Basin and date to three different time periods.

Wood Utilization

As previously mentioned, fuel-wood selection at Spaceport sites seems to focus on saltbush during earlier occupations of the area and on mesquite in the Late Mesilla, Protohistoric, and Historic samples. However, when abundance is calculated based on the number of samples in which a taxon occurs rather than weight, the picture is somewhat different. Saltbush is not only the most common wood found in Spaceport samples from the Archaic and Late Archaic/Early Mesilla but in all Mesilla phases (with the exception of Feature 141 at LA 155963), and in the Protohistoric/Historic, mesquite and saltbush occur in all of the samples (Table 17.29). Wood charcoal was not recovered in the flotation sample associated with the Doña Ana/El Paso phase from LA 155963 (Feature 8). Mesquite is the dominant taxon at Keystone Dam and at LA 97941, LA 97943, LA 97944, and LA 97945. Creosotebush is the most common wood identified from LA 117712 and 117713, while tarbush is the most frequently encountered wood at LA 126395 and 126396, followed by mesquite. Wood use probably correlates with the percentage of woody species present at the time of site occupation. O'Laughlin (1980) states that studies by Ford (1977), Holloway (n.d.), and O'Laughlin (1979) support this because "woods recorded by them in archeological sites near El Paso generally follow the contemporary ecological distribution of these same plants." At Keystone Dam, shrub species found presently on or near Site 33 are represented in the prehistoric wood assemblage and like the plant assemblage, is the most diverse of all sites compared. Mesquite not only occurs on the alluvial fan, but in nearby arroyos as well. LA 97941, LA 97943, LA 97944, and LA 97945 are also on an alluvial fan among mesquite-stabilized dunes. LA 117712 and LA 117713 are on Otero Mesa where small shrubs like creosotebush and Torrey croton dominate the landscape. LA 126395 and LA 126396 are near the eastern edge of the Hueco Bolson in a transition zone between mesquite-dominated coppice dunes and creosote and tarbush communities found where aeolian deposition decreases. The wood assemblage represents exploitation of both of these vegetation communities.

Summary and Conclusions

The archaeobotanical analysis results indicate that prehistoric, Protohistoric, and Historic groups that visited the Jornada del Muerto in the vicinity of the Spaceport America Facility targeted yucca and cacti and made some use of annual taxa such as amaranth, goosefoot, and purslane, and possibly grass seeds. Mesquite pods were probably an important source of carbohydrates (pod pulp is 25–30 percent sugar; Rea 1997:184) and if the seeds were ground with the pods to make flour, the protein and fat content would have increased markedly (the whole pod of *Prosopis juliflora* has a mere 11.2 m/gram, while the seed contains anywhere from 65.2 m/gram to 33.9 m/gram, depending on the analyst reported in Hiles 1993:69). Indeed, ethnographic studies from the historic era point to a heavy focus on concentrated perennial resources such as leaf succulents, cacti, and mesquite (Basehart 1974; Bell and Castetter 1937, 1941; Castetter and Opler 1936; Castetter et al. 1938). After examining archaeobotanical and coprolite data from three cave sites in the lower Pecos, Sobolik (1996:203), stated that:

> In combination, desert succulents and prickly pear were extremely important because they are available for food and other purposes year-round. As a result, they probably were dietary staples, particularly when other food resources were unavailable or during times of stress.

The list of plant taxa used during the occupation of the area suggests that Mesilla, Protohistoric, and Early Historic collection forays took place from mid-summer through the fall. Goosefoot and purslane seeds begin to ripen in mid-summer, while hedgehog cactus fruits mature in late summer to early fall. There are two harvest seasons for mesquite pods: one from the end of June until around the end of July and another in October (Rea 1997). Yucca stems and crowns and prickly-pear cactus pads can be collected all year, although the stems are best when gathered young in the spring; Bell and Castetter (1941:19) state that the crowns were "gathered any time from the middle of March until

Table 17.28. Summary of regional plant remains from Archaic to Protohistoric sites.

Period	Location	Site	Food Remains	Feature Types	Reference
Archaic	El Paso	Unit 45SE, Unit 48NW	Am, purslane, dropseed, grass, lily family stalk or pod, yucca pod	pits, PHs	O'Laughlin, 1988
		Site 33, Zone 4	Bulrush, ch-am, dock, four-wing saltbush, grass, love grass, prickly pear, purslane, smartweed, tornillo, Turk's cap, poss. yucca/agave carpel	houses, hearths	O'Laughlin, 1980
Middle Archaic	SPA	LA 111435	Aster family, bean family, dropseed grass, goosefoot, prickly pear	stain	current project
		LA 111435	Yucca basal ca	rock-filled fire pit	current project
Late Archaic/Early Mesilla	Ft. Bliss	LA 97533	Maize cupule	hearth	Holloway, 2009
	SPA	LA 111429	Yucca basal ca	large RP	current project
		LA 155963	Yucca basal ca	stain or small fire pit	
Mesilla	Ft. Bliss	LA 97943	Juniper, maize cupules, prickly pear, yucca	PH hearths, XM hearths	Holloway, 2008
		LA 97944	Prickly pear	PH fill	
		LA 156101	Agave/sotol l frag., mesquite pod frag., seed, thorn	ring midden, ash stain	Dering, 2009
		LA 157662	Agave/sotol l and fiber frags.	ring midden	
		LA 126395, LA 126396	Am, bugseed, Ch-Am, dropseed grass, globemallow, goosefoot, hedgehog cactus, mustard, prickly pear, purslane, sunflower	basin hearths	McBride, 2003
	SPA	LA 111422	Ch-Am, yucca basal ca	deflated FP	current project
		LA 111435	False purslane, grass s, hedgehog cactus, yucca basal ca, fiber,	possible structure	
		LA 155963	Am, ch-am, grass s, hedgehog cactus, mesquite, purslane, yucca basal ca	FPs	
		LA 155968	Yucca basal ca	large RP	

(Table 17.28, continued)

Doña Ana	Otero Mesa, Ft. Bliss	LA 117713	cf. Rain lily bulb, cf. sotol basal ca	burned rock TFs	Dering, 2002
	Ft. Bliss	LA 37027	Maize cupules, yucca	TFs	Holloway, 2010
Doña Ana/ El Paso	SPA	LA 155963	Goosefoot, yucca basal ca	small FP w/FCR	current project
Early Historic		LA 111429	Cactus ar& ep, caltrop, ch-am, dropseed, grass, monocot s, prickly pear embryo, poss. fruit frag., spurge, yucca basal ca, l, & s	large rock-filled RP	
		LA 155963	Goosefoot	stain	
Historic		LA 155964	Am, bug, cactus ar, ep, pad frag., & stem tissue frags., grass stems, mesquite end, yucca basal ca, fiber, & l	large rock-filled RP	
Historic	Otero Mesa, Ft. Bliss	LA 117712	Sotol l	burned rock TF	Dering, 2002

Am = amaranth, ar = areole, ca = caudex, cf. = resembles taxon, ch-am = Cheno-Am;
ep = epidermis, FP = fire pit, l = leaf, PH = pithouse, RP = roasting pit, s = stem, XM = extramural
TF = thermal feature, FCR = fire-cracked rock

Table 17.29. Comparison of wood assemblages by site and time period in the southern New Mexico/El Paso regions (percentage of samples taxon was found in).

Time Period	Archaic	Late Archaic/ Early Mesilla	Mesilla Phase	Doña Ana	Protohistoric/ Historic
Conifers					
Juniper	–	–	D (22): 5%	–	–
Unknown conifer	–	–	D: 5%	F (15): 13%	–
Nonconifers					
Aoache Plume	–	B (78): 1%	–	–	–
Broom snakeweed	–	–	–	–	E: 17%
Cholla	–	–	A (15): 13%	–	A (36): 3%
Cottonwood	–	B: 3%	–	–	–
Creosotebush	–	B: 6%	C (14): 7%	E (9): 67%	E(12): 58%
Desert willow	–	B: 1%	–	–	–
Mesquite	–	B: 85%	A: 33%; C: 64%; D: 91%	E: 11%; F: 33%	A: 94%; E: 1%
Saltbush	A (3) : 100%	A (6): 100%	A: 93%; C: 14%; D: 32%	E: 22%; F: 87%	A: 94%; E: 1%
Tarbush	–	–	C: 79%	–	A: 6%
Torrey croton	–	–	–	E: 22%	–
Unknown	–	–	A: 7%; C: 36%	F: 7%	–
Wolfberry	–	B: 4%	–	–	–

Note: The number of samples from each project and time period are indicated in parentheses.
A: Spaceport; B: Keystone Dam (O'Laughlin, 1980); C: LA 126395, 126396 (McBride, 2003);
D: LA 97941, 97943, 97944, 97945 (Holloway, 2008); E: LA 117712, 117713 (Dering, 2002)
F: LA 37027 (Holloway, 2010)

the end of summer," indicating that they were not generally gathered year-round.

Wood use at the Spaceport focused on saltbush prior to the Protohistoric, when saltbush and mesquite show up in an equal number of samples, possibly indicating mesquite was not nearly as widespread as it is in the area today. Exceptions to this pattern are the prevalence of mesquite wood in Mesilla-phase Features 125 and 141 at LA 155963. Mesquite seeds were also found in Feature 141, the only context where seeds were recovered. Mesquite was the most common wood found at sites in the Hueco Bolson east of El Paso and seemed to be preferred even at "those sites where it is not particularly abundant today" (O'Laughlin 1980:83). This is probably because of its high energy content per kilogram of material; mesquite has an energy content of 411 calories/kg versus saltbush, which has an energy content of 114 calories/kg (Kaul and Jain 1967; Nord and Countryman 1972, cited in Church 2003).

Comparison to other sites in the region, and based on extant vegetation, indicates a focus on exploitation of wild plant resources in close proximity to sites. According to ethnographic literature, forager camps located in arid settings are moved when the distance from basecamps to resources reaches approximately a 5–6 km radius (Williams 1974:74; Vincent 1984). The catchment area may have been even more restricted; Kelly (1995) found that while a forager responsible for collecting about 50 percent of the diet can collect to about a maximum of 5.75 km from camp, for one who is responsible for 100 percent of the diet, the effective foraging radius is reduced to about 1.5 km from camp. This is predicated on the premise that the amount of energy expended on gathering (walking distance, harvesting, processing time) is directly related to the return rates of the catchment area. On the other hand, wood procurement may have been based on a preference for taxa that have a higher caloric output, no matter how far the resource was from the basecamp, or wood choice could have been functionally dependent—a fire for parching seeds could be made with expediently gathered dead branches of small desert shrubs, while a fire intended to heat rocks in the base of a roasting pit may have required a denser wood with a capacity for greater heat production per kilogram, such as oak, which is used by the Mescalero Apache in agave roasting pits (personal observation and Castetter et al. 1938).

18 | Ceramic Analysis

C. Dean Wilson

Introduction

A total of 1,041 sherds from six sites investigated as part of the Spaceport America project were analyzed. These include 227 sherds from LA 111422, 1 from LA 111429, 69 from LA 111435, 735 from LA 155963, and 9 from LA 155968 (Tables 18.1, 18.2). This analysis involved the recording of descriptive attributes, typological categories, and quantitative (count and weight) variables that provide the basis for the examination of various issues presented in the research design (Moore et al. 2010). The consistent recording of this combination of data allows for the characterization and comparison of pottery assemblages in a manner that may provide a basis for assigning ceramic dates as well as insights relating to cultural affiliation or tradition, area of origin, exchange, form, and use of pottery vessels. In order to compare trends noted at these sites to those in surrounding areas, attempts were made to adopt strategies and categories similar to those employed in studies of ceramics from the general region (Harsbargen and Railey 2008; Jelinek 1967; Kelley 1984; Mera 1943; Reed et al. 2002; Runyon and Hedrick 1987; Wilson 2000, 2003; Wiseman 1991, 1996, 2000, 2003, 2004).

Descriptive Attributes

Ceramic attributes recorded during this study include temper type, pigment, surface manipulation, and vessel form.

Temper Categories

Temper categories were assigned to each sherd based on observations noted during the examination of freshly broken surfaces through a binocular microscope. Different temper categories were identified based on observations about the color, size, shape, and crystalline structure of the associated particles. The great majority of the sherds examined during this project were tempered with some form of crushed igneous rock that is most likely indicative of production somewhere in the Jornada Mogollon region.

It is important to note that the recognition and distinction of different temper groups commonly occurring in pottery from different parts of the Jornada Mogollon region can be difficult. Criteria used to define temper categories for the Jornada Mogollon are often based on slight differences in size, color, and composition. Despite overlap in criteria utilized to define different categories, the distributions noted may still be statistically important, and various trends concerning temper distribution, particularly between ceramic types and sites, may provide useful insights relating to the production, distribution, and use of pottery vessels found in sites distributed over a wide area.

Most of the pottery examined during this project exhibited similar light-colored temper fragments, which are referred to here as *crystalline igneous*. Examples assigned to this category are dominated by light-colored angular particles that are similar in size. While the great majority of these fragments are white they may range from buff to light gray and appear to represent feldspar along with some quartz. Smaller black particles are also sometimes present. These particles tend to be small and somewhat roundish and usually occur outside the lighter grains, although in rare cases such fragments may be included within large white particles. Larger grains tend to be glossy and opaque, although some are crystalline or sugary in structure. This temper

Table 18.1. Ceramic type by site; counts and column percentages.

Ware	Pottery Type		LA 111422	LA 111429	LA 111435	LA 155963	LA 155968	**Total**
Cibola White Ware	Unpainted, Polished, White Ware	Count	–	–	–	4	–	4
		Col. %	–	–	–	0.5%	–	0.4%
	Mineral Paint Undifferentiated	Count	–	–	–	2	–	2
		Col. %	–	–	–	0.3%	–	0.2%
El Paso Brown Ware	El Paso Brown Rim	Count	1	–	–	12	–	13
		Col. %	0.4%	–	–	1.6%	–	1.2%
	El Paso Brown Body	Count	9	–	44	556	9	618
		Col. %	4.0%	–	63.8%	75.6%	100.0%	59.4%
	El Paso Brown (Large Sand Temper)	Count	–	–	–	8	–	8
		Col. %	–	–	–	1.1%	–	0.8%
El Paso Polychrome	El Paso Polychrome	Count	1	–	–	1	–	2
		Col. %	0.4%	–	–	0.1%	–	0.2%
Jornada Red Ware	Plain Slipped Red (Sand Temper)	Count	–	–	–	3	–	3
		Col. %	–	–	–	0.4%	–	0.3%
	Plain Slipped Red	Count	–	–	–	2	–	2
		Col. %	–	–	–	0.3%	–	0.2%
Jornada Brown Ware	Jornada Brown Rim	Count	5	–	–	–	–	5
		Col. %	2.2%	–	–	–	–	0.5%
	Jornada Brown Body	Count	211	1	25	62	–	299
		Col. %	93.0%	100.0%	36.2%	8.4%	–	28.7%
	Incised Brown	Count	–	–	–	2	–	2
		Col. %	–	–	–	0.3%	–	0.2%
	South Pecos Brown Body	Count	–	–	–	77	–	77
		Col. %	–	–	–	10.5%	–	7.4%
Mimbres White Ware	Mimbres White Ware Unpainted	Count	–	–	–	2	–	2
		Col. %	–	–	–	0.3%	–	0.2%
	Mimbres Black-on-white Undifferentiated	Count	–	–	–	4	–	4
		Col. %	–	–	–	0.5%	–	0.4%
Total		Count	227	1	69	735	9	1,041
		Col. %	21.8%	0.1%	6.6%	70.6%	0.9%	100.0%

Table 18.2. Tradition and ware group by site; counts and column percentages.

Tradition	LA 111422	LA 111429	LA 111435	LA 155963	LA 155968	**Total**
El Paso Brown Ware	10	–	44	576	9	639
	4.4%	–	63.8%	78.4%	10.0%	61.4%
El Paso Polychrome	1	–	–	1	–	2
	0.4%	–	–	0.1%	–	0.2%
Jornada Red Ware	–	–	–	5	–	5
	–	–	–	0.7%	–	0.5%
Jornada Brown Ware	216	1	25	141	–	383
	95.2%	100.0%	36.2%	19.2%	–	36.8%
Cibola White Ware	–	–	–	6	–	6
	–	–	–	0.8%	–	0.6%
Mimbres White Ware	–	–	–	6	–	6
	–	–	–	0.8%	–	0.6%
Total	227	1	69	735	9	1,041
	21.8%	0.1%	6.6%	70.6%	0.9%	100.0%

appears to represent crushed granites or monzonites as commonly used in the mountainous areas of the Northern Jornada Mogollon region.

Another temper class seems to reflect *granite* and consists of larger fragments that include feldspar with hornblende or other dark particles; occasional larger quartz fragments are often present. This group is often identified by the dominance of relatively white to clear gray grains, which probably represent feldspar along with some quartz. This temper is particularly common in brownware vessels that appear to have been produced in the El Paso area. This temper may reflect the use of granites derived from sources in the Franklin Mountains. It is also possible that some specimens assigned to this temper type could represent the use of granites from sources in other parts of the Jornada region.

Another variation is *dark feldspar,* which has been previously characterized as reflecting the use of crushed igneous rock presumably obtained from somewhere in the Sierra Blanca Mountains. Feldspar fragments tend to be similar in appearance, and angular and sparsely scattered (Wiseman 1994). Smaller grains of other minerals are rare if present at all. Feldspar fragments are large compared to other temper fragments and tend to be opaque and gray to off-white in color. A variation of this temper is reflected by the dominance of more angular and slightly smaller brownish feldspar grains and was described here as *indeterminate feldspar*.

Another category noted in both white wares and rare examples of Jornada brown wares is *sand;* this determination is based on the presence of rounded or sub-rounded white to translucent well-sorted medium-to-coarse quartz grains. In addition, sometimes sand temper occurs along with crushed potsherds, and is recorded as *sherd and sand*.

Another temper category is described here as *Mogollon volcanics,* and is characterized by the presence of fine, shiny, white to gray quartz and tuff particles. This combination of particles appears to reflect the use of weathered volcanic-clastic rocks and represents the dominant temper used in Mogollon Brown wares and Mimbres White wares produced in the Mogollon Highlands that cover much of southwest New Mexico (Wilson 1999).

Surface Manipulation

Surface manipulation categories provide information relating to the presence and type of surface texture, polish, and slip treatment. These categories were recorded for both interior and exterior sherd surfaces. *Surface missing* refers to cases where the original surface treatment could not be identified due to wear or spalling. *Plain unpolished* refers to surfaces that are unpolished and smoothed. *Plain polished* surfaces are those that have been intentionally polished after smoothing. Polishing implies intentional smoothing with a polishing stone to produce a compact and lustrous surface. *Plain striated* refers to the presence of a series of extremely shallow parallel striations or marks presumably resulting from brushing an unpolished surface with a fibrous tool. Surfaces of white wares to which a distinct light-colored low-iron slip was applied were classified as *polished white slip*. Surfaces of red wares reflecting the use of a high-iron clay slip to create a red surface were assigned to a *polished red sli*p category. A few sherds with linearly spaced impressed designs were assigned to a *punctated* category.

Vessel Form

Vessel form categories were assigned based on observations relating to the shape or portion of the vessel from which a sherd most likely derived. Criteria used to make such identifications include rim shape and the presence and location of polish and painted decorations. While it is often easy to identify the basic form (bowl versus jar) of body sherds from many southwestern regions by the presence and location of polishing or painted decorations, such distinctions are not always possible for Jornada brown-ware types since Jornada brown-ware bowl and jar sherds can be polished or smoothed on either side. Therefore, some of the body sherd descriptive categories are based on the occurrence of polishing on different surfaces. Descriptive categories to which body sherds were assigned include *body sherds polished on both surfaces*, *body sherds unpolished on both surfaces*, *body sherds polished on interior surface only*, and *body sherds polished on exterior surface only*. In most cases, the *bowl body* category was limited to sherds from decorated vessels with heavier polish, slip, or painted decorated on the interior surface. In contrast, many of the brown-ware sherds exhibiting exterior polish were assigned to a *jar body* category. *Jar neck* sherds were identified by the presence of distinct saddle-shaped curves characteristic of jar necks. *Jar rim* sherds also exhibit the distinct shape of a necked jar.

Post-Firing Modifications

Evidence of the intentional modification of vessels or sherds by repair or for subsequent use was also recorded. Most sherds did not exhibit evidence of modification and were recorded as *none*. Modification categories recognized during the present study include *drill-hole complete*, *beveled edge*, *interior worn from cooking*, *abraded surface exterior*, *interior-exterior erosion*, and *exterior partially exfoliated from erosion*.

Ceramic Types

Ceramic types refer to convenient categories that can be used to document and relay information about the distribution of pottery with combinations of traits with temporal, spatial, and functional significance. Types recognized during the present study were lumped into one of several basic groups reflecting both regional tradition and ware type. Ceramic groups recognized include Cibola White Ware, El Paso Brown Ware, El Paso Polychrome, Jornada Red Ware, Jornada Brown Ware, and Mimbres White Ware.

Brown utility ware pottery thought to have been produced in different areas of the Jornada Mogollon region has long been divided into a series of types based on combinations of attributes—surface color, polish, and temper—considered to be temporally and spatially sensitive (Jelinek 1967; Jennings 1940; Lehmer 1948; Whalen 1994; Wilson 2000a, 2003; Wiseman 1996, 2001). Unfortunately, some studies indicate there is potential for overlap in these attributes in the region (Hill 1996; Whalen 1994). Even petrographic analysis, which has provided detailed characterizations of paste and temper from distinct areas, cannot always distinguish pottery originating in various parts of the Jornada Mogollon country (Hill 1996). Therefore, many recent studies have simply lumped plain brown-ware sherds previously assigned to types such as El Paso Brown, Jornada Brown, or South Pecos Brown into a single Plain Brown Ware type, and have attempted to subsequently make geographic-based associations through the independent examination of various paste and technological attributes (Hill 1996; Whalen 1994).

There are some indications, however, that subdivisions within brown-ware types defined for the greater Jornada Mogollon region may in fact provide for the definition of types and traditions with spatial and cultural significance. Wiseman (1996, 2000, 2004) has used modified versions of brown-ware types described by Jelinek (1967) to distinguish a range of brown-ware types occurring at Jornada Mogollon sites. My own attempts to adapt these categories to Jornada Mogollon assemblages (Wilson 2000b, 2003) indicate that these distinctions, while often very difficult to define and operationalize, still provide a way to document and monitor potentially important variations. In addition, the documentation of such variability using previously defined type categories tends to be less cumbersome than a continual reference to observations relating to attribute categories. The major brown-ware divisions used in this study involve the distinctions of Jornada Brown Ware and El Paso Brown Ware types.

Jornada Brown Ware

As used here, Jornada Brown includes types that have also been recently referred to as Sierra Blanca variety, and includes pottery assigned during this study to the *Jornada Brown body* and *Jornada Brown rim* types. Jornada Brown was first defined by Jennings (1940), based on the excavation of sites along the Peñasco River. Jennings (1940) referred to the dominant pottery recovered from these sites as Common or Unnamed Brown, which was distinguished from "the El Paso type" based on rim form and surface polish. Jornada Brown Ware as used here refers to the long sequence of brown-ware pottery produced in the northern variant (Sierra Blanca region) of the Jornada Branch (Kelley 1984). Surfaces tend to be smoothed and polished, and temper grains are seldom visible through the surface. Tool marks and polishing streaks are often visible. Vessel walls tend to be fairly thick, usually ranging from about 6 to 8 mm. Earlier forms tend to be thinner and later increases in the thickness of vessel walls may ultimately be related to technological changes in the overall forms and uses of jars through time.

Pastes consistently turn red when refired in a controlled oxidizing atmosphere and reflect the use of high-iron clays. Pastes are often dark and a distinct carbon core is sometimes present. A wide range of surface colors is represented, including dark gray, gray, tan, brown, yellow-red, and red. Significant color differences may occur in a single vessel, and firing clouds are fairly common. Together, these characteristics indicate poorly controlled atmospheres, particularly during the final stages of firing. Temper fragments are variable in size, with those in later forms tending to be fairly small and crystalline in structure. Most of the Jornada Brown Ware sherds examined during the present study are tempered with feldspar fragments of a similar size. Jornada Brown sherds were also placed into a variety of vessel form classes. Jornada Brown from early components appears to represent a wide range of forms that may be dominated by bowls, while later forms (post-AD 1100) are mostly dominated by necked jars.

South Pecos Brown is another type that seems to reflect a variety of Jornada Brown Ware; it contains tempering materials used in areas of the Sierra Blanca Mountains (Wiseman 2002). This type is generally well-smoothed, and polishing may be strong to absent. Temper is represented by sparse, large gray feldspar fragments that frequently show through the surface, although variation in feldspar inclusions resulted in the definition of two temper groups for pottery assigned to this type. This type of temper causes blocky to tabular paste cross-sections. The protruding temper cracks are sometimes surrounded by very small radial cracks and surface clays that have contracted or shrunk toward the body clay. Vessel shapes tend to be more irregular than Jornada Brown vessels are.

Of all the pottery recovered during the present study, the most difficult type to define and interpret was represented by two sherds from different vessels that were simply assigned to Incised Brown. In both of these sherds, the paste cross-section is very dark and the temper consists of a crystalline igneous rock similar to that seen in Jornada Brown Ware. Surfaces are unpolished and brown-gray in color. Both sherds are derived from jars, and the exterior surfaces display intentionally incised designs. The design on the smaller of the sherds consists of two intersecting linear and thin incised lines. The larger of the two is a jar rim sherd with at least two rows of fingernail-shaped indentations that run horizontally just below the rim (Fig. 18.1). The surface over which the designs were applied displays vertical striations. The rim is tapered and slightly worn. Difficulties in classifying these sherds illustrate the poor understanding of the full nature of sequences of ceramic change for the Jornada region in which the Spaceport America project is located. One possibility is that these sherds could represent textured forms of Jornada Brown that have previously been described as Jornada Incised, many of which may represent an unslipped form of Playas Incised (Wilson 2004). Most of the sherds assigned to this type, however, seem to exhibit a greater degree

Figure 18.1. Punctated brown ware sherd.

of surface polish and oxidation. It is likely that the sherd decorated with incised lines represents a variation of this type. Another possibility, particularly for the rim sherd with fingernail-shaped indentations, is an Apachean association. Both the rim and decorations seem to conform to the expectations of a widespread "Athabaskan" technology that spread across much of the Southwest by the sixteenth or seventeenth century (Ferg 1988, 2004; Seymore 2008). For the Chiricahua Apache, one or more rows of fingernail indentations along the neck are used to define a Rimrock variety, while the presence of the same type of indentations over most of the vessel surface is the basis for the recognition of a Strawberry Variety (Ferg 2004). Thus, it is quite possible that forms produced by Mescalero and Chiricahua Apache groups, known to have occupied the southern part of New Mexico during the Protohistoric and Historic periods, may be represented. While the single fingernail-incised sherd is the best, if not conclusive, ceramic evidence of a Protohistoric component, it is also possible that some of the unpolished sherds with plain surfaces assigned to Jornada types could have originated in Apache vessels, since most complete Apache vessels identified thus far do not exhibit surface texture. Unfortunately, none of the sherds recovered during this project were large enough to exhibit clues relating to overall vessel shape, such as the presence of a pointed bottom, which often provide the basis for the identification of Apache vessels.

Jornada (Three Rivers) Red Ware

Pottery with a combination of Jornada Brown paste and red slip or painted decorations is commonly assigned to various types of the Three Rivers Red Ware tradition (Wimberly and Rogers 1977). This tradition includes such painted types as Three Rivers Red-on-terracotta and Lincoln Black-on-red, which do not appear to have been produced until after the beginning of the twelfth century AD (Wiseman 2002). Evidence for the development of Three Rivers Red Ware out of earlier Mogollon types, such as San Francisco Red and Mogollon Red-on-brown, has long been noted (Mera 1943). The use of a red slip over a brown-ware paste appears to have been derived from San Francisco Red, a Mogollon type that appeared during the early period of pottery production in the Mogollon region (Wilson 1999). Examples assigned to this type exhibit thin to moderately thick red slips and no painted decorations. By the late sixth century AD, red-slipped plain wares with a variety of pastes and tempers were produced in most Southwest regions (Daifuku 1961; LeBlanc 1982; Reed et al. 2000). It is possible that some of the slipped red sherds identified in this analysis could actually have derived from painted vessels. Sherds assigned to *Plain Slipped Red* exhibit a thin red, slightly polished slip applied to at least one surface of vessels that were produced with pastes and tempers typical of Jornada Brown. Examples assigned *to Plain Slipped Red (Sand Temper)* exhibit sand temper and a red slip with a highly polished surface.

El Paso Brown and Polychrome Ware

The most common type identified during the present study includes *El Paso Brown Rim* and *El Paso Brown Body*. This type is sometimes distinguished from Jornada Brown Ware by the absence of a distinct polished surface, more scraping marks on the interior surface, and the presence of large temper fragments that include rounded quartz (Miller 1995; Miller and Kenmotsu 2004; Runyon and Hendrick 1987; Whalen 1981, 1994); temper often protrudes through the surface. A few examples may display temper characteristic of other Jornada Brown ware groups, although almost all the sherds assigned to this type during the present study contain large temper fragments. Pastes on El Paso Brown sherds also tend to be soft and dark gray or brown with a dark core; surfaces are often dark gray to chocolate brown. Sherds exhibiting this combination of characteristics were classified as either El Paso Rim or El Paso Body. Rim sherds exhibit the straight rims considered characteristic of early forms, distinguishing them from those found on El Paso Polychrome vessels. This observation is supported by the general absence of other characteristics, such as red slips and very thin vessel walls, which are typical of El Paso Polychrome. However, two sherds that have pastes similar to that found with El Paso Polychrome, but also exhibit probable black pigment, were assigned to El Paso Polychrome.

Despite the presence of painted decorations, surfaces tend to be crudely smoothed or scraped. Vessel types are commonly very large and thin jars, although some examples of bowls also occur. Surfaces may be brown and unslipped or may exhibit a thin red slip. Painted decorations often combine red slip and black mineral paint. In some schemes, sherds thought to be derived from vessels exhibiting painted decoration in pigments of only one color are classified as El Paso Bichrome, while those with decorations in both black and red pigment are classified as El Paso Polychrome (Seaman and Mills 1988). It is likely, however, that many smaller sherds previously classified as El Paso Bichrome could be from El Paso Polychrome vessels. All painted brownware sherds identified during this study were assigned to El Paso Polychrome, although information regarding pigment color combinations was recorded separately. El Paso Polychrome is characterized by large geometric motifs executed in red and black paint (Stallings 1931). Designs are often fairly crude and include alternating lines in black and red. Since decoration on jars is often limited to the rim or neck areas, unpainted body sherds from El Paso Polychrome may be classified as El Paso Brown body.

Mimbres White Ware

Mimbres White Ware refers to white slipped and painted pottery that was produced mainly in the southern Mogollon highlands area of the Mimbres region (Brody 1977; Haury 1936; Wilson 1999). Mogollon Painted and Mimbres White Ware types exhibit high-iron pastes and fine volcanic temper similar to other Mogollon pottery types. Painted decorations are executed in iron-based mineral pigments applied over a white slipped surface. The white slipped surfaces contrast dramatically with the gray to brown colors seen in the paste and unslipped surface. Slips tend to be soft and easily weathered, resulting in the common obliteration of surfaces. Surfaces are usually moderately to lightly polished, but are not as lustrous as contemporaneous white ware types from other regions. A long-lived tradition reflecting the gradual development of Mimbres White Ware types from Three Circles Red-on-white to Mimbres Black-on-white is indicated.

Mimbres White Ware types were distinguished based on the presence of a slip, paint color, and stylistic attributes. Given the small number and size of specimens represented, the few Mimbres white-ware sherds identified were assigned to descriptive types including *Mimbres White Ware Unpainted* and *Mimbres Black-on-white Undifferentiated*.

Cibola White Ware

Other white wares examined during this study exhibit combinations of traits potentially indicative of pottery types defined for the Cibola White Ware tradition. Types associated with this tradition appear to have been produced over wide areas mostly in the Colorado Plateau. Cibola white ware types were recognized based on the presence of sand, sand and sherd, or sherd temper, light low-iron paste, and decorations in mineral paint. Unpainted sherds exhibiting sherd or sand temper and white clay paste and slip were assigned *to Unpainted Polished White Ware*. Those with similar pastes but with indistinct decorations in mineral paint were assigned to *Mineral Paint Undifferentiated*. Surface treatments and decorations in fine lines noted in the painted sherds most likely indicate earlier types such as San Marcial or Red Mesa Black-on-white.

Examination of Trends

Distributions of types and attributes in sherds recovered from six of the sites investigated during the Spaceport America project may be used to examine various patterns. The rarity of pottery recovered during this study may reflect the long-term use of the project area as part of a much larger seasonal strategy. This would have included both horticulture and seasonal foraging that encompassed an extremely wide area over several different environmental zones. Formative components, most commonly identified by the occurrence of ceramics, likely reflect just one aspect of a much larger adaptive pattern that would have sometimes included both horticulture practiced in surrounding upland and riparian landscapes along with the continued importance of earlier foraging patterns in landscapes not conducive to horticulture such as that represented by the project area. Such use is supported by the large number of components reflecting a very long occupational sequence during both the pre-ceramic and ceramic periods (Moore et al. 2010). Variation in strategies employed over a large area appears to be supported by the widespread distribution of similar pottery on both small seasonal sites throughout the Jornada del Muerto and adjacent areas, as well as in surrounding communities, including those along the western slopes of the San Andres Mountains, where agriculture was practiced from at least AD 900 to 1400. (Browning 1991; Duran 1982; Kemrer 2008, 2010; Lekson and Rorex 1987; Sale and Lambauch 1989). Ceramic data from these communities provide important insights into the nature of the seasonal use of the project area by ceramic producing groups. Pottery may provide some clues concerning the dating of these components, although the very small size as well as the generalized and conservative nature of the types of vessels that would have been used in foraging activities may limit the types of interpretation that can be made based on these data. It is safe to assume that vessels associated with seasonal sites investigated during this study were not produced in the locality of their recovery. This pottery seems to have been produced at localities where groups resided through much of the year or in those regions with which they regularly interacted. Thus, the identification of pottery assigned to types associated with various regional traditions or production areas may provide important insights concerning the nature of broad economic strategies that would have included a mixture of horticulture in some areas, as well as foraging over the extremely diverse combination of desert, plains, mountainous, and riparian environments that cover surrounding areas of southwest and south-central New Mexico and west Texas.

In addition, the characterization of overall vessel form may provide important clues about the nature of activities in which pottery was used in seasonal activities. Such trends can be compared with those seen in seasonal and horticultural sites in other areas of the Jornada Mogollon region as well as elsewhere in the Southwest to better understand the nature of patterns associated with the diverse range of activities for which ceramics were used to adapt to the varied and challenging environments in southern New Mexico. Distributions of surface characteristics and vessel forms may provide insights into the importance and nature of pottery vessels in critical tasks as indicated by distributions of vessel form and ware group attributes.

One perspective that may provide insights into the role of pottery associated with different strategies involving varying levels of mobility focuses on the role of containers in evening out spatial and temporal resource variation. The use of ceramic containers in the storage and processing of foods would have reduced risks imposed by resource heterogeneity that provided alternatives to strategies associated with full-scale mobility (Mills 1989). A model for understanding such changes involves the distinction between maintainable and reliable technological systems (Mills 1989). Maintainable systems sacrifice durability for other features such as portability, while reliable systems provide for increased durability. The expected characteristics of ceramic vessels that reflect maintainable systems include simple and easily transferred manufacturing and repairing techniques, portability, and use in a limited range of tasks. Those associated with maintainable systems tend to require specialized and time-consuming manufacturing and firing techniques that also commonly include an emphasis on more elaborate and visible decorative conventions as commonly reflected in decorated wares. Containers associated with reliable production systems tend to be abundant and sturdy, and often involve more specialized decorated forms that are more resistant to failure during specific tasks. Thus, most of the pottery used by Jornada Mogollon groups practicing mobile patterns of subsistence in marginal areas (similar to that associated with earlier non-ceramic groups) would be expected to exhibit the overall characteristics of maintainable systems. It is also possible that the dominance of generalized brown wares at later sites in the project area and surrounding localities could reflect the continuation of ceramic forms suitable for foraging activities. Finally, the rarity of pottery at Protohistoric sites in general, as well as characteristics of the few Athabaskan utility wares that may be present in the assemblage, seems to reflect an almost complete reliance on a maintainable technology by the mobile groups who resettled this region after its abandonment by Formative groups.

Ceramic Dating

One of the major uses of ceramic data recovered from sites across the Southwest involves the determination of the likely temporal span of occupation as reflected by the combination of dated pottery types noted in assemblages from a particular site or context. The assignment of dates to small seasonal sites in the Jornada Mogollon area of southeast and south-central New Mexico is often made difficult by the small size and conservative nature of these assemblages. Their conservative nature is reflected by the overwhelming dominance of similar plain brown-ware types over much of the region from at least AD 500 to 1400 (Batcho et al. 1985; Hasbargen and Railey 2008; Hogan 2006; Katz and Katz 1992; Sebastian and Larralde 1989; Wilson 2000b, 2003; Wiseman 1996, 2002, 2003, 2004). For assemblages that are overwhelmingly dominated by, or only contain plain brown-ware types, it is often difficult or impossible to assign a specific dating span to small assemblages from almost any period. Thus, the recovery of independent (particularly radiocarbon) dates from the sites investigated during this project is particularly important.

While ceramics from the project area reflect several traditions, the ceramic sequence defined for the Southern Mogollon region that is best known for areas to the west and southwest of the project area adjacent to the Rio Grande in far west Texas and south-central New Mexico appears to be applicable. The earliest phase defined for this region is the long-lived Mesilla phase (AD 200 to 1000), for which ceramics are almost exclusively represented by similar plain brown-ware pottery assigned to El Paso Brown (Miller 1995; Miller and Kenmotsu 2004; Whalen 1993, 1994). Despite the long dominance of El Paso Brown, there is some evidence of gradual changes in the overall range of characteristics noted for pottery assigned to this type (Whalen 1981, 1994). These trends may reflect slight decreases in the overall range of temper size and wall thickness, and increases in fineness of surface finish and surface hardness through time (Whalen 1994). Distinct types associated with other regional traditions that may occur on sites dating to this period may include various plain and early textured Mogollon brown-ware types, San Francisco Red, and Mimbres white ware assumed to have been produced in the Mimbres or southern Mogollon region, as well as Cibola white ware types such as San Marcial Black-on-white (AD 750 to 950) and Red Mesa Black-on-white (AD 900 to 1050) occurring on sites in the Rio Abajo region (Marshall and Walt 1984).

The local ceramic tradition reflected in earlier periods by El Paso Brown in the El Paso region underwent a series of changes from about AD 1000 to 1350 that are largely reflected by the emergence of El Paso Polychrome as the dominant pottery type (O'Laughlin 1980; Mauldin 1993; Miller 2004; Whalen 1981). Design trends in El Paso painted forms exhibit increasing elaboration, including the addition of secondary design elements and multiple band layouts. Trends in unpainted brown-ware pottery include the augmentation of assemblages dominated by bowls with short-necked jars that have increasingly thin walls. These types were replaced by AD 1250–1300 with necked jars with everted rims, which increasingly dominate later assemblages. Early and late variants of El Paso Polychrome have been identified based on increases in variation of rim thickness. The most common technique for establishing and dating changes during these later periods is based on the calculation of a rim-sherd index (Seaman and Mills 1988). This technique requires fairly large sherds because two different thicknesses are taken on each sherd. Such changes aid in the recognition and differentiations of assemblages dating to the Doña Ana (AD 1000–1275) and El Paso (AD 1275–1450) phases.

Sequences of pottery changes have also been defined for areas in the Sierra Blanca Mountains to the east and north of the project area (Kelley 1984).

Phases defined for this region include the Glencoe and Lincoln. Jornada Brown appears to dominate the pottery produced in this area during all phases, though later phases may be recognized by the occurrence of locally produced textured types such as Corona Corrugated and a range of decorated types including Chupadero Black-on-white dating from about AD 1100 to AD 1450 (Kelley 1984; Farwell et al. 1992; Hayes et al. 1981; Wiseman 1986), Three Rivers Red-on-terracotta produced from about AD 1100 to 1350 (Kelley 1984), and Lincoln Black-on-red from about AD 1300 to 1400 (Mera and Stallings 1931; Wiseman 2002). Types produced outside the Jornada region that occur in later components may include Rio Grande Glaze Ware (Hayes et al. 1981), Salado Polychrome (Crown 1994; Lindsay and Jennings 1968; Wilson 1998; Wood 1987), late Cibola White Ware (Rinaldo and Bluhm 1956), White Mountain Red Ware (Carlson 1970), and Chihuahua Polychrome and utility ware types (DiPeso et al. 1974).

Another temporally important change that may be represented in southeast and south-central New Mexico at small habitation and seasonal sites that are dominated by undecorated ceramics consists of a change from assemblages dominated by El Paso Brown to those dominated by Jornada Brown and contemporary decorated ware types that occur after AD 1100 (Wilson 2000b; 2003; Wiseman 1991). This change may reflect shifts in regional interaction and economic systems and may even occur in small assemblages that have very few decorated pottery types, or that have none at all.

The Jornada Mogollon region was abandoned by agricultural groups by about AD 1450. Much of this region appears to have been exploited by highly mobile Athabaskan-speaking groups, such as the Mescalero and Chiricahua Apache, sometime during the Protohistoric period, and may include components dating possibly as early as the sixteenth century. It is likely that Apachean groups used the abandoned parts of the Jornada region, as well as other Southwest regions, as part of an extremely extensive year-round strategy, which would have included both the use of widely scattered faunal and wild-plant resources as well as interaction (including trade and raiding) with widely scattered Pueblo and Spanish settlements from whom agricultural foods were obtained (Baugh 1984; Spielmann 1983, 1996). While ceramics tend to be extremely rare on Apache sites, distinctive utility wares of apparent Apache manufacture have been identified in widely scattered areas (Brugge 1982; Ferg 2004). Thus, the identification of any pottery that is potentially of Apache origin may be crucial to the identification of Protohistoric components, which could otherwise be mistaken for seasonal sites occupied during the Formative or aceramic periods.

Pottery Distributions for Spaceport Sites

Data relating to traits and distributions of pottery from sites investigated as part of the Spaceport project are presented here; they provide the basis for the examination of various trends. The pottery assemblage from the sites investigated during this project was dominated by plain ware types assigned to either El Paso Brown or Jornada Brown (Tables 18.1, 18.2). Similarities noted in this pottery appear to reflect the very long-term production of similar plain brown-ware forms across the Jornada region as well as the use of simple maintainable technologies suitable for foraging-related activities. Slight differences in the characteristics of pottery recovered from different sites or assemblages may indicate shifts in seasonal foraging patterns that reflect changes in cultural association or area of origin as well as the overall form of pottery vessels used in activities conducted at different locations.

LA 111422

The 227 sherds recovered and examined from LA 111422 are almost exclusively unpainted plain brown-ware types (Tables 18.1–18.3). Recovery locations for this pottery include surface collection (22 sherds), Surface Strip 1 (50 sherds), Surface Strip 2 (148 sherds), Surface Strip 4 (1 sherd), and the surface strip around Feature 4 (6 sherds). The great majority (95.2 percent) of this pottery consists of Jornada brown-ware types, with most of the remaining sherds being assigned to El Paso Brown. Jornada Brown sherds are characterized by a fine, crystalline igneous temper (Table 18.4) and reddish to dark gray paste. Two sherds assigned to this tradition exhibit a fine volcanic temper similar to that noted in pottery from the Mogollon Highland region. Most surfaces are tan-brown in color, and most sherds display a light to moderate polish on the exterior and are unpolished on the interior. Most of the remaining sherds display similar polish on the interior and an unpolished exterior (Table 18.5). This may indicate that most of these sherds are derived from jars with a lower but significant frequency of bowls. One brown-ware sherd exhibits a beveled edge, which indicates subsequent use as a tool. The presence of jar rim and neck sherds indicate that jars are definitely represented in this assemblage, while no bowl rim sherds were identified. Both shape and abrasion of some brown-ware sherds indicate the probable use of some vessels for cooking. Sherds assigned to El Paso Brown exhibit slightly larger granite temper and dark paste. All sherds assigned to this type appear to have slight exterior polish suggesting they are derived from jars. Specimens assigned to El Paso Brown include single examples of jar neck and jar rim sherds. One jar body sherd was assigned to El Paso Polychrome based on the possible presence of the remnant of a thin line of black paint on the exterior surface. Whether this effect was intentionally achieved, which would indicate that this sherd represents a painted type, could not be definitely ascertained; its characterization as El Paso Polychrome should be considered problematic.

Charcoal samples recovered from two contexts at LA 111422 yielded radiocarbon dates. A sample from Feature 1 yielded a two-sigma date range of AD 540 to 650 while that from Feature 4 yielded a 2-sigma date range of AD 570 to 650. Pottery recovered from these features was limited to seven Jornada Brown Body sherds from Feature 4. It is possible that most of the pottery recovered from LA 111422 is contemporary with the very early dates associated with these features, given these periods seem to be roughly contemporaneous with the earliest dates ascribed to the production of Jornada Brown in the Sierra Blancas (Campbell and Railey 2006; Rocek 1991, 1995). While the single sherd assigned to El Paso Polychrome would postdate that period by several centuries, if this sherd is actually El Paso Brown rather than El Paso Polychrome it would also be consistent with these early dates. Another observation slightly at odds with a very early ceramic component is the absence of sherds derived from seed jars, which is a form that is commonly noted in early Mesilla-phase ceramic assemblages (Miller 1994, 1995). Thus, there is the intriguing possibility, slim as it is, that pottery from this site may reflect use during a very early ceramic phase. Contrary to initial expectations for a very early ceramic component in this area, Jornada Brown outnumbers El Paso Brown and could indicate a very early wave of use of this area by groups from the Sierra Blanca region. Such use would have involved the breakage of a very small number of vessels that would have mostly comprised jars, and that may indicate peripheral environments were exploited by Formative-period groups at a very early date.

LA 111429

Only one sherd was recovered from the surface of LA 111429 (Tables 18.1 and 18.2) and was not associated with any specific analytic provenience. This sherd was assigned to Jornada Brown and exhibits temper typical of this type. This specimen is a body sherd with polish on the exterior only.

LA 111435

Pottery from LA 111435 includes a mixture of sherds classified as El Paso Brown (63.8 percent) and Jornada Brown (36.2 percent). These include 16 sherds collected from the surface, 24 from Surface Strip 2, and 29 from Surface Strip 3 (Table 18.6). The majority of the sherds from this site that are assigned to El Paso Brown are unpolished on both sides, exhibit large fragments of granite temper, have gray-brown to chocolate-brown pastes, and are fairly thick. In contrast, those assigned to Jornada Brown tend to have fine tempers in tan-brown to brown pastes, exhibit one polished surface, and tend to be relatively thin (Table 18.7). Most of these sherds are probably derived from jars, although some of the Jornada Brown sherds exhibit interior polish and may be derived from bowls (Table 18.8). While Feature 8 from this site yielded a radiocarbon date of AD 880 to 990, no ceramics were recovered from this feature. Still, a small assemblage dominated by El Paso Brown seems consistent with observations from sites across much of southern New Mexico that include components roughly dating to a span covering the eighth through the early tenth centuries (Katz and Katz 1985; Rocek 1991, 1995; Staley et al. 1996; Wilson 2002, 2003; Wiseman, ms. in prep.). The relatively wide distribution of very small brown-ware assemblages that are often dominated by El Paso Brown at small shallow habitations and seasonal sites seems to reflect influences from areas in the El Paso region dating to the Mesilla phase. This pottery could reflect seasonal use of the

Spaceport area by Formative-period groups during the Mesilla phase, as well as pottery that may have been distributed to mobile groups who exploited this area as part of their seasonal rounds.

LA 155968

Nine El Paso Brown sherds were recovered from LA 155968. These include four sherds collected from the general surface, four from surface stripping of Feature 1, and one from excavation of Feature 1 (Table 18.9). Five radiocarbon samples from Feature 1 yielded dates from the seventh and the eighth or ninth centuries AD. All but one sherd was classified as a jar body and one was a jar neck. Pottery from this site seems to reflect trends associated with the seasonal use of the project area during the early Formative period, similar to those noted for other sites from which early brown wares represent the sole ceramics.

LA 155963

A total of 735 sherds were recovered from LA 155963, including 77 sherds from the surface, 4 sherds from Surface Strip 1, 539 sherds from Surface Strip 2, 85 sherds from Surface Strip 3, 2 sherds from the Feature 8 surface strip, 5 sherds from the Feature 8 surface collection, 8 sherds from the Feature 125 surface strip, 1 sherd from the Feature 125 surface collection, 5 sherds from Feature 125 excavation, and 9 sherds from Feature 141 excavation (Table 18.10). Radiocarbon dates from this site cover a very long span ranging from the Late Archaic into the Protohistoric and early Historic periods. Variability noted in paste, temper, and surface attributes indicate a wider range of traditions and types than is seen at the other Spaceport sites (Table 18.11). This variation is reflected by Jornada Mogollon types that exhibit a range of tempers, including at least four distinct temper groups, which are indicative of three types, as well as tempers indicative of Cibola and Mimbres white-ware types. As is the case for the other sites examined by this study, the great majority of the pottery from LA 155963 was assigned to plain brown-ware types, which include 715 (97.3 percent) of the sherds examined from this site. Most of these sherds were assigned to El Paso Brown, which comprises 78.3 percent of the ceramic assemblage, while Jornada Brown makes up another 18.9 percent. Because of the presence of red slipped, textured utility, and decorated types, a wider range of pottery types is reflected at this site than at other project sites. The presence of these types may in part be due to the larger sample of pottery available from LA 155963, though it could also reflect slightly later use or a wider range of temporal components than are seen at the other sites.

The presence of white wares in Surface Strip 2, where all of the white wares and most of the pottery from LA 155963 were recovered, reflects combinations of pottery types noted at sites dating from the tenth to eleventh centuries AD (Kemrer 2005, 2007; Lambach et al. 2002; Levine 1997; McCluney 1961, 1962; Mera 1943; Peckham 1976). While not included in the analysis of pottery from the research-oriented investigations, one Chupadero Black-on-white bowl rim sherd and one unpainted white ware with sherd temper, apparently from the Chupadero area, were collected during the testing phase. Red-ware types that may be expected to occur in components dating after AD 1100—such as Three Rivers Red-on-terracotta and Lincoln Black-on-white (Kelley 1984; Wiseman 2002)—were not noted. While none of the white wares from this site could be assigned to a specific type, overall characteristics may be indicative of Cibola white wares that exhibit the thin lines common in early forms such as Red Mesa Black-on-white. Other decorated pottery included six Mimbres undifferentiated white ware sherds, including four unpainted and two painted sherds. While the great majority of the sherds represent unpainted brown wares that are mostly derived from jars, all of the white ware sherds appear to represent bowls (Table 18.12). Wear noted in some of these sherds indicates their probable use in cooking (Table 18.13). An abraded edge on one brown-ware sherd is indicative of its subsequent use as a tool. Thus, functionally, these assemblages most closely resemble those associated with early parts of the Formative period, though the low frequency of white wares may reflect slight differences in the type and range of activities performed at this site versus the other early Formative-period sites examined by this study.

Other ceramic types recovered from LA 155963 are evidence of later components. As previously noted, two sherds collected during the testing phase are derived from Chupadero Black-on-white bowls. While a single sherd assigned to El Paso Polychrome (based on the presence of mineral paint) may also reflect a later component, most of the sherds assigned to El Paso Brown exhibit surface character-

Table 18.3. LA 111422, distribution of pottery types by recovery location.

Pottery Type	Surface Collection		Surface Strip 1		Surface Strip 2		Surface Strip 4		Feature 4 Surface Strip		**Total**	
	Count	Col. %	Count	Col. %	Count	Col. %	Count	Col. %	Count	Col. %	Count	Col. %
El Paso Brown Rim	–	–	–	–	1	0.7	–	–	–	–	1	0.4
El Paso Brown Body	9	40.9	–	–	–	–	–	–	–	–	9	4.0
El Paso Polychrome	–	–	–	–	1	0.7	–	–	–	–	1	0.4
Jornada Brown Rim	1	4.5	3	6	1	0.7	–	–	–	–	5	2.2
Jornada Brown Body	12	54.5	47	94	145	97.2	1	100.0	6	100.0	211	93.0
Total	22	100.0	50	100.0	148	100.0	1	100.0	6	100.0	227	100.0

Table 18.4. LA 111422, distribution of temper types by ware group.

Temper Type	El Paso Brown		El Paso Polychrome		Jornada Brown		**Total**	
	Count	Col. %	Count	Col. %	Count	Col. %	Count	Col. %
Granite	10	100.0	1	100.0	–	–	11	4.8
Crystalline igneous	–	–	–	–	215	99.5	215	94.7
Mogollon volcanics	–	–	–	–	1	0.5	1	0.4
Total	10	100.0	1	100.0	216	100.0	227	100.0

Table 18.5. LA 111422, distribution of vessel forms by ware group.

Vessel Form	El Paso Brown Ware		El Paso Polychrome		Jornada Brown Ware		**Total**	
	Count	Col. %	Count	Col. %	Count	Col. %	Count	Col. %
Jar neck	1	10.0	–	–	16	7.4	17	7.5
Jar rim	1	10.0	–	–	3	1.4	4	1.8
Jar body	8	80.0	1	100.0	2	0.9	11	4.8
Body sherd polished interior and exterior	–	–	–	–	1	0.5	1	0.4
Body sherd unpolished	–	–	–	–	44	20.4	44	19.4
Body sherd unpolished interor-polished exterior	–	–	–	–	148	68.5	148	65.2
Indeterminate rim	–	–	–	–	2	0.9	2	0.9
Total	10	100.0	1	100.0	216	100.0	227	100.0

Table 18.6. LA 111435, distribution of pottery types by provenience.

Pottery Type	Surface Collection		Surface Strip 2		Surface Strip 3		**Total**	
	Count	Col. %	Count	Col. %	Count	Col. %	Count	Col. %
El Paso Brown Body	6	37.5	9	37.5	29	100	44	63.8
Jornada Brown Body	10	62.5	15	62.5	–	–	25	36.2
Total	16	100	24	100	29	100	69	100.0

Table 18.7. LA 111435, distribution of temper types by ware group.

Temper Type	El Paso Brown Ware		Jornada Brown Ware		Total	
	Count	Col. %	Count	Col. %	Count	Col. %
Granite	44	100	–	–	44	63.8
Crystalline igneous	–	–	25	100	25	36.2
Total	44	100	25	100	69	100.0

Table 18.8. LA 111435, distribution of vessel forms by ware group.

Vessel Form	El Paso Brown Ware		Jornada Brown Ware		**Total**	
	Count	Col. %	Count	Col. %	Count	Col. %
Jar neck	1	2.3	2	8	3	4.3
Jar body	43	97.7	–	–	43	62.3
Body sherd unpolished	–	–	2	8	2	2.9
Body sherd unpolished interior-polished exterior	–	–	21	84	21	30.4
Total	44	100.0	25	100	69	100.0

Table 18.9. LA 155968, distribution of pottery types by provenience.

Pottery Type	Surface Collection		Feature 1 Surface Strip		Feature 1 Excavation		**Total**	
	Count	Col. %	Count	Col. %	Count	Col. %	Count	Col. %
El Paso Brown Body	4	100	4	100	1	100	9	100

Table 18.10. LA 155963, distribution of pottery types by provenience.

Ware	Pottery Type	Surface Collection		Surface Strip 1		Surface Strip 2		Surface Strip 3		Feature 8 Surface Strip		Feature 8 Surface Collection		Feature 125 Surface Strip		Feature 125 Surface Collection		Feature 125 Excavation		Feature 141 Excavation		**Total**	
		Count	Col. %	Count	Col. %	Count	Col. %	Count	Col. %	Count	Col. %	Count	Col. %	Count	Col. %	Count	Col. %	Count	Col. %	Count	Col. %	Count	Col. %
Cibola White Ware	Unpainted, Polished, White Ware	–	–	–	–	4	0.7	–	–	–	–	–	–	–	–	–	–	–	–	–	–	4	0.5
	Mineral Paint Undifferentiated	–	–	–	–	1	0.2	1	1.2	–	–	–	–	–	–	–	–	–	–	–	–	2	0.3
El Paso Brown Ware	El Paso Brown Rim	5	6.5	–	–	7	1.3	–	–	–	–	–	–	–	–	–	–	–	–	–	–	12	1.6
	El Paso Brown Body	68	88.3	4	100.0	422	78.3	39	45.9	2	100.0	5	100.0	8	100.0	–	–	1	20.0	7	77.8	556	75.6
	Indeterminate Brown Ware with Large Sand	–	–	–	–	6	1.1	2	2.4	–	–	–	–	–	–	–	–	–	–	–	–	8	1.1
El Paso Polychrome	El Paso Polychrome	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	20.0	–	–	1	0.1
Jornada Red Ware	Plain Slipped Red	–	–	–	–	2	0.4	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2	0.3
	Plain Slipped Red	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	3	60.0	–	–	3	0.4
Jornada Brown Ware	Jornada Brown Body	–	–	–	–	37	6.9	23	27.1	–	–	–	–	–	–	–	–	–	–	2	22.2	62	8.4
	Incised Brown	–	–	–	–	1	0.2	–	–	–	–	–	–	–	–	1	100.0	–	–	–	–	2	0.3
	South Pecos Brown Body	–	–	–	–	57	10.6	20	23.5	–	–	–	–	–	–	–	–	–	–	–	–	77	10.5
Mimbres White Ware	Mimbres White Ware Unpainted	–	–	–	–	2	0.4	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2	0.3
	Mimbres Black-on-white Undifferentiated	4	5.2	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	4	0.5
Total		77	10.48	4	0.5	539	73.3	85	11.6	2	0.3	5	0.7	8	1.1	1	0.1	5	0.7	9	1.2	735	100.0

Table 18.11. LA 155963, distribution of temper types by ware group.

Temper Type	Cibola White Ware		El Paso Brown Ware		El Paso Polychrome		Jornada Red Ware		Jornada Brown Ware		Mimbres White Ware		**Total**	
	Count	Col.%	Count	Col.%	Count	Col.%	Count	Col.%	Count	Col.%	Count	Col.%	Count	Col.%
Sand	1	16.7	8	1.4	–	–	3	60	–	–	–	–	12	1.6
Sherd and sand	5	83.3	–	–	–	–	–	–	–	–	–	–	5	0.7
Granite	–	–	568	98.6	1	100.0	–	–	–	–	–	–	569	77.4
Crystalline igneous	–	–	–	–	–	–	2	40	64	45.4	–	–	66	9.0
Mogollon volcanics	–	–	–	–	–	–	–	–	–	–	6	100.0	6	0.8
Dark feldspar	–	–	–	–	–	–	–	–	5	3.5	–	–	5	0.7
Indeterminate feldspar	–	–	–	–	–	–	–	–	72	51.1	–	–	72	9.8
Total	6	100.0	576	100.0	1	100.0	5	100	141	100.0	6	100.0	735	100.0

Table 18.12. LA 155963, distribution of vessel forms by ware group.

Vessel Form	Cibola White Ware		El Paso Brown Ware		El Paso Polychrome		Jornada Red Ware		Jornada Brown Ware		Mimbres White Ware		**Total**	
	Count	Col. %	Count	Col. %	Count	Col. %	Count	Col. %	Count	Col. %	Count	Col. %	Count	Col. %
Bowl body	2	33.3	–	–	–	–	3	60.0	–	–	5	83.3	10	1.4
Jar neck	–	–	37	6.4	–	–	–	–	6	4.3	1	16.7	44	6.0
Jar rim	–	–	12	2.1	–	–	–	–	3	2.1	–	–	15	2.0
Jar body	4	66.7	524	91.0	1	100	2	40.0	5	3.5	–	–	536	72.9
Body sherd polished interior and exterior	–	–	1	0.2	–	–	–	–	–	–	–	–	1	0.1
Body sherd unpolished	–	–	1	0.2	–	–	–	–	99	70.2	–	–	100	13.6
Body sherd unpolished interior-polished exterior	–	–	1	0.2	–	–	–	–	23	16.3	–	–	24	3.3
Body sherd polished interior-unpolished exterior	–	–	–	–	–	–	–	–	5	3.5	–	–	5	0.7
Total		100.0	576	100.0	1	100	5	100.0	141	100.0	6	100.0	735	100.0

Table 18.13. Wear or modification by ware and site.

Ware	Modification	LA 111422		LA 111429		LA 111435		LA 155963		LA 155968		**Total**	
		Count	Col. %	Count	Col. %	Count	Col. %	Count	Col. %	Count	Col. %	Count	Col. %
White Ware	None	–	–	–	–	–	–	12	1.6	–	–	12	1.2
Red Ware	None	–	–	–	–	–	–	5	0.7	–	–	5	0.5
Brown Ware	None	152	67.0	–	–	49	71.0	594	80.8	9	100	804	77.2
	Drill hole complete	–	–	–	–	–	–	1	0.1	–	–	1	0.1
	Beveled edge	1	0.4	–	–	–	–	1	0.1	–	–	2	0.2
	Interior worn from cooking	73	32.2	1	100.0	20	29.0	78	10.6	–	–	172	16.5
	Abraded surface exterior	–	–	–	–	–	–	17	2.3	–	–	17	1.6
	Interior-exterior erosion	–	–	–	–	–	–	25	3.4	–	–	25	2.4
	Exterior partly exfoliated/ eroded	–	–	–	–	–	–	1	0.1	–	–	1	0.1
Polychrome	None	1	0.4	–	–	–	–	1	0.1	–	–	2	0.2
Total		227	100.0	1	100.0	69	100.0	735	100.0	9	100	1,041	100.0

istics and rim shapes reflecting forms dating prior to the El Paso phase. This specimen represents one of six sherds recovered from Feature 125. The ceramics from this feature could indicate a Doña Ana-phase component (AD 1000 to 1275), which could also be reflected by some of the plain brown-ware sherds recovered from this site. Three of the sherds from Feature 125 display red slip and could be derived from El Paso Polychrome vessels, which may in turn indicate that this feature represents a later component, dating to the El Paso phase. However, the radiocarbon date derived for Feature 125 suggests an earlier occupation, in the eighth or ninth centuries, and old wood is likely not responsible for these earlier dates, making this feature difficult to accurately place in a temporal framework. The absence of other late decorated types at LA 155963 may in part be a result of the long history this site has of being visited and surface collected.

The only other feature from which pottery was recovered here is Feature 141, which is represented by numerous radiocarbon dates that span the seventh to ninth centuries AD. This early date seems to be consistent with the identification of types associated with this feature, which include seven El Paso Brown and two Jornada Brown sherds.

As noted earlier, at least one sherd exhibiting finger-nail shaped indentations may have been derived from a vessel produced by Apachean groups sometime during the Historic or Protohistoric periods. Given that the temper in this sherd is similar to that seen in Jornada types, it is also possible that some of the plain-ware sherds identified during this study are also from Apache Utility Ware vessels. Thus, the presence of pottery associated with a Protohistoric component is possible and, considering the late dates for features on several sites, likely.

Summary

The small size of the assemblages examined during this study, combined with the conservative nature of pottery in the Jornada Mogollon region, considerably limits the assignment of dates and other interpretations relating to the nature and use of ceramics recovered from these sites. Still, the characteristics and associations of small assemblages largely dominated by plain brown wares may provide some important clues concerning the nature of these occupations. First, it is likely that ceramic components in this area are at the early end of the Jornada Mogollon range, especially when compared with the larger and better known residential sites in the region, such as those at the edge of the San Andres Mountains. Data from such sites seem to indicate sequences of occupations spanning the period from about AD 900 to 1400 (Kemrer 2005, 2007; McCluney 1961, 1962). For example, radiocarbon dates may indicate that the use of several sites and components investigated during the project—including LA 111422, LA 111435, the Feature 1 area at LA 155968, and the sherd area at LA 155963—may all predate this time period and so reflect the seasonal use of this area from the sixth through the tenth centuries AD. Interestingly, these sites and components include pottery assemblages dominated by both Jornada Brown and El Paso Brown. These components seem to coincide with the long-lived (AD 200 to 1000) Mesilla phase. This phase is thought to be characterized by a very conservative technology that involved a mixture of horticultural and gathering activities (Whalen 1981). Certainly, the simple bowl and jar vessel forms associated with this type of technology would have been very suitable for temporary storage and processing of wild foodstuffs during seasonal rounds into the Jornada del Muerto area. Potential causes for the presence of assemblages dominated by plain-ware associated with different regional types (El Paso versus Jornada Brown) are difficult to determine. One explanation is that assemblages dominated by Jornada Brown may be slightly later in time, given trends seen in other areas. Still, both types appear to have first been made during the early part of the Formative period, and it is also possible that such differences reflect the seasonal rounds of groups residing in different areas of the Jornada Mogollon region.

Almost all evidence for later decorated types—including Cibola White Wares, Mimbres White Wares, Chupadero Black-on-white, and El Paso Polychrome—is from LA 155963, and may reflect use of the region between the tenth and early thirteenth centuries AD, during the time in which agricultural villages were occupied in the San Andres Mountains. The later assemblages that contain these decorated types are still overwhelmingly dominated by plain brown utility wares and seem to reflect the persistence of earlier patterns of vessel use. The absence of components dating to later phases of the Formative period seems to be supported by the distribution of ceramic types and the lack of brown wares exhibiting a sherd-rim index indicative of later occupations. It is also possible, however, that later decorated types at some of these sites may have been removed by visitors or collectors, largely erasing any ceramic evidence of later Formative-period components. As noted earlier, a single sherd of possible Apache origin was also recovered from LA155963, and given similarities of pastes in pottery associated with the Jornada Mogollon and Apache traditions, it possible that other sherds classified as Jornada Mogollon by this study are actually of Apache origin. This is consistent with radiocarbon dates produced by a number of different features on the investigated sites, and both the presence of this sherd and the late dates reflect use of the region during the Protohistoric and early Historic periods.

19 | Radiocarbon Analysis

Jeffrey L. Boyer

Introduction

Chronological control is the first of four research themes for the Spaceport America investigations. Survey and testing excavations in the Spaceport America project area pointed to human presence from Paleoindian to historic and modern time periods (Moore et al. 2010). Moore and Dello-Russo (2010:68–69) define two specific research questions that coordinate relative dating techniques focused on temporally diagnostic ceramic and projectile point types with chronometric dating techniques that include optically stimulated luminescence (OSL), and radiocarbon dating to obtain occupation/use dates for each site; identify and date distinct temporal components for sites where these are present; compare components between sites; refine the regional chronologies of the middle Jornada del Muerto region; and aid in fitting the middle Jornada del Muerto region into evolving pictures of human use of southern New Mexico.

Seventy-two samples were collected from the Spaceport America sites for radiocarbon dating. Of those, 37 samples of burned organic material and two samples of soil from six sites were submitted to Beta Analytic, Inc. (Table 19.1, Appendix 6). Specific provenience types include charcoal stains (n = 4), fire pits (n = 6), roasting pits (n = 5), fire-cracked rock concentrations (n = 2), and a possible ephemeral structure, as well as the A horizon of a paleosol. Selection of dating samples was based on the presence of adequate amounts of burned materials, their potential to provide dates for each site, and their potential to confirm and provide dates for both intra- and inter-site temporal components. Samples were also selected from materials with different carbon pathways, providing data for comparing dates obtained from different materials and, potentially, from different use and depositional contexts.

Radiocarbon dates from the Spaceport America sites range from the early third millennium BC, during the Middle Archaic period, to the AD nineteenth or early twentieth centuries. Twenty samples (51.3 percent) yielded conventional radiocarbon dates in the Mesilla phase or the transition from the Late Archaic period to the Mesilla phase, ca. 30 BC to AD 1000. Fourteen samples (35.9 percent) yielded conventional dates between the fifteenth century AD, the Protohistoric period, and the twentieth century, an interesting result since neither protohistoric nor historic components were identified during survey and testing (Moore and Dello-Russo 2010:68). Of the remaining samples, one dates to the Middle Archaic period, three to the Late Archaic period, and two to the late Doña Ana or early El Paso phases, ca. AD 1250 to 1300.

Methodological Background

Following material identification, the 39 selected samples were submitted to Beta Analytic, Inc., for standard radiometric (n = 3) or accelerator mass spectrometry (AMS; n = 36) radiocarbon analysis and dating. The results for each sample include the measured radiocarbon age in years BP (before AD 1950), which is corrected for $\delta^{13}C$—the ratio of ^{13}C to ^{12}C in ‰ (“isotopic fractionation”)—in the sample, producing the conventional radiocarbon age, also in years BP. Inherent variability in the presence of carbon isotopes in each sample as well as in detection and counting procedures produces an error factor that is represented in the results as a single standard deviation (1 sigma) value before and after the mean age. Beta Analytic, Inc. also provides dates calibrated to calendar years as 1-sigma and 2-sigma “calibrated results” (atmospheric curve IntCal09; Reimer et al. 2009). The Beta Analytic calibration process uses the conventional radiocarbon age (BP) as a single value, the mean age without its 1-sigma range, and follows that single value as it intercepts the calendar-year curve—or, more accurately, one or more points comprising the curve—and assigns one or more calendar-year values to the conventional age. Those values are presented as "intercept dates." The calibration process then provides 1-sigma and 2-sigma ranges of calibrated dates that account for the intercept date(s) and the range of the conventional age about its mean as it intercepts the calibration curve. The calibrated results are presented as BP and calendar-year date ranges and can include, for a single sample, multiple 1-sigma and 2-sigma ranges derived from the shape of the calibration curve and its interception with the conventional age.

For each sample, the conventional age (BP) and its 1-sigma error value calculated by Beta Analytic, Inc. were then used with two on-line applications, OxCal (v. 4.1.7; https://c14.arch.ox.ac.uk/oxcal/OxCal.html, first accessed August 30, 2012; atmospheric curve IntCal 09) and Calib (v. 6.1.0; http://calib.qub.ac.uk/calib, first accessed August 27, 2012; atmospheric curve IntCal 09) for additional calendar-year recalibrations. Tables 19.2a and 19.2b show that calendar year calibrations produced by Beta Analytic, Inc., and by OxCal and Calib on-line applications are usually very similar and often identical. Since the three calibration processes use the same atmospheric curve (IntCal09), this should not be surprising; differences are related to variations in ways that the three processes present their results. Recalibrations using OxCal and Calib provide results that allow estimation of probability of accuracy and, depending largely on the shape of the calibration curve in relation to specific conventional radiocarbon ages, precision. The Beta Analytic process uses the conventional radiocarbon age as a point with a 1-sigma standard deviation error that creates a range of dates within which any single date has the same probability of accuracy as any other single date. Beta Analytic calibration involves the "interception" of the range of conventional ages with the calibration curve (Fig. 19.1). "Intercept dates" are the points at which the mean conventional age intersects the calibration curve. Ranges of calibrated dates result from the interception of the range of conventional ages with the calibration curve, which is constructed as a best-fit line following data points. Since every conventional age within a range has equal probability of accuracy, every range of calibrated dates also has equal probability of accuracy. Consequently, the Beta Analytic calibration process cannot assign differential probabilities of accuracy to multiple ranges of calibrated dates for a single sample.

For each conventional radiocarbon age with its 1-sigma error, on the other hand, OxCal provides one or more 1-sigma and 2-sigma calendar date ranges with percentage numbers that represent the portions of overall 1-sigma and 2-sigma ranges comprised of smaller ranges. The conventional radiocarbon age is used, not as a single point with a standard deviation, but as a normal probability distribution curve (Fig. 19.2). Additionally, any location on the calibration curve is identified as a range of values rather than a single value. The curve, therefore, is not a single best-fit line; visually, the curve resembles a ribbon rather than a single line. Thus, there is no single point or set of single points at which the mean conventional age intercepts the calibration curve. Rather, the conventional age distribution curve intersects the "ribbon" of calibration curve values and the OxCal calibration process determines ranges of calendar-year values that result from that intersection. In doing so, OxCal determines how much of the conventional age distribution curve intersects the calibration curve at one or more locations along the latter, and presents those data as 1-sigma and 2-sigma calendar-year ranges with percentages of the distribution curve intersecting the calibration curve. Because it determines the portions of overall 1-sigma and 2-sigma date ranges that are made up of smaller ranges, the OxCal percentage values for 1-sigma ranges add up to 68.2 percent, while the percentage values for 2-sigma ranges add up to 95.4 percent (Tables 19.2a, 19.2b). The OxCal percentages can be interpreted as probabilities of accuracy and, depending on the shape of the calibration curve, as the precision of date ranges because higher percentage values represent date ranges within which a sample's actual age is more likely to fall.

OxCal analyses also provide mean and median dates for overall 1-sigma and 2-sigma calendar date ranges, as well as the 1-sigma standard deviation value for each mean date (Tables 19.2a, 19.2b). Telford and others (2004) point out problems with single-year calibration-curve intercept dates. The problems focus on difficulties determining single

Table 19.1. Radiocarbon samples by provenience.

Site	Provenience	Provenience Type	No. of Samples
LA 111422	Feature 1	charcoal stain	1
	Feature 4	small, rock-filled fire pit	1
Total			2
LA 111429	Feature 3	large roasting pit	2
	Feature 11	large, rock-filled roasting pit	3
	Soil A horizon beneath coppice dune		2
Total			7
LA 111435	Feature 3	rock-lined fire pit	1
	Feature 6	fire-cracked rock scatter	3
	Feature 7	charcoal stain in rodent burrow	1
	Feature 8	possible structure	3
	Feature 10	fire-cracked rock scatter with charcoal	1
Total			9
LA 155963	Feature 1	large fire pit with rocks	2
	Feature 6	disturbed fire pit with rocks	1
	Feature 8	small fire pit with fire-cracked rocks	2
	Feature 9	charcoal stain	1
	Feature 14	rock-filled roasting pit	1
	Feature 15	charcoal stain or small fire pit	1
	Feature 125	small fire pit with fire-cracked rocks	1
	Feature 141	fire pit with fire-cracked rocks	3
Total			12
LA 155964	Feature 1	large, rock-filled roasting pit	5
LA 155968	Feature 1	large roasting pit	5

Table 19.2a. Radiocarbon samples and dates by site and feature; Beta-Analytic data.

Site	Feature No.	OAS Field Specimen No.	OAS Sample No.	Sample Material and Condition	Weight (g)	Beta-Analytic Data							
						Sample No.	Analysis Type	Measured Radiocarbon Age (BP)	δ13C (0/00)	Conventional Radiocarbon Age (BP)	2 Sigma Calibrated Age	1 Sigma Calibrated Age	Radiocarbon Age Calibration Curve Intercept Dates
LA 111422	1	FS 74	422-F1-74-s	Saltbush wood, charred	0.08	317545	AMS	1230±30	-11.1	1480±30	AD 540–640	AD 560–610	AD 600
	4	FS 68, FS 76	422-F4-68-y	Yucca caudex, charred	0.17	318168	AMS	1420±30	-23.7	1440±30	AD 570–650	AD 600–650	AD 620
LA 111429	3	FS 300, 301	429-F3-300-s	Saltbush wood, charred	41.20	317580	Radio-metric	1600±30	-12.6	1800±30	AD 130–260 AD 300–320	AD 180–190 AD 210–250	AD 240
	3	FS 302, 305	429-F3-302-y	Yucca caudex, charred	0.62	317546	AMS	1800±30	-21.9	1850±30	AD 80–240	AD 130–220	AD 130
	11	FS 297	429-F11-297-m	Mesquite wood, charred	38.09	317581	Radio-metric	270±30	-23.3	300±30	AD 1490–1600 AD 1610–1650	AD 1520–1570 AD 1590–1590 AD 1630–1650	AD 1640
	11	FS 321	429-F11-321-s	Saltbush wood, charred	12.80	317547	AMS	not reported	-10.9	220±30	AD 1640–1680 AD 1740–1760 AD 1760–1800 AD 1940–1950	AD 1680–1730 AD 1810–1890 AD 1910–1930 AD Post–1950	AD 1690 AD 1730 AD 1810 AD 1840 (x2) AD 1850 AD 1860 (x2) AD 1870 AD 1920 AD Post–1950
	11	FS 321	429-F11-321-y	Yucca stem, charred	8.00	317548	AMS	170±30	-19.7	260±30	AD 1520–1560 AD 1630–1670 AD 1780–1800 AD 1950–1950	AD 1640–1660	AD 1650
	Soil A horizon beneath coppice dune	NA	429-HALL 1	Bulk soil		317549	AMS	350±30	-18.4	460±30	AD 1420–1450	AD 1430–1450	AD 1440

(Table 19.2a, continued)

Site	Feature No.	OAS Field Specimen No.	OAS Sample No.	Sample Material and Condition	Weight (g)	Beta-Analytic Data							
						Sample No.	Analysis Type	Measured Radiocarbon Age (BP)	δ13C (0/00)	Conventional Radiocarbon Age (BP)	2 Sigma Calibrated Age	1 Sigma Calibrated Age	Radiocarbon Age Calibration Curve Intercept Dates
	Soil A horizon beneath coppice dune	NA	429-HALL 2	Bulk soil		317550	AMS	340±30	-15.7	490±30	AD 1410–1450	AD 1420–1440	AD 1430
LA 111435	3	FS 23	435-F3-23-t	"cf. tarbush" wood, charred	0.22	317551	AMS	2900±30	-24.6	2910±30	1210–1010 BC	1190–1180 BC 1150–1150 BC 1130–1050 BC	1120 BC
	6	FS 38	435-F6-38-y	Yucca caudex, charred	0.10	317552	AMS	1560±30	-20.8	1630±30	AD 380–440 AD 450–460 AD 480–530	AD 400–430	AD 420
	6	FS 39	435-F6-39-s	Saltbush wood, charred	16.54	317553	AMS	1370±30	-10.8	1600±30	AD 400–540	AD 420–440 AD 450–460 AD 480–530	AD 430
	6	FS 39	435-F6-39-y	Yucca caudex, charred	1.24	317554	AMS	1580±30	-22.3	1620±30	AD 390–540	AD 410–430	AD 420
	7	FS 50	435-F7-50-s	Saltbush wood, charred	0.34	317555	AMS	2190±30	-10.3	2430±30	750–690 BC 660–640 BC 590–580 BC 570–400 BC	730–690 BC 660–650 BC 540–410 BC	510 BC
	8 (struct-ure?)	FS 49	435-F8-49-y	Yucca caudex, charred	0.32	317556	AMS	1140±30	-22.4	1180±30	AD 770–900 AD 920–940	AD 780–790 AD 800–890	AD 880
	8 (struct-ure?)	FS 98	435-F8-98-y	Yucca caudex, charred	0.05	317557	AMS	1070±30	-22.3	1110±30	AD 880–990	AD 890–980	AD 900 AD 920 AD 970
	8 (struct-ure?)	FS 102	435-F8-102-s	Saltbush wood, charred	3.11	317558	AMS	890±30	-11.5	1110±30	AD 880–990	AD 890–980	AD 900 AD 920 AD 970
	10	FS 30	435-F10-30-s	Saltbush wood, charred	0.35	317559	AMS	4070±30	-11.3	4290±30	2920–2880 BC	2910–2890 BC	2900 BC
LA 155963	1	FS 404	963-F1-404-m	Mesquite wood, charred	7.40	317560	AMS	410±30	-22.3	440±30	AD 1430–1470	AD 1440–1450	AD 1440

(Table 19.2a, continued)

Site	Feature No.	OAS Field Specimen No.	OAS Sample No.	Sample Material and Condition	Weight (g)	Beta-Analytic Data							
						Sample No.	Analysis Type	Measured Radiocarbon Age (BP)	δ13C (0/00)	Conventional Radiocarbon Age (BP)	2 Sigma Calibrated Age	1 Sigma Calibrated Age	Radiocarbon Age Calibration Curve Intercept Dates
	1	FS 404	963-F1-404-s	Saltbush wood, charred	2.74	317561	AMS	140±30	-12.7	340±30	AD 1450–1640	AD 1480–1530 AD 1540–1550 AD 1530–1630	AD 1520 AD 1590 AD 1620
	6	FS 621	963-F6-621-mo	Monocot stems, charred	0.14	317562	AMS	10±30	-22.1	60±30	AD 1690–1730 AD 1810–1840 AD 1840–1850 AD 1860–1860 AD 1870–1920 AD Post–1950	AD 1890–1910 AD Post–1950	AD 1950
	8	FS 485	963-F8-485-y	Yucca caudex, charred	0.30	317563	AMS	690±30	-22.3	730±30	AD 1260–1290	AD 1270–1280	AD 1280
	8	FS 486	963-F8-486	Bulk soil (feature fill)		317564	AMS	640±30	-20.2	720±30	AD 1260–1290	AD 1270–1280	AD 1280
	9	FS 511	963-F9-511-m	Mesquite wood, charred	3.26	317565	AMS	220±30	-23.2	250±30	AD 1530–1540 AD 1550–1550 AD 1630–1670 AD 1780–1800 AD 1940–1950	AD 1640–1660	AD 1650
	14	FS 574	963-F14-574-s	Saltbush wood, charred	0.04	317566	AMS	1300±30	-10.5	1540±30	AD 430–600	AD 440–450 AD 460–480 AD 530–560	AD 540
	15	FS 585	963-F15-585	Bulk soil (feature fill)		317567	AMS	1760±30	-13.6	1950±30	30–30 BC 20–10 BC AD 0–90 AD 100–120	AD 20–80	AD 60
	125	FS 25	963-F125-25-s	Saltbush wood, charred	7.67	317568	AMS	960±30	-10.9	1190±30	AD 730–740 AD 770–900 AD 920–940	AD 780–890	AD 830 AD 840 AD 870
	141	FS 618	963-F141-618-m	Mesquite wood, charred	1.62	317569	AMS	1360±30	-24.2	1370±30	AD 640–680	AD 650–660	AD 660
	141	FS 618	963-F141-618-s	Saltbush wood, charred	0.93	317570	AMS	1010±30	-11.6	1230±30	AD 690–880	AD 720–740 AD 770–780 AD 790–810 AD 850–850	AD 780

(Table 19.2a, continued)

Site	Feature No.	OAS Field Specimen No.	OAS Sample No.	Sample Material and Condition	Weight (g)	Beta-Analytic Data							
						Sample No.	Analysis Type	Measured Radiocarbon Age (BP)	δ13C (0/00)	Conventional Radiocarbon Age (BP)	2 Sigma Calibrated Age	1 Sigma Calibrated Age	Radiocarbon Age Calibration Curve Intercept Dates
	141	FS 619	963-F141-619-m	Mesquite seeds, charred	0.08	317571	AMS	1240±30	-22.6	1280±30	AD 660–780	AD 680–730 AD 740–770	AD 690 AD 750 AD 760
LA 155964	1	FS 24	964-F1-24-y	Yucca caudex, charred	0.37	317572	AMS	80±30	-22.8	120±30	AD 1670–1780 AD 1800–1940 AD Post–1950	AD 1680–1730 AD 1810–1890 AD 1910–1930 AD Post–1950	AD 1690 AD 1730 AD 1810 AD 1840 (x2) AD 1850 AD 1860 (x2) AD 1870 AD 1920 AD Post–1950
	1	FS 33	964-F1-33-c	Cactus pad, charred	1.10	317573	AMS	not reported	-10.8	110±30	AD 1680–1760 AD 1770–1780 AD 1800–1940 AD Post–1950	AD 1680–1730 AD 1810–1890 AD 1910–1930 AD Post–1950	AD 1700 AD 1720 AD 1820 AD 1830 AD 1880 AD 1920 AD Post–1950
	1	FS 44	964-F1-44-t	"cf. tarbush" wood, charred	6.41	317574	AMS	50±30	-23.4	80±30	AD 1680–1730 AD 1810–1930 AD Post–1950	AD 1700–1720 AD 1820–1830 AD 1880–1920 AD Post–1950	AD 1890 AD 1900 AD Post–1950
	1	FS 24, 30	964-F1-24-y	Yucca stem, charred	0.13	317582	AMS	100±30	-23.4	130±30	AD 1670–1780 AD 1800–1900 AD 1900–1940 AD 1950–Post–1950	AD 1680–1710 AD 1720–1740 AD 1760–1760 AD 1800–1830 AD 1830–1890 AD 1910–1940 AD Post–1950	AD 1690 AD 1730 AD 1810 AD 1920 AD Post–1950
	1	FS 45	964-F1-45-m	Mesquite wood, charred	67.42	317583	Radio-metric	100±30	-23.6	120±30	AD 1670–1780 AD 1800–1940 AD Post–1950	AD 1680–1730 AD 1810–1890 AD 1910–1930 AD Post–1950	AD 1690 AD 1730 AD 1810 AD 1840 (x2) AD 1850 AD 1860 (x2) AD 1870 AD 1920 AD Post–1950

(Table 19.2a, continued)

Site	Feature No.	OAS Field Specimen No.	OAS Sample No.	Sample Material and Condition	Weight (g)	Beta-Analytic Data							
						Sample No.	Analysis Type	Measured Radiocarbon Age (BP)	δ13C (0/00)	Conventional Radiocarbon Age (BP)	2 Sigma Calibrated Age	1 Sigma Calibrated Age	Radiocarbon Age Calibration Curve Intercept Dates
LA 155968	1	FS 475	968-F1-475-t	"cf. tarbush" wood, charred	0.30	317576	AMS	1200±30	-23.5	1220±30	AD 690–750 AD 760–890	AD 730–740 AD 770–830 AD 840–870	AD 780
	1	FS 475	968-F1-475-y	Yucca stem, charred	0.08	317577	AMS	1170±30	-21.2	1230±30	AD 690–880	AD 720–740 AD 770–780 AD 790–810 AD 850–850	AD 780
	1	FS 479	968-F1-479-s	Saltbush wood, charred	11.40	317578	AMS	1100±30	-12.3	1310±30	AD 660–730 AD 740–770	AD 660–690 AD 750–760	AD 680
	1	FS 480	968-F1-480-u	Unknown charcoal	0.60	317579	AMS	1250±30	-23.0	1280±30	AD 660–780	AD 680–730 AD 740–770	AD 690 AD 750 AD 760
	1	FS 473, 474, 476, 478, 480, 508	968-F1-473-y	Yucca caudex, charred	0.71	317575	AMS	1230±30	-21.2	1290±30	AD 690–750 AD 760–890	AD 670–720 AD 740–770	AD 690

* OxCal v. 4.1.7; https://c14.arch.ox.ac.uk/oxcal/OxCal.html, first accessed August 30, 2012; atmospheric curve IntCal 09.

** Dates in **bold** font have the highest-percentage probabilities (more thn half of the total range) of being the most accurate dates.

OxCal calibrations: Percentage numbers represent the portions of 1-sigma (68.2% total) and 2-sigma (95.4% total) ranges comprised of smaller, internal ranges.

Calib calibrations: Percentage numbers represent the proportions of 1-sigma (100.0% total) and 2-sigma (100.0% total) ranges comprised of smaller, internal ranges.

*** Calib v. 6.1.0; http://calib.qub.ac.uk/calib, first accessed August 27, 2012; atmospheric curve IntCal 09.

Table 19.2b. Radiocarbon samples and dates by site and feature; OxCal and Calib calibration data.

Site No.	Sample No.	OxCal* Calibration Data**					Calib*** Calibration Data**	
		2 Sigma Calibrated Age	1 Sigma Calibrated Age	Mean Date	Mean 1 Sigma Years	Median Date	2 Sigma Calibrated Age	1 Sigma Calibrated Age
LA 111422	317545	**AD 540–644 (95.4%)**	**AD 555–615 (68.2%)**	AD 586	32	AD 588	**AD 541–642 (100.0%)**	**AD 557–613 (100.0%)**
	318168	**AD 566–655 (95.4%)**	**AD 601–646 (68.2%)**	AD 615	23	AD 618	**AD 568–654 (100.0%)**	**AD 601–645 (100.0%)**
LA 111429	317580	**AD 130–260 (82.8%)** **AD 282–325 (12.6%)**	AD 139–196 (33.9%) AD 208–252 (34.3%)	AD 215	52	AD 215	**AD 130–260 (86.9%)** **AD 282–324 (10.1%)**	AD 139–160 (18.4%) AD 165–196 (29.3%) AD 208–252 (52.3%)
	317546	**AD 85–235 (95.4%)**	**AD 128–215 (68.2%)**	AD 165	43	AD 167	**AD 85–235 (100.0%)**	**AD 128–214 (100.0%)**
	317581	**AD 1489–1604 (69.4%)** **AD 1610–1654 (26.0%)**	**AD 1522–1575 (46.2%)** **AD 1584–1590 (4.0%)** **AD 1625–1646 (18.0%)**	AD 1573	98	AD 1564	**AD 1489–1603 (72.7%)** **AD 1611–1654 (27.3%)**	**AD 1522–1574 (66.8%)** **AD 1584–1590 (6.21%)** **AD 1625–1646 (26.9%)**
	317547	AD 1642–1684 (36.7%) AD 1735–1805 (44.5%) AD 1932–1955 (14.2%)	AD 1647–1674 (30.2%) AD 1778–1799 (27.6%) AD 1942–1953 (10.4%)	AD 1757	98	AD 1769	AD 1642–1683 (30.4%) AD 1735–1805 (48.2%) AD 1933–1951+ (12.45%)	AD 1648–1672 (45.9%) AD 1778–1799 (41.7%) AD 1942–1951+ (12.4%)
	317548	AD 1521–1575 (14.1%) AD 1584–1590 (0.5%) AD 1626–1680 (54.5%) AD 1764–1801 (21.4%) AD 1939–1955 (4.8%)	**AD 1639–1668 (50.0%)** **AD 1782–1798 (18.2%)**	AD 1681	99	AD 1656	AD 1519–1593 (29.3%) AD 1619–1670 (56.8%) AD 1779–1799 (12.6%) AD 1943–1951+ (1.4%)	AD 1529–1542 (14.3%) AD 1634–1666 (71.9%) AD 1784–1795 (13.8%)
	317549	**AD 1412–1469 (95.4%)**	**AD 1425–1450 (68.2%)**	AD 1439	17	AD 1439	**AD 1413–1467 (100.0%)**	**AD 1427–1448 (100.0%)**
	317550	**AD 1403–1450 (95.4%)**	**AD 1417–1440 (68.2%)**	AD 1426	16	AD 1428	**AD 1405–1449 (100.0%)**	**AD 1418–1439 (100.0%)**
LA 111435	317551	1251–1243 BC (1.1%) 1213–1008 BC (94.3%)	1190–1179 (5.0%) 1159–1144 (6.4%) 1131–1041 (56.9%)	1107 BC	58	1101 BC	1250–1243 BC (0.9%) 1212–1008 BC (99.0%)	1190–1179 BC (7.1%) 1158–1144 BC (9.1%) 1131–1042 BC (83.9%)
	317552	AD 347–370 (5.4%) AD 378–535 (90.0%)	**AD 387–437 (47.8%)** **AD 489–530 (20.4%)**	AD 438	52	AD 425	AD 348–369 (5.3%) AD 378–535 (94.7%)	**AD 387–437 (71.0%)** **AD 489–510 (18.7%)** **AD 483–553 (10.4%)**
	317553	**AD 404–540 (94.5%)**	AD 419–422 (19.6%) AD 453–461 (5.2%) AD 484–533 (43.3%)	AD 474	41	AD 478	**AD 404–540 (100.0%)**	AD 419–442 (28.0%) AD 451–461 (10.8%) AD 483–553 (61.2%)
	317554	AD 357–364 (0.9%) AD 382–539 (94.5%)	**AD 397–440 (37.3%)** **AD 486–532 (30.9%)**	AD 454	49	AD 447	AD 358–362 (0.6%) AD 382–538 (99.4%)	**AD 398–439 (54.0%)** **AD 486–531 (46.0%)**
	317555	750–687 BC (18.9%) 666–642 BC (5.4%) 592–403 BC (71.0%)	716–695 (7.8%) 540–411 BC (60.4%)	542 BC	105	510 BC	749–687 BC (19.9%) 666–642 BC (5.6%) 592–576 BC (2.0%) 571–404 BC (72.5%)	706–695 BC (6.7%) 539–411 BC (93.3%)

(Table 19.2b, continued)

Site No.	Sample No.	OxCal* Calibration Data**					Calib*** Calibration Data**	
		2 Sigma Calibrated Age	1 Sigma Calibrated Age	Mean Date	Mean 1 Sigma Years	Median Date	2 Sigma Calibrated Age	1 Sigma Calibrated Age
	317556	**AD 771–900 (86.1%)** **AD 917–965 (9.3%)**	AD 781–791 (6.9%) AD 807–888 (61.3%)	AD 845	49	AD 843	**AD 772–900 (90.4%)** **AD 1002–1013 (9.7%)**	AD 781–790 (10.0%) AD 808–888 (90.0%)
	317557	**AD 880–1014 (95.4%)**	AD 895–925 (29.2%) AD 937–976 (39.0%)	AD 936	36	AD 939	**AD 880–998 (98.6%)** **AD 1002–1013 (1.4%)**	AD 895–925 (42.3%) AD 937–975 (57.7%)
	317558	**AD 880–1014 (95.4%)**	AD 895–925 (29.2%) AD 937–976 (39.0%)	AD 936	36	AD 939	**AD 880–998 (98.6%)** **AD 1002–1013 (1.4%)**	AD 895–925 (42.3%) AD 937–975 (57.7%)
	317559	3011–2979 BC (5.2%) 2956–2951 BC (0.4%) 2941–2877 BC (89.8%)	**2914–2889 (68.2%)**	2909 BC	29	2903 BC	3010–2979 BC (5.2%) 2940–2877 BC (94.9%)	**2913–2890 BC (100.0%)**
LA 155963	317560	**AD 1416–1491 (94.1%)** **AD 1603–1609 (1.3%)**	**AD 1431–1463 (68.2%)**	AD 1454	31	AD 1447	**AD 1417–1489 (98.9%)** **AD 1604–1608 (1.1%)**	**AD 1431–1460 (100.0%)**
	317561	**AD 1470–1640 (95.4%)**	AD 1491–1526 (23.0%) AD 1557–1603 (30.6%) AD 1610–1632 (14.6%)	AD 1555	51	AD 1560	**AD 1470–1639 (100.0%)**	AD 1490–1526 (33.8%) AD 1556–1603 (45.2%) AD 1609–1632 (20.9%)
	317562	AD 1693–1729 (23.6%) AD 1811–1920 (71.8%)	AD 1700–1720 (15.7%) AD 1819–1833 (11.9%) AD 1880–1915 (40.6%)	AD 1832	77	AD 1857	AD 1694–1727 (24.1%) AD 1812–1919 (74.0%) AD 1952–1954 (1.9%)	AD 1700–1703 (2.9%) AD 1705–1720 (19.6%) AD 1819–1833 (16.2%) AD 1880–1915 (58.7%) AD 1952–1954 (2.7%)
	317563	**AD 1224–1297 (95.4%)**	**AD 1262–1287 (68.2%)**	AD 1273	23	AD 1274	**AD 1224–1296 (100.0%)**	**AD 1263–1286 (100.0%)**
	317564	**AD 1228–1302 (90.2%)** **AD 1367–1383 (5.2%)**	**AD 1265–1290 (68.2%)**	AD 1282	28	AD 1278	AD 1228–1232 (0.8%) AD 1238–1249 (2.1%) AD 1250–1301 (92.0%) AD 1367–1382 (5.1%)	**AD 1267–1289 (100.0%)**
	317565	AD 1521–1575 (14.1%) AD 1584–1590 (0.5%) AD 1626–1680 (54.5%) AD 1764–1801 (21.4%) AD 1939–1955 (4.8%)	**AD 1639–1668 (50.0%)** **AD 1782–1798 (18.2%)**	AD 1656	99	AD 1656	AD 1552–1574 (15.0%) AD 1584–1587 (0.2%) AD 1626–1680 (59.4%) AD 1764–1800 (22.2%) AD 1939–1951+ (3.3%)	**AD 1639–1667 (75.0%)** **AD 1782–1797 (25.0%)**
	317566	**AD 430–591 (95.4%)**	**AD 437–489 (36.3%)** **AD 513–516 (1.3%)** **AD 530–567 (30.5%)**	AD 509	47	AD 512	**AD 430–585 (98.9%)** **AD 587–590 (1.1%)**	**AD 437–489 (53.7%)** **AD 514–515 (1.6%)** **AD 530–567 (44.8%)**
	317567	37–30 BC (1.4%) 22–11 BC (2.6%) 2 BC–125 AD (91.4%)	**AD 18–81 (68.2%)**	AD 49	36	AD 51	36–30 BC (1.5%) 21–11 BC (2.5%) 2 BC–AD 94 (85.4%) AD 96–125 (10.6%)	AD 10–10 (0.9%) AD 17–81 (99.1%)

(*Table 19.2b, continued*)

Site No.	Sample No.	OxCal* Calibration Data**					Calib*** Calibration Data**	
		2 Sigma Calibrated Age	1 Sigma Calibrated Age	Mean Date	Mean 1 Sigma Years	Median Date	2 Sigma Calibrated Age	1 Sigma Calibrated Age
	317568	AD 720–742 (2.9%) AD 769–898 (88.8%) AD 921–944 (3.7%)	AD 980–792 (8.8%) AD 806–882 (59.4%)	AD 834	47	AD 835	AD 720–741 (3.0%) AD 770–897 (93.3%) AD 921–994 (3.8%)	AD 781–791 (12.7%) AD 807–882 (87.3%)
	317569	**AD 608–689 (95.4%)**	**AD 643–671 (68.2%)**	AD 657	22	AD 656	**AD 608–688 (100.0%)**	**AD 644–669 (100.0%)**
	317570	AD 689–752 (31.1%) AD 761–882 (64.3%)	AD 713–745 (19.4%) AD 767–828 (35.2%) AD 839–865 (13.6%)	AD 786	55	AD 789	AD 689–752 (32.6%) AD 761–882 (67.4%)	AD 714–745 (28.6%) AD 767–784 (17.0%) AD 786–827 (35.5%) AD 840–864 (18.9%)
	317571	**AD 681–780 (94.2%)** **AD 793–803 (1.2%)**	**AD 680–723 (39.6%)** **AD 740–770 (28.6%)**	AD 727	38	AD 724	**AD 662–779 (99.0%)** **AD 794–801 (1.0%)**	**AD 681–722 (57.9%)** **AD 741–770 (42.1%)**
LA 155964	317572	AD 1679–1765 (32.4%) AD 1774–1776 (0.4%) AD 1800–1940 (62.6%)	AD 1685–1709 (12.0%) AD 1718–1732 (6.9%) AD 1808–1889 (40.7%) AD 1910–1927 (8.6%)	AD 1814	80	AD 1832	AD 1680–1764 (33.6%) AD 1774–1775 (0.2%) AD 1800–1899 (49.4%) AD 1901–1939 (15.9%) AD 1951–1953 (0.9%)	AD 1685–1708 (17.1%) AD 1718–1731 (10.4%) AD 1808–1827 (14.5%) AD 1831–1889 (44.9%) AD 1910–1927 (12.7%) AD 1952–1952 (0.4%)
	317573	AD 1681–1763 (29.9%) AD 1801–1938 (65.5%)	AD 1692–1728 (19.1%) AD 1812–1891 (43.1%) AD 1908–1920 (6.1%)	AD 1817	78	AD 1836	AD 1681–1739 (28.4%) AD 1752–1762 (1.9%) AD 1802–1938 (69.0%) AD 1951–1954 (0.8%)	AD 1692–1712 (16.5%) AD 1716–1728 (9.9%) AD 1812–1891 (64.3%) AD 1908–1919 (9.0%) AD 1952–1952 (0.3%)
	317574	AD 1690–1730 (25.2%) AD 1810–1926 (70.2%)	AD 1697–1725 (20.9%) AD 1815–1835 (14.9%) AD 1878–1917 (32.4%)	AD 1825	77	AD 1845	AD 1690–1729 (25.7%) AD 1810–1925 (72.8%) AD 1951–1954 (1.5%)	AD 1697–1725 (31.0%) AD 1814–1835 (21.0%) AD 1850–1850 (0.8%) AD 1877–1917 (46.6%) AD 1952–1954 (0.6%)
	317582	AD 1675–1778 (37.9%) AD 1799–1894 (42.5%) AD 1905–1942 (15.0%)	AD 1683–1706 (12.1%) AD 1720–1737 (8.6%) AD 1758–1761 (1.1%) AD 1804–1820 (8.0%) AD 1833–1883 (27.0%) AD 1914–1936 (11.4%)	AD 1810	81	AD 1822	AD 1675–1778 (39.7%) AD 1779–1893 (44.2%) AD 1905–1941 (15.7%) AD 1950–1953 (0.4%)	AD 1682–1707 (17.4%) AD 1791–1737 (12.0%) AD 1758–1761 (1.7%) AD 1803–1825 (38.1%) AD 1913–1936 (16.4%) AD 1951–1952 (0.5%)

(Table 19.2b, continued)

Site No.	Sample No.	OxCal* Calibration Data**					Calib*** Calibration Data**	
		2 Sigma Calibrated Age	1 Sigma Calibrated Age	Mean Date	Mean 1 Sigma Years	Median Date	2 Sigma Calibrated Age	1 Sigma Calibrated Age
	317583	AD 1679–1765 (32.4%) AD 1774–1776 (0.4%) AD 1800–1940 (62.6%)	AD 1685–1709 (12.0%) AD 1718–1732 (6.9%) AD 1808–1889 (40.7%) AD 1910–1927 (8.6%)	AD 1814	80	AD 1832	AD 1680–1764 (33.6%) AD 1774–1775 (0.2%) AD 1800–1899 (49.4%) AD 1901–1939 (15.9%) AD 1951–1953 (0.9%)	AD 1685–1708 (17.1%) AD 1718–1731 (10.4%) AD 1808–1827 (14.5%) AD 1831–1889 (44.9%) AD 1910–1927 (12.7%) AD 1952–1952 (0.4%)
LA 155968	317576	AD 692–749 (20.5%) AD 763–888 (74.9%)	AD 729–736 (4.1%) AD 772–870 (64.1%)	AD 801	53	AD 804	AD 692–749 (21.2%) AD 764–887 (78.9%)	AD 729–736 (5.0%) AD 772–834 (63.14%) AD 835–870 (31.9%)
	317577	AD 689–752 (31.1%) AD 761–882 (64.3%)	AD 713–745 (19.4%) AD 767–828 (35.2%) AD 839–865 (13.6%)	AD 786	55	AD 789	AD 689–752 (32.6%) AD 761–882 (67.4%)	AD 714–745 (28.6%) AD 767–784 (17.0%) AD 786–827 (35.5%) AD 840–864 (18.9%)
	317578	**AD 656–773 (95.4%)**	**AD 662–708 (49.0%)** **AD 747–766 (19.2%)**	AD 709	36	AD 700	**AD 656–728 (70.0%)** **AD 736–772 (30.0%)**	**AD 662–695 (61.3%)** **AD 699–708 (10.0%)** **AD 747–765 (28.7%)**
	317579	**AD 661–723 (94.2%)**	**AD 680–723 (39.6%)** **AD 740–770 (28.6%)**	AD 727	38	AD 724	**AD 662–779 (99.0%)** **AD 794–801 (1.0%)**	**AD 681–722 (58.0%)** **AD 741–770 (42.0%)**
	317575	**AD 663–775 (95.4%)**	**AD 674–715 (42.8%)** **AD 744–768 (25.4%)**	AD 721	36	AD 716	**AD 663–775 (100.0%)**	**AD 673–716 (63.0%)** **AD 744–768 (37.0%)**

* OxCal v. 4.1.7; https://c14.arch.ox.ac.uk/oxcal/OxCal.html, first accessed August 30, 2012; atmospheric curve IntCal 09.

** Dates in **bold** font have the highest-percentage probabilities (more than half of the total range) of being the most accurate dates.

OxCal calibrations: Percentage numbers represent the portions of 1-sigma (68.2% total) and 2-sigma (95.4% total) ranges comprised of smaller, internal ranges.

Calib calibrations: Percentage numbers represent the proportions of 1-sigma (100.0% total) and 2-sigma (100.0% total) ranges comprised of smaller, internal ranges.

*** Calib v. 6.1.0; http://calib.qub.ac.uk/calib, first accessed August 27, 2012; atmospheric curve IntCal 09.

CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-11.1:lab. mult=1)

Laboratory number:	**Beta-317545**
Conventional radiocarbon age:	**1480±30 BP**
2 Sigma calibrated result: (95% probability)	**Cal AD 540 to 640 (Cal BP 1410 to 1310)**

Intercept data

Intercept of radiocarbon age with calibration curve:	Cal AD 600 (Cal BP 1360)
1 Sigma calibrated result: (68% probability)	Cal AD 560 to 610 (Cal BP 1390 to 1340)

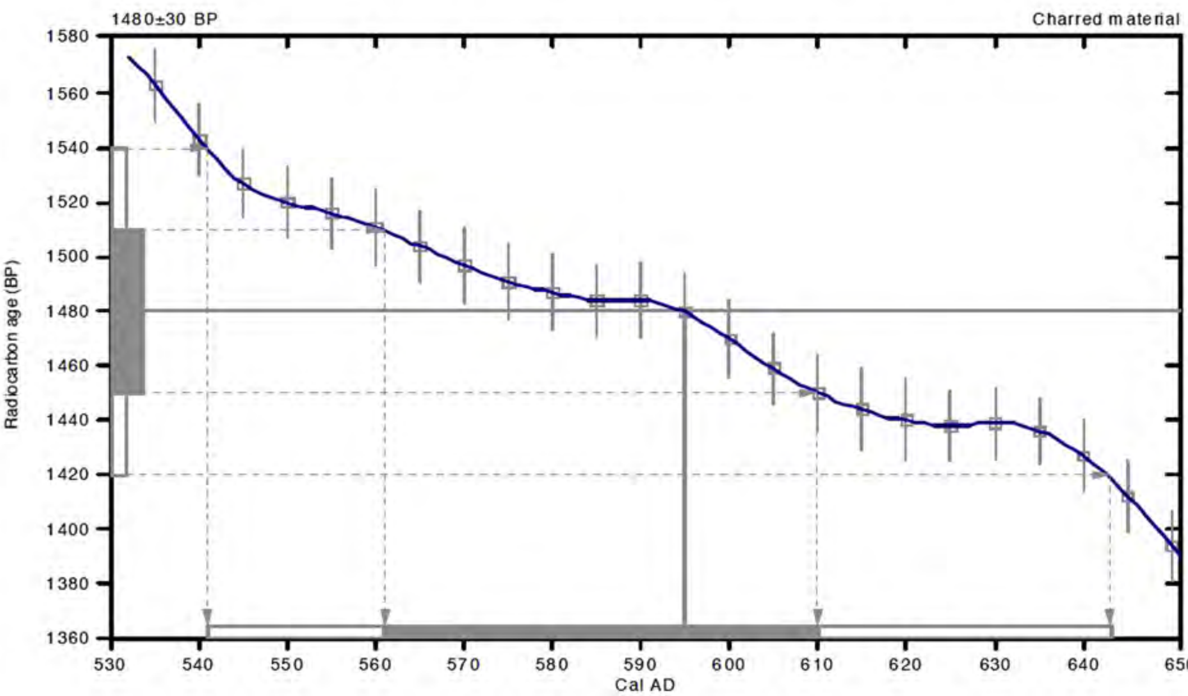

Figure 19.1. LA 111422, Feature 1, example of Beta Analytic, Inc., curve plot (Beta-317545).

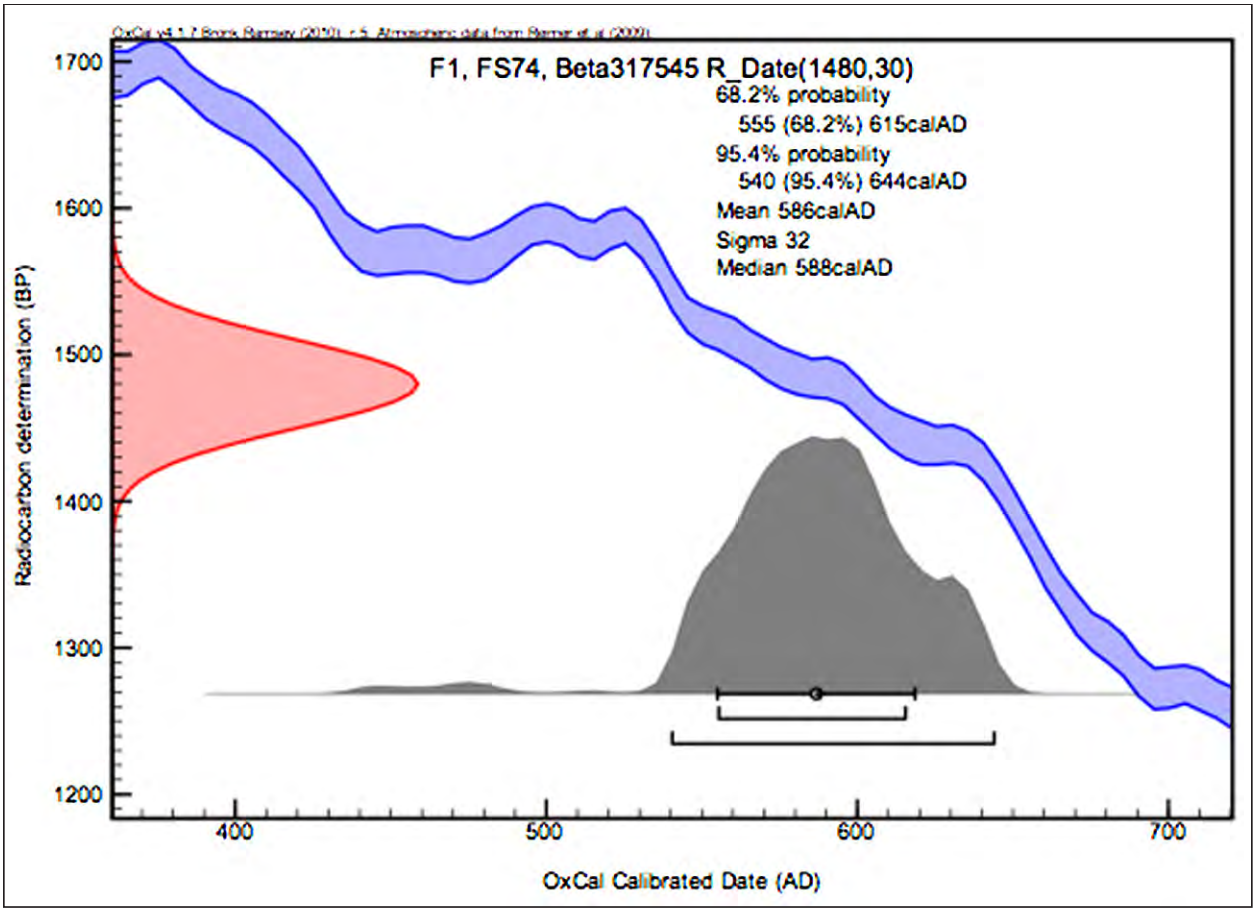

Figure 19.2. LA 111422, Feature 1, example of OxCal curve plot (Beta-317545).

points at which dates, expressed as ranges of values within confidence limits, intersect a calibration curve also made up of ranges of values. Further, because the calibration curve is subject to revision as new atmospheric data are acquired, intercept dates are directly related to the version of the curve in use at the time of analysis. Consequently, Telford and others (2004) conclude that mean and median dates, calculated as they are from ranges of dates representing the intersection(s) of conventional age curves and calibration curves, are more accurate single-year values than intercept dates. It is important to remember, however, that inherent variation in samples and in calibration processes mean that single-year values represent specific dates within ranges of dates and that, excepting the precision provided by percentage values, no one year within those ranges is more likely than any other to be "the" year. That is, single-year precision is not possible. Still, because analytical results from Beta Analytic include intercept dates, they are reported here.

Like OxCal, Calib also provides one or more 1-sigma and 2-sigma calendar date ranges representing the intersection(s) of a conventional age distribution curve with the calendar-year calibration curve, and provides percentage values for each range. Unlike the OxCal percentages, though, Calib percentages represent the proportions of overall 1-sigma and 2-sigma ranges comprised of smaller ranges. Consequently, the Calib percentages associated with each range, whether 1 sigma or 2 sigma, add up to 100.0 percent. Like OxCal percentage values, Calib percentage values can be interpreted as probabilities of accuracy and, potentially, as the precision of date ranges, also because higher percentage values represent date ranges within which a sample's actual age is most likely to fall. Differences between OxCal and Calib calibration dates are likely related to equational differences between the applications.

In addition to calendar-year calibrations, Calib was used to calculate mean pooled conventional radiocarbon ages, including 1-sigma standard deviations (*see* Table 19.6). Calib was then used to convert mean pooled conventional ages to calibrated radiocarbon ages in order to make them more comparable with other calibrated ages (*see* Table 19.6). Mean pooled calibrated ages are not, however, accorded the same weight in this analysis as comparing 1-sigma and 2-sigma dates from site features because the process of combining (pooling) any series of mean dates and their standard deviation values and calculating a mean value and mean standard deviation value for that pooled group necessarily minimizes differences within the group and, therefore, results in smaller standard deviation values and shorter ranges of dates than are evident when simply comparing the values within the group. Further, the process of calibrating the conventional pooled mean ages produces both 1- and 2-sigma standard deviation ranges that represent proportions of 1-sigma ranges for the conventional ages, that is 68.2 and 95.4 percents, respectively, of a 68.2 percent range. Consequently, I am not confident of the apparent increased precision provided by pooled mean ages. Therefore, when assessing the dates from features and sites, emphasis is placed on comparison of the calibrated 1-sigma and 2-sigma radiocarbon ages; the results are compared with pooled mean ages and their similarities are observed but the latter are not given the same weight when identifying most accurate and most precise dates.

Additionally, Calib calculated Student's T-test values. The results of these tests show whether the dates from each site make up a single group, that is, whether they are statistically the same at a 95.4 percent confidence level. If they are not the same, however, these tests do not confirm whether more than one group of dates are present or whether the dates are all different from each other. To determine whether groups of dates are present, I used Grubbs' test to determine whether site date assemblages contain dates that are statistical outliers. For this test, I used the Beta Analytic conventional radiocarbon age for each sample because this value is the common basis for Beta Analytic, Calib, and OxCal calibrations. Because no dates are determined by Grubb's test, it was not necessary to use calibrated ages. Grubbs' test assigns a Z (standardized) value to each conventional radiocarbon age that represents the statistical distance of each age from the group mean; it then compares each individual Z value to a critical Z value determined by the number of ages in the group. Ages whose Z values exceed the critical Z value are statistical outliers. For each group, the test also identifies the conventional age that is furthest from the group mean but is not a statistical outlier.

The protocol for outliers in these analyses was to remove the outlier age from the group and re-run the Grubb's test. If the second test identified another outlier, that age was then removed and the test run again, and so on until all outliers were identified and removed. Outliers were grouped together and tested to determine whether they were a cohesive set of dates. Identification of statistical outliers does not, in itself, tell us why they are outliers, which can only be determined in light of archaeological context, material integrity, and material suitability for radiocarbon dating, as well as comparison with other dates from related samples and proveniences.

The protocol for those mean conventional ages that were identified by Grubb's test as furthest from their group means was the same as for outliers, realizing that those ages were not actually statistically different from the others in their groups. The results, therefore, cannot be used to securely identify different groups of dates within a site assemblage; they are, however, used to suggest intra-site groups of dates that can be examined with other tests. In part this is because the group mean and standard deviation calculated for any group of ages by the Grubbs' test reflects both the number of individual ages and their range or span of years. The case of LA 111429 is a good example and the reader is referred to the LA 111429 discussion later in this chapter.

In addition to intra-site date groups shown or suggested by outlier testing, some intra-site groups were intuitively obvious; again I refer the reader to the LA 111429 example.

Intra-site groups identified or suggested by outlier testing and by simple observation were then examined by calculating mean pooled ages and standard deviations and with Student's T-tests to determine whether the groups could be confirmed. It was, therefore, the interplay of outlier testing with t-testing and mean pooled ages that identified and confirmed or denied groups of site dates.

Tables 19.2a and 19.2b presents the radiocarbon data for the Spaceport America sites by sample, including proveniences and descriptions of the samples, the Beta Analytic analytical data, and Beta Analytic, OxCal, and Calib calibration dates. To facilitate comparison, Tables 19.3 and 19.4, respectively, show only the 2-sigma and 1-sigma calibrated dates for each site by sample. In the following section of this chapter, I summarize radiocarbon dates from the Spaceport America sites and my intra-site and inter-site assessments of those dates. For each site and intra-site feature, I present recommendations for most accurate radiocarbon age, most precise radiocarbon age, as well as the pooled mean calibrated radiocarbon ages. Within each site group, features are arranged from earliest to latest. The reader is referred to specific site chapters in this report for site and feature descriptions that provide the archaeological contexts for these samples.

LA 111422

Site Assemblage

Dates
Most accurate: cal AD 540–655
Most precise: cal AD 540–655
Pooled mean: cal AD 565–644 (2 sigma); cal AD 590–635 (1 sigma)

Discussion: Two samples were submitted from two features at LA 111422 (Tables 19.2a, 19.2b). One was a small amount of burned saltbush wood from Feature 1, a charcoal stain, and the other a small combination of yucca caudex fragments from Feature 4, a small fire pit. Two-sigma calibrated dates consistently fall in the late sixth and early seventh centuries AD, ca. AD 540 to 655 (Table 19.3), and 1-sigma dates fall within the same range (Table 19.4). Figures 19.3 and 19.4 are, respectively, the OxCal multiple and curve plots of the LA 111422 dates.

The 1-sigma dates for the saltbush sample, interestingly, fall in the first half of the AD 540–655 range while those from the yucca sample fall in the second half of that range, overlapping in the first 1.5 decades of the AD 600s. Those differences are also shown in the OxCal mean and median dates for the two samples (Tables 19.2a, 19.2b).

Because there are only two samples, a test for outliers cannot be performed (Table 19.5). Student's T-test results show that a single group comprises the two samples and that the 1-sigma differences are not significant. Comparing the 2-sigma and 1-sigma calibrated ranges shows that the latter potentially increases the precision of the former by 15 and nine years at the beginning and ending of the range, respectively, supporting the conclusion that the two samples are a single group. The 2-sigma mean pooled age is slightly shorter in length than the 1-sigma calibrated range, which likely supports the increased precision suggested by the latter.

Since the 1-sigma range is, however, only 24 years shorter than the 2-sigma range, which is 115 years long, and that possible increase in precision comes with a significant decrease in confidence, the radiocarbon date for LA 111422 with the greatest accuracy and precision is AD 540 to 655.

LA 111429

Site Assemblage

Dates: Not applicable.

Discussion: Seven samples from two features and the A horizon of a paleosol were submitted for LA 111429 dating (Tables 19.2a, 19.2b). One sample from Feature 3 was a combination of burned saltbush wood, while the other was a combination of burned yucca caudex; they yielded dates between about AD 80 and 325. The three samples from Feature 11 were burned mesquite wood, burned saltbush wood, and burned yucca caudex, and yielded dates between about AD 1490 and 1950. The A horizon soil samples yielded dates between about AD 1400 and 1467.

Thus, the seven samples from LA 111429 span a range of about 1630 years. Grubb's outlier test of the whole assemblage, however, reveals no outliers in the group (Table 19.5). The sample size requires a relatively high critical Z value, in this case 2.02. Since five LA 111429 conventional ages are between 220 and 490 BP while the other two are 1800 and 1850 BP, the group mean, 768.57 BP, reflects the dominance of the younger dates, while the standard deviation value of 728.62 years reflects the broad range of the dates.

Since the group mean accounts for two conventional ages at 1800+ years BP, the furthest from the

Table 19.3. Radiocarbon samples and 2-sigma calibrated dates by site and feature.

Site	Feature	OAS Sample No.	Beta-Analytic Sample No.	Beta–Analytic 2 Sigma Calibrated Age	OxCal 2 Sigma Calibrated Age	Calib 2 Sigma Calibrated Age
LA 111422	Feature 1	422-F1-74-s	317545	AD 540–640	**AD 540–644 (95.4%)**	**AD 541–642 (100.0%)**
	Feature 4	422-F4-68-y	318168	AD 570–650	**AD 566–655 (95.4%)**	**AD 568–654 (100.0%)**
LA 111429	Feature 3	429-F3-300-s	317580	AD 130–260 AD 300–320	**AD 130–260 (82.8%)** **AD 282–325 (12.6%)**	**AD 130–260 (86.9%)** **AD 282–324 (10.1%)**
	Feature 3	429-F3-302-y	317546	AD 80–240	**AD 85–235 (95.4%)**	**AD 85–235 (100.0%)**
	Feature 11	429-F11-297-m	317581	AD 1490–1600 AD 1610–1650	**AD 1489–1604 (69.4%)** **AD 1610–1654 (29.0%)**	**AD 1489–1603 (72.7%)** **AD 1611–1654 (27.3%)**
	Feature 11	429-F11-321-s	317547	AD 1640–1680 AD 1740–1760 AD 1760–1800 AD 1940–1950	AD 1642–1684 (36.7%) AD 1735–1805 (44.5%) AD 1932–1955 (14.2%)	AD 1642–1683 (30.4%) AD 1735–1805 (48.2%) AD 1933–1951+ (12.45%)
	Feature 11	429-F11-321-y	317548	AD 1520–1560 AD 1630–1670 AD 1780–1800 AD 1950–1950	AD 1521–1575 (14.1%) AD 1584–1590 (0.5%) AD 1626–1680 (54.5%) AD 1764–1801 (21.4%) AD 1939–1955 (4.8%)	AD 1519–1593 (29.3%) AD 1619–1670 (56.8%) AD 1779–1799 (12.6%) AD 1943–1951+ (1.4%)
	Soil A horizon beneath coppice dune	429-HALL 1	317549	AD 1420–1450	**AD 1412–1469 (95.4%)**	**AD 1413–1467 (100.0%)**
	Soil A horizon beneath coppice dune	429-HALL 2	317550	AD 1410–1450	**AD 1403–1450 (95.4%)**	**AD 1405–1449 (100.0%)**
LA 111435	Feature 3	435-F3-23-t	317551	1210–1010 BC	1251–1243 BC (1.1%) 1213–1008 BC (94.3%)	1250–1243 BC (0.9%) 1212–1008 BC (99.0%)
	Feature 6	435-F6-38-y	317552	AD 380–440 AD 450–460 AD 480–530	AD 347–370 (5.4%) AD 378–535 (90.0%)	AD 348–369 (5.3%) AD 378–535 (94.7%)
	Feature 6	435-F6-39-s	317553	AD 400–540	**AD 404–540 (94.5%)**	**AD 404–540 (100.0%)**
	Feature 6	435-F6-39-y	317554	AD 390–540	AD 357–364 (0.9%) AD 382–539 (94.5%)	AD 358–362 (0.6%) AD 382–538 (99.4%)
	Feature 7	435-F7-50-s	317555	750–690 BC 660–640 BC 590–580 BC 570–400 BC	750–687 BC (18.9%) 666–642 BC (5.4%) 592–403 BC (71.0%)	749–687 BC (19.9%) 666–642 BC (5.6%) 592–576 BC (2.0%) 571–404 BC (72.5%)
	Feature 8 (structure?)	435-F8-49-y	317556	AD 770–900 AD 920–940	**AD 771–900 (86.1%)** **AD 917–965 (9.3%)**	**AD 772–900 (90.4%)** **AD 1002–1013 (9.7%)**
	Feature 8 (structure?)	435-F8-98-y	317557	AD 880–990	**AD 880–1014 (95.4%)**	**AD 880–998 (98.6%)** **AD 1002–1013 (1.4%)**
	Feature 8 (structure?)	435-F8-102-s	317558	AD 880–990	**AD 880–1014 (95.4%)**	**AD 880–998 (98.6%)** **AD 1002–1013 (1.4%)**
	Feature 10	435-F10-30-s	317559	2920–2880 BC	3011–2979 BC (5.2%) 2956–2951 BC (0.4%) 2941–2877 BC (89.8%)	3010–2979 BC (5.2%) 2940–2877 BC (94.9%)
LA 155963	Feature 1	963-F1-404-m	317560	AD 1430–1470	**AD 1416–1491 (94.1%)** **AD 1603–1609 (1.3%)**	**AD 1417–1489 (98.9%)** **AD 1604–1608 (1.1%)**
	Feature 1	963-F1-404-s	317561	AD 1450–1640	**AD 1470–1640 (95.4%)**	**AD 1470–1639 (100.0%)**
	Feature 6	963-F6-621-mo	317562	AD 1690–1730 AD 1810–1840 AD 1840–1850 AD 1860–1860 AD 1870–1920 AD Post–1950	AD 1693–1729 (23.6%) AD 1811–1920 (71.8%)	AD 1694–1727 (24.1%) AD 1812–1919 (74.0%) AD 1952–1954 (1.9%)
	Feature 8	963-F8-485-y	317563	AD 1260–1290	**AD 1224–1297 (95.4%)**	**AD 1224–1296 (100.0%)**
	Feature 8	963-F8-486	317564	AD 1260–1290	**AD 1228–1302 (90.2%)** **AD 1367–1383 (5.2%)**	AD 1228–1232 (0.8%) AD 1238–1249 (2.1%) AD 1250–1301 (92.0%) AD 1367–1382 (5.1%)

(Table 19.3, continued)

Site	Feature	OAS Sample No.	Beta-Analytic Sample No.	Beta–Analytic 2 Sigma Calibrated Age	OxCal 2 Sigma Calibrated Age	Calib 2 Sigma Calibrated Age
	Feature 9	963-F9-511-m	317565	AD 1530–1540 AD 1550–1550 AD 1630–1670 AD 1780–1800 AD 1940–1950	AD 1521–1575 (14.1%) AD 1584–1590 (0.5%) AD 1626–1680 (54.5%) AD 1764–1801 (21.4%) AD 1939–1955 (4.8%)	AD 1552–1574 (15.0%) AD 1584–1587 (0.2%) AD 1626–1680 (59.4%) AD 1764–1800 (22.2%) AD 1939–1951+ (3.3%)
	Feature 14	963-F14-574-s	317566	AD 430–600	**AD 430–591 (95.4%)**	**AD 430–585 (98.9%)** **AD 587–590 (1.1%)**
	Feature 15	963-F15-585	317567	30–30 BC 20–10 BC AD 0–90 AD 100–120	37–30 BC (1.4%) 22–11 BC (2.6%) 2 BC–125 AD (91.4%)	36–30 BC (1.5%) 21–11 BC (2.5%) 2 BC–AD 94 (85.4%) AD 96–125 (10.6%)
	Feature 125	963-F125-25-s	317568	AD 730–740 AD 770–900 AD 920–940	AD 720–742 (2.9%) AD 769–898 (88.8%) AD 921–944 (3.7%)	AD 720–741 (3.0%) AD 770–897 (93.3%) AD 921–994 (3.8%)
	Feature 141	963-F141-618-m	317569	AD 640–680	**AD 608–689 (95.4%)**	**AD 608–688 (100.0%)**
	Feature 141	963-F141-618-s	317570	AD 690–880	AD 689–752 (31.1%) AD 761–882 (64.3%)	AD 689–752 (32.6%) AD 761–882 (67.4%)
	Feature 141	963-F141-619-m	317571	AD 660–780	**AD 681–780 (94.2%)** **AD 793–803 (1.2%)**	**AD 662–779 (99.0%)** **AD 794–801 (1.0%)**
LA 155964	Feature 1	964-F1-24-y	317572	AD 1670–1780 AD 1800–1940 AD Post–1950	AD 1679–1765 (32.4%) AD 1774–1776 (0.4%) AD 1800–1940 (62.6%)	AD 1680–1764 (33.6%) AD 1774–1775 (0.2%) AD 1800–1899 (49.4%) AD 1901–1939 (15.9%) AD 1951–1953 (0.9%)
	Feature 1	964-F1-33-c	317573	AD 1680–1760 AD 1770–1780 AD 1800–1940 AD Post–1950	AD 1681–1763 (29.9%) AD 1801–1938 (65.5%)	AD 1681–1739 (28.4%) AD 1752–1762 (1.9%) AD 1802–1938 (69.0%) AD 1951–1954 (0.8%)
	Feature 1	964-F1-44-t	317574	AD 1680–1730 AD 1810–1930 AD Post–1950	AD 1690–1730 (25.2%) AD 1810–1926 (70.2%)	AD 1690–1729 (25.7%) AD 1810–1925 (72.8%) AD 1951–1954 (1.5%)
	Feature 1	964-F1-24-y	317582	AD 1670–1780 AD 1800–1900 AD 1900–1940 AD 1950–Post–1950	AD 1675–1778 (37.9%) AD 1799–1894 (42.5%) AD 1905–1942 (15.0%)	AD 1675–1778 (39.7%) AD 1779–1893 (44.2%) AD 1905–1941 (15.7%) AD 1950–1953 (0.4%)
	Feature 1	964-F1-45-m	317583	AD 1670–1780 AD 1800–1940 AD Post–1950	AD 1679–1765 (32.4%) AD 1774–1776 (0.4%) AD 1800–1940 (62.6%)	AD 1680–1764 (33.6%) AD 1774–1775 (0.2%) AD 1800–1899 (49.4%) AD 1901–1939 (15.9%) AD 1951–1953 (0.9%)
LA 155968	Feature 1	968-F1-475-t	317576	AD 690–750 AD 760–890	AD 692–749 (20.5%) AD 763–888 (74.9%)	AD 692–749 (21.2%) AD 764–887 (78.9%)
	Feature 1	968-F1-475-y	317577	AD 690–880	AD 689–752 (31.1%) AD 761–882 (64.3%)	AD 689–752 (32.6%) AD 761–882 (67.4%)
	Feature 1	968-F1-479-s	317578	AD 660–730 AD 740–770	**AD 656–773 (95.4%)**	**AD 656–728 (70.0%)** **AD 736–772 (30.0%)**
	Feature 1	968-F1-480-u	317579	AD 660–780	**AD 661–723 (94.2%)**	**AD 662–779 (99.0%)** **AD 794–801 (1.0%)**
	Feature 1	968-F1-473-y	317575	AD 690–750 AD 760–890	**AD 663–775 (95.4%)**	**AD 663–775 (100.0%)**

** Dates in **bold** font have the highest-percentage probabilities (more than half of total range) of being the most accurate dates.
OxCal calibrations: Percentage numbers represent the portions of 2-sigma (95.4% total) ranges comprised of smaller, internal ranges.
Calib calibrations: Percentage numbers represent the proportions of 2-sigma (100.0% total) ranges comprised of smaller, internal ranges.

Table 19.4. Radiocarbon samples and 1-sigma calibrated dates by site and feature.

Site	Feature	OAS Sample No.	Beta-Analytic Sample No.	Beta-Analytic 1 Sigma Calibrated Age	OxCal 1 Sigma Calibrated Age	Calib 1 Sigma Calibrated Age
LA 111422	Feature 1	422-F1-74-s	317545	AD 560–610	**AD 555–615 (68.2%)**	**AD 557–613 (100.0%)**
	Feature 4	422-F4-68-y	318168	AD 600–650	**AD 601–646 (68.2%)**	**AD 601–645 (100.0%)**
LA 111429	Feature 3	429-F3-300-s	317580	AD 180–190 AD 210–250	AD 139–196 (33.9%) AD 208–252 (34.3%)	AD 139–160 (18.4%) AD 165–196 (29.3%) AD 208–252 (52.3%)
	Feature 3	429-F3-302-y	317546	AD 130–220	**AD 128–215 (68.2%)**	**AD 128–214 (100.0%)**
	Feature 11	429-F11-297-m	317581	AD 1520–1570 AD 1590–1590 AD 1630–1650	**AD 1522–1575 (46.2%)** **AD 1584–1590 (4.0%)** **AD 1625–1646 (18.0%)**	**AD 1522–1574 (66.8%)** **AD 1584–1590 (6.21%)** **AD 1625–1646 (26.9%)**
	Feature 11	429-F11-321-s	317547	AD 1680–1730 AD 1810–1890 AD 1910–1930 AD Post–1950	AD 1647–1674 (30.2%) AD 1778–1799 (27.6%) AD 1942–1953 (10.4%)	AD 1648–1672 (45.9%) AD 1778–1799 (41.7%) AD 1942–1951+ (12.4%)
	Feature 11	429-F11-321-y	317548	AD 1640–1660	**AD 1639–1668 (50.0%)** **AD 1782–1798 (18.2%)**	AD 1529–1542 (14.3%) AD 1634–1666 (71.9%) AD 1784–1795 (13.8%)
	Soil A horizon beneath coppice dune	429-HALL 1	317549	AD 1430–1450	**AD 1425–1450 (68.2%)**	**AD 1427–1448 (100.0%)**
	Soil A horizon beneath coppice dune	429-HALL 2	317550	AD 1420–1440	**AD 1417–1440 (68.2%)**	**AD 1418–1439 (100.0%)**
LA 111435	Feature 3	435-F3-23-t	317551	1190–1180 BC 1150–1150 BC 1130–1050 BC	1190–1179 (5.0%) 1159–1144 (6.4%) 1131–1041 (56.9%)	1190–1179 BC (7.1%) 1158–1144 BC (9.1%) 1131–1042 BC (83.9%)
	Feature 6	435-F6-38-y	317552	AD 400–430	**AD 387–437 (47.8%)** **AD 489–530 (20.4%)**	**AD 387–437 (71.0%)** **AD 489–510 (18.7%)** **AD 483–553 (10.4%)**
	Feature 6	435-F6-39-s	317553	AD 420–440 AD 450–460 AD 480–530	AD 419–422 (19.6%) AD 453–461 (5.2%) AD 484–533 (43.3%)	AD 419–442 (28.0%) AD 451–461 (10.8%) AD 483–533 (61.2%)
	Feature 6	435-F6-39-y	317554	AD 410–430	**AD 397–440 (37.3%)** **AD 486–532 (30.9%)**	**AD 398–439 (54.0)%)** **AD 486–531 (46.0%)**
	Feature 7	435-F7-50-s	317555	730–690 BC 660–650 BC 540–410 BC	716–695 (7.8%) 540–411 BC (60.4%)	706–695 BC (6.7%) 539–411 BC (93.3%)
	Feature 8 (structure?)	435-F8-49-y	317556	AD 780–790 AD 800–890	AD 781–791 (6.9%) AD 807–888 (61.3%)	AD 781–790 (10.0%) AD 808–888 (90.0%)
	Feature 8 (structure?)	435-F8-98-y	317557	AD 890–980	AD 895–925 (29.2%) AD 937–976 (39.0%)	AD 895–925 (42.3%) AD 937–975 (57.7%)
	Feature 8 (structure?)	435-F8-102-s	317558	AD 890–980	AD 895–925 (29.2%) AD 937–976 (39.0%)	AD 895–925 (42.3%) AD 937–975 (57.7%)
	Feature 10	435-F10-30-s	317559	2910–2890 BC	**2914–2889 (68.2%)**	**2913–2890 BC (100.0%)**
LA 155963	Feature 1	963-F1-404-m	317560	AD 1440–1450	**AD 1431–1463 (68.2%)**	**AD 1431–1460 (100.0%)**
	Feature 1	963-F1-404-s	317561	AD 1480–1530 AD 1540–1550 AD 1530–1630	AD 1491–1526 (23.0%) AD 1557–1603 (30.6%) AD 1610–1632 (14.6%)	AD 1490–1526 (33.8%) AD 1556–1603 (45.2%) AD 1609–1632 (20.9%)

(Table 19.4, continued)

Site	Feature	OAS Sample No.	Beta-Analytic Sample No.	Beta-Analytic 1 Sigma Calibrated Age	OxCal 1 Sigma Calibrated Age	Calib 1 Sigma Calibrated Age
	Feature 6	963-F6-621-mo	317562	AD 1890–1910 AD Post–1950	AD 1700–1720 (15.7%) AD 1819–1833 (11.9%) AD 1880–1915 (40.6%)	AD 1700–1703 (2.9%) AD 1705–1720 (19.6%) AD 1819–1833 (16.2%) AD 1880–1915 (58.7%) AD 1952–1954 (2.7%)
	Feature 8	963-F8-485-y	317563	AD 1270–1280	**AD 1262–1287 (68.2%)**	**AD 1263–1286 (100.0%)**
	Feature 8	963-F8-486	317564	AD 1270–1280	**AD 1265–1290 (68.2%)**	**AD 1267–1289 (100.0%)**
	Feature 9	963-F9-511-m	317565	AD 1640–1660	**AD 1639–1668 (50.0%)** **AD 1782–1798 (18.2%)**	**AD 1639–1667 (75.0%)** **AD 1782–1797 (25.0%)**
	Feature 14	963-F14-574-s	317566	AD 440–450 AD 460–480 AD 530–560	**AD 437–489 (36.3%)** **AD 513–516 (1.3%)** **AD 530–567 (30.5%)**	**AD 437–489 (53.7%)** **AD 514–515 (1.6%)** **AD 530–567 (44.8%)**
	Feature 15	963-F15-585	317567	AD 20–80	**AD 18–81 (68.2%)**	AD 10–10 (0.9%) AD 17–81 (99.1%)
	Feature 125	963-F125-25-s	317568	AD 780–890	AD 780–792 (8.8%) AD 806–882 (59.4%)	AD 781–791 (12.7%) AD 807–882 (87.3%)
	Feature 141	963-F141-618-m	317569	AD 650–660	**AD 643–671 (68.2%)**	**AD 644–669 (100.0%)**
	Feature 141	963-F141-618-s	317570	AD 720–740 AD 770–780 AD 790–810 AD 850–850	AD 713–745 (19.4%) AD 767–828 (35.2%) AD 839–865 (13.6%)	AD 714–745 (28.6%) AD 767–784 (17.0%) AD 786–827 (35.5%) AD 840–864 (18.9%)
	Feature 141	963-F141-619-m	317571	AD 680–730 AD 740–770	**AD 680–723 (39.6%)** **AD 740–770 (28.6%)**	**AD 681–722 (57.9%)** **AD 741–770 (42.1%)**
LA 155964	Feature 1	964-F1-24-y	317572	AD 1680–1730 AD 1810–1890 AD 1910–1930 AD Post–1950	AD 1685–1709 (12.0%) AD 1718–1732 (6.9%) AD 1808–1889 (40.7%) AD 1910–1927 (8.6%)	AD 1685–1708 (17.1%) AD 1718–1731 (10.4%) AD 1808–1827 (14.5%) AD 1831–1889 (44.9%) AD 1910–1927 (12.7%) AD 1952–1952 (0.4%)
	Feature 1	964-F1-33-c	317573	AD 1680–1730 AD 1810–1890 AD 1910–1930 AD Post–1950	AD 1692–1728 (19.1%) AD 1812–1891 (43.1%) AD 1908–1920 (6.1%)	AD 1692–1712 (16.5%) AD 1716–1728 (9.9%) AD 1812–1891 (64.3%) AD 1908–1919 (9.0%) AD 1952–1952 (0.3%)
	Feature 1	964-F1-44-t	317574	AD 1700–1720 AD 1820–1830 AD 1880–1920 AD Post–1950	AD 1697–1725 (20.9%) AD 1815–1835 (14.9%) AD 1878–1917 (32.4%)	AD 1697–1725 (31.0%) AD 1814–1835 (21.0%) AD 1850–1850 (0.8%) AD 1877–1917 (46.6%) AD 1952–1954 (0.6%)
	Feature 1	964-F1-24-y	317582	AD 1680–1710 AD 1720–1740 AD 1760–1760 AD 1800–1830 AD 1830–1890 AD 1910–1940 AD Post–1950	AD 1683–1706 (12.1%) AD 1720–1737 (8.6%) AD 1758–1761 (1.1%) AD 1804–1820 (8.0%) AD 1833–1883 (27.0%) AD 1914–1936 (11.4%)	AD 1682–1707 (17.4%) AD 1791–1737 (12.0%) AD 1758–1761 (1.7%) AD 1803–1825 (38.1%) AD 1913–1936 (16.4%) AD 1951–1952 (0.5%)
	Feature 1	964-F1-45-m	317583	AD 1680–1730 AD 1810–1890 AD 1910–1930 AD Post–1950	AD 1685–1709 (12.0%) AD 1718–1732 (6.9%) AD 1808–1889 (40.7%) AD 1910–1927 (8.6%)	AD 1685–1708 (17.1%) AD 1718–1731 (10.4%) AD 1808–1827 (14.5%) AD 1831–1889 (44.9%) AD 1910–1927 (12.7%) AD 1952–1952 (0.4%)

(Table 19.4, continued)

Site	Feature	OAS Sample No.	Beta-Analytic Sample No.	Beta-Analytic 1 Sigma Calibrated Age	OxCal 1 Sigma Calibrated Age	Calib 1 Sigma Calibrated Age
LA 155968	Feature 1	968-F1-475-t	317576	AD 730–740 AD 770–830 AD 840–870	AD 729–736 (4.1%) AD 772–870 (64.1%)	AD 729–736 (5.0%) AD 772–834 (63.14%) AD 835–870 (31.9%)
	Feature 1	968-F1-475-y	317577	AD 720–740 AD 770–780 AD 790–810 AD 850–850	AD 713–745 (19.4%) AD 767–828 (35.2%) AD 839–865 (13.6%)	AD 714–745 (28.6%) AD 767–784 (17.0%) AD 786–827 (35.5%) AD 840–864 (18.9%)
	Feature 1	968-F1-479-s	317578	AD 660–690 AD 750–760	**AD 662–708 (49.0%)** **AD 747–766 (19.2%)**	**AD 662–695 (61.3%)** **AD 699–708 (10.0%)** **AD 747–765 (28.7%)**
	Feature 1	968-F1-480-u	317579	AD 680–730 AD 740–770	**AD 680–723 (39.6%)** **AD 740–770 (28.6%)**	**AD 681–722 (58.0%)** **AD 741–770 (42.0%)**
	Feature 1	968-F1-473-y	317575	AD 670–720 AD 740–770	**AD 674–715 (42.8%)** **AD 744–768 (25.4%)**	**AD 673–716 (63.0%)** **AD 744–768 (37.0%)**

** Dates in **bold** font have the highest-percentage probabilities (>50%) of being the most accurate dates.
OxCal calibrations: Percentage numbers represent the portions of 1-sigma (68.2% total) ranges comprised of smaller, internal ranges.
Calib calibrations: Percentage numbers represent the proportions of 1-sigma (100.0% total) ranges comprised of smaller, internal ranges.

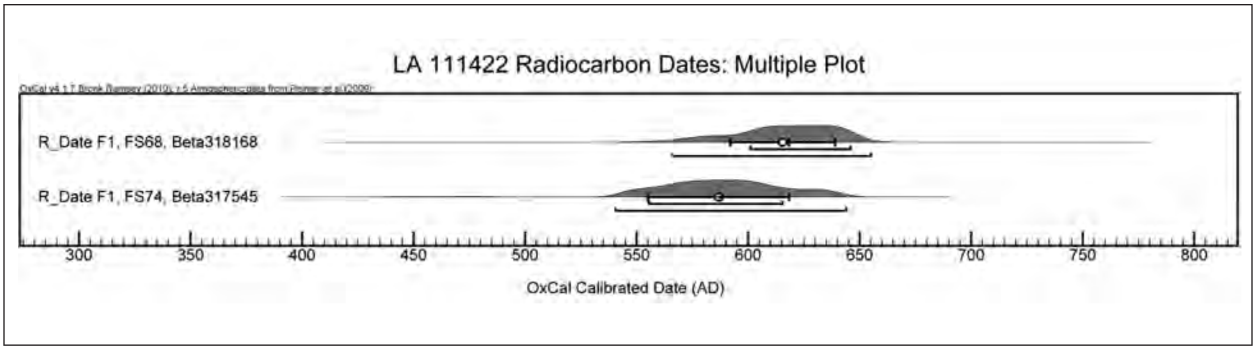

Figure 19.3. LA 111422, OxCal multiple plot of radiocarbon dates.

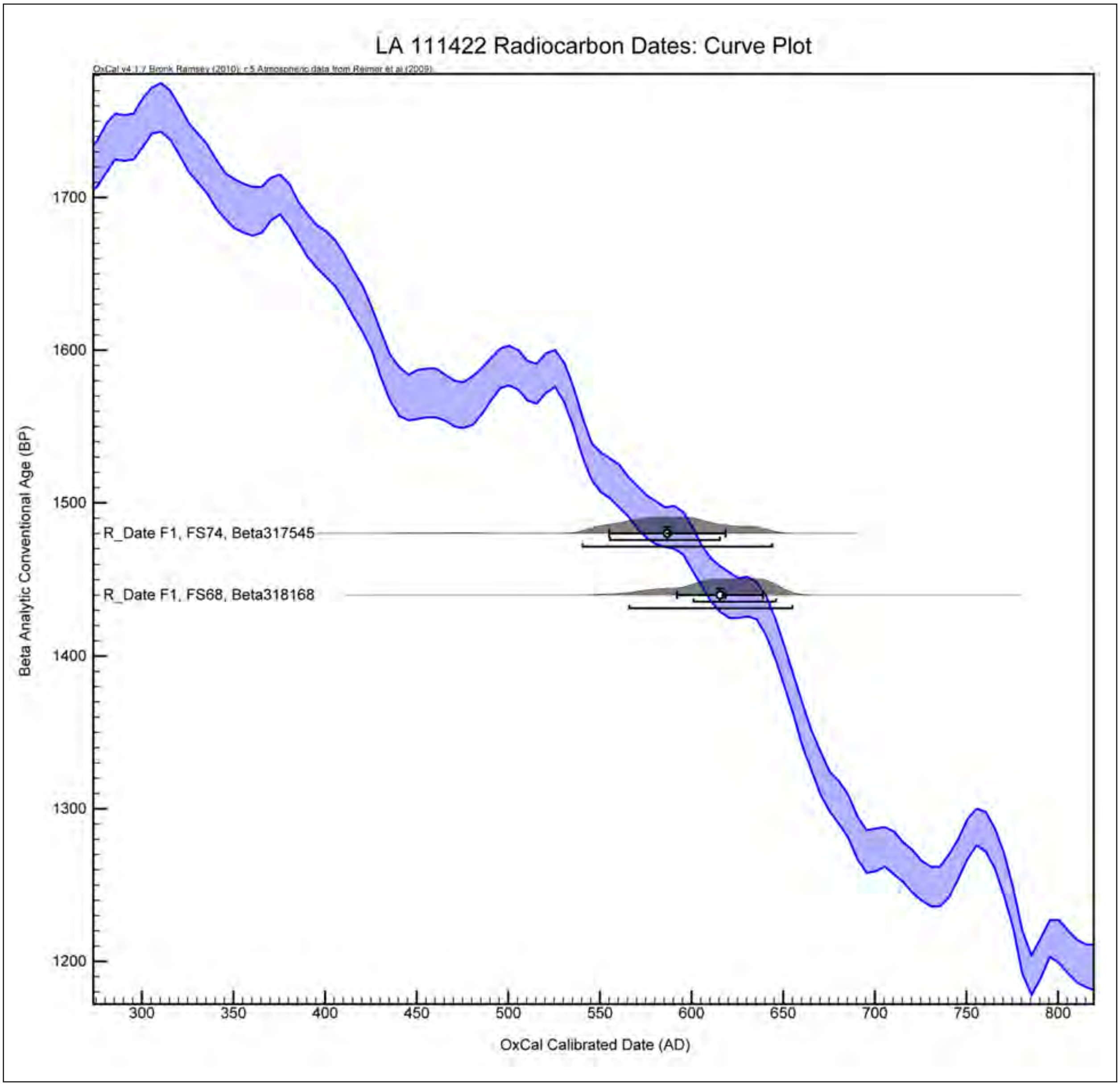

Figure 19.4. LA 111422, OxCal curve plot of radiocarbon dates.

Table 19.5. Radiocarbon dates, Grubb's outlier test results.

Conventional 14C Age (BP)	Z Value	Mean Conventional Age (BP)	Standard Deviation	No. of Samples	Critical Z Value for Sample Size	Outlier at 95% Confidence Level
LA 111429						
All samples		768.57	728.62	7	2.02	
220	0.75					no
260	0.7					no
300	0.64					no
460	0.42					no
490	0.38					no
1800	1.42					no
1850	1.48					no*
* Not an outlier but highest Z value, thus furthest from group mean. Calibration T-test (Table 19.6) shows that this not a single group of dates.						
Remove 1850 BP sample		588.33	603.47	6	1.89	
220	0.61					no
260	0.54					no
300	0.48					no
460	0.21					no
490	0.16					no
1800	2.01					yes*
* Removing the 1850 date makes the 1800 date an outlier by decreasing the group mean, confirming that the 19th-century dates are a single, separate group. Calibration T-test (Table 19.6) shows that the 19th century dates are a single group.						
Remove 1800 and 1850 BP sa		346.00	121.57	5	1.71	
220	1.04					no
260	0.71					no
300	0.38					no
460	0.94					no
490	1.18					no
Calibration T-test (Table 19.6) shows that, although there are no outliers, this is not a single group of dates.						
Remove A horizon samples		260	40	3	1.15	
220	1.00					no
260	0.00					no
300	1.00					no
Calibration T-test (Table 19.6) confirms that this is a single group of dates. The 5th century, A horizon dates are also a single group.						
LA 111435						
All samples		1986.67	1057.91	9	2.21	
1110	0.83					no
1110	0.83					no
1180	0.76					no
1600	0.37					no
1620	0.35					no
1630	0.34					no
2430	0.42					no
2910	0.87					no
4290	2.18					no*
* Not an outlier but highest Z value, thus furthest from group mean. Only 0.003 from being an outlier. Calibration T-test shows that this is not a single group of dates.						
Remove 4290 BP sample		1698.75	653.00	8	2.13	
1110	0.90					no
1110	0.90					no
1180	0.79					no
1600	0.15					no
1620	0.12					no
1630	0.11					no
2430	1.12					no
2910	1.85					no*
* Not an outlier but highest Z value, thus furthest from group mean. Calibration T-test shows that this is not a single group of dates.						

(Table 19.5, continued)

Conventional 14C Age (BP)	Z Value	Mean Conventional Age (BP)	Standard Deviation	No. of Samples	Critical Z Value for Sample Size	Outlier at 95% Confidence Level
Remove two oldest samples		1525.71	466.94	7	2.02	
1110	0.89					no
1110	0.89					no
1180	0.74					no
1600	0.16					no
1620	0.20					no
1630	0.22					no
2430	1.94					no*
* Not an outlier but highest Z value, thus furthest from group mean. Only 0.008 from being an outlier. Calibration T-test shows that this is not a single group of dates.						
Remove three oldest samples		1375.00	266.14	6	1.89	
1110	0.89					no*
1110	0.89					no*
1180	0.74					no
1600	0.16					no
1620	0.20					no
1630	0.22					no
* Not an outlier but highest Z value, thus furthest from group mean.						
Although this group of dates does not include any outliers, it is obvious that it comprises two separate groups of dates, one in the 12th century and one in the 17th century, confirmed by their clustered Z values. Further, calibration T-test shows that this is not a single group of dates. It makes sense, then, to test those two groups for internal integrity.						
Feature 6 samples		1616.67	15.28	3	1.15	
1600	1.09					no*
1620	0.22					no
1630	0.87					no
* Not an outlier but highest Z value, thus furthest from group mean. Calibration T-test shows that this is a single group of dates.						
Feature 8 samples		1133.33	40.41	3	1.15	
1110	0.89					no
1110	0.89					no
1180	0.74					yes*
* Date is an outlier because the other dates are identical. Calibration T-test shows that this is a single group of dates.						
Feature 6 samples		1616.67	15.28	3	1.15	
1600	1.09					no*
1620	0.22					no
1630	0.87					no
* Not an outlier but highest Z value, thus furthest from group mean. Calibration T-test shows that this is a single group of dates.						
LA 155963						
All samples		925	586.01	12	2.41	
60	1.48					no
250	1.15					no
340	1.00					no
440	0.83					no
720	0.35					no
730	0.33					no
1190	0.45					no
1230	0.52					no
1280	0.61					no
1370	0.76					no
1540	1.05					no
1950	1.75					no*
* Not an outlier but highest Z value, thus furthest from group mean. Calibration T-test shows that this is not a single group of dates.						

(Table 19.5, continued)

Conventional 14C Age (BP)	Z Value	Mean Conventional Age (BP)	Standard Deviation	No. of Samples	Critical Z Value for Sample Size	Outlier at 95% Confidence Level
Remove oldest date		831.82	512.97	11	2.36	
60	1.50					no*
250	1.13					no
340	0.96					no
440	0.76					no
720	0.22					no
730	0.20					no
1190	0.70					no
1230	0.78					no
1280	0.87					no
1370	1.05					no
1540	1.38					no
* Not an outlier but highest Z value, thus furthest from group mean. Calibration T-test shows that this is not a single group of dates.						
Note: The consistent pattern with the LA 155963 samples is that there are no outliers. Each test identifies one date as furthest from the group mean. The first is the oldest date, 1950 BP. When that is removed, the test next identifies the youngest date, 60 BP. After removing that date, the test sequentially identifies the next youngest date, never as an outlier, until all dates younger than 1100 BP are eliminated. Then the test sequentially identifies the oldest remaining dates, also never as outliers. Not only are there no outliers, there are no clusters of dates identified by this test.						
Feature 141 samples		1293.33	70.95	3	1.15	
1230	0.89					no
1280	0.19					no
1370	1.08					no*
* Not an outlier but highest Z value, thus furthest from group mean. Calibration T-test shows that this is not a single group of dates.						
Features 125 and all 141		1267.50	77.62	4	1.48	
1190	1.00					no
1230	0.48					no
1280	0.16					no
1370	1.32					no*
* Not an outlier but highest Z value, thus furthest from group mean. Calibration T-test shows that this is not a single group of dates.						
Features 125 & young 141		1233.33	45.09	3	1.15	
1190	0.96					no
1230	0.07					no
1280	1.03					no*
* Not an outlier but highest Z value, thus furthest from group mean. Calibration T-test shows that this is a single group of dates.						
LA 155964						
All samples		112	19.24	5	1.71	
80	1.66					no*
110	0.10					no
120	0.42					no
120	0.42					no
130	0.94					no
* Not an outlier but highest Z value, thus furthest from group mean. Calibration T-test shows that this is a single group of dates.						
LA 155968						
All samples		1266	39.12	5	1.71	
1220	1.18					no*
1230	0.92					no
1280	0.36					no
1290	0.61					no
1310	1.12					no
* Not an outlier but highest Z value, thus furthest from group mean. Calibration T-test shows that this is a single group of dates.						

Note: LA 111422 results are not presented because there are only two samples and they are statistically the same.

mean, 1850 BP, has a Z value of 1.48, well below the critical value of 2.02. Had there been only one BP date with a value of 1800 or older, it would have been an outlier. Instead, the oldest date is not an outlier. When I removed it from the group as the value furthest from the group mean, though, the 1-sigma standard deviation value was actually larger than the mean conventional age value, and the next oldest value, 1800 BP, was identified as an outlier (Table 19.5). When both 1800+ BP dates, which are from Feature 3, are removed from the site group, the Grubb's test reveals a group with a much younger mean age and a much smaller standard deviation, thus a much "tighter" group of dates (Table 19.5). Figures 19.5 and 19.6, the OxCal LA 111429 multiple and curve plots, show that the dates from Feature 3 can be intuitively distinguished from those in the "tighter" group, which consists of the dates from Feature 11 and the paleosol A horizon. As I show later, this group of Feature 11 dates is actually two groups of dates, a result not shown by the Grubb's test results.

Feature 3 (large roasting pit)

<u>Dates</u>
Most accurate: cal AD 85–260
Most precise and accurate: cal ca. AD 130–215
Pooled mean: cal AD 130–239 (2 sigma); cal AD 138–227 (1 sigma)

<u>Discussion</u>: Since there are only two samples from Feature 3 at LA 111429, an outlier test cannot be performed. Student's T-test results confirm that a single group comprises the two samples from Feature 3 (Table 19.6). The highest accuracy probability, calibrated, 2-sigma dates from sample Beta-317580 are AD 130 to 260, while those from sample Beta-317546 are AD 85 to 235, overlapping between AD 130 and 235. Not surprisingly, this overlap period is very similar to the pooled mean calibrated ages.

Like the LA 111422 dates, the 1-sigma dates from Feature 3 suggest slightly increased precision within the 2-sigma range, with two shorter ranges that overlap between AD 208 and 215 (Table 19.4). It is important to note that the OxCal and Calib 1-sigma dates from sample Beta-317580 are split almost evenly between AD 139 to 196 and AD 208 to 252, with the second range having only a slightly higher probability in each case. The OxCal and Calib 1-sigma dates from sample Beta-317546 are AD 128 to 214/215, which are most similar to the AD 139 to 196 range from the other Feature 3 sample. In turn, both of those ranges are similar to and slightly shorter than the AD 130–235 overlap period in the 2-sigma range.

The radiocarbon date for Feature 3 at LA 111429 with the greatest accuracy is AD 85 to 260. This period accommodates the calibrated dates, the pooled mean age, and the OxCal mean and median dates. It may be possible, if less statistically secure, to increase the precision of the age of Feature 3 to ca. AD 130 to 215, which encompasses the highest probability 1-sigma dates and most of the pooled mean age, as well as the OxCal mean and median dates for the samples (Tables 19.2a, 19.2b). The more precise but less confident date range is 45 years shorter at its beginning and 45 years shorter at its ending than the 2-sigma date range, decreasing the latter by about half (48.6 percent). That the median of the 2-sigma range is AD 172.5, that of the 1-sigma range is AD 180, and the differences between them are evenly distributed on their older and younger ends, lend support to a conclusion, albeit with lower statistical confidence, that the shorter range, ca. AD 130 to 215, is both accurate and precise.

Feature 11 and Paleosol A Horizon Samples

<u>Dates</u>
Pooled mean: cal AD 1474–1632 (2 sigma); cal AD 1490–1625 (1 sigma)

<u>Discussion</u>: As I observed earlier for LA 111429, simple observation as well as outlier and t-tests show that the two Feature 3 radiocarbon dates are statistically different than an apparent group of three dates from Feature 11 and two dates from a paleosol A horizon (Figs. 19.5, 19.6). Grubbs' test shows that there are no outliers among this group of five dates and that no date stands out as furthest from the group mean since the oldest and youngest dates are almost the same distance from the group mean (Table 19.5). However, the OxCal calibrated curve plot (Fig. 19.7) indicates that the five dates fall into two groups, one comprising the two soil dates and the other comprising the three Feature 11 dates. Student's t-test results confirm that the five dates are statistically different and, therefore, are not a single group of dates (Table 19.6). For contextual

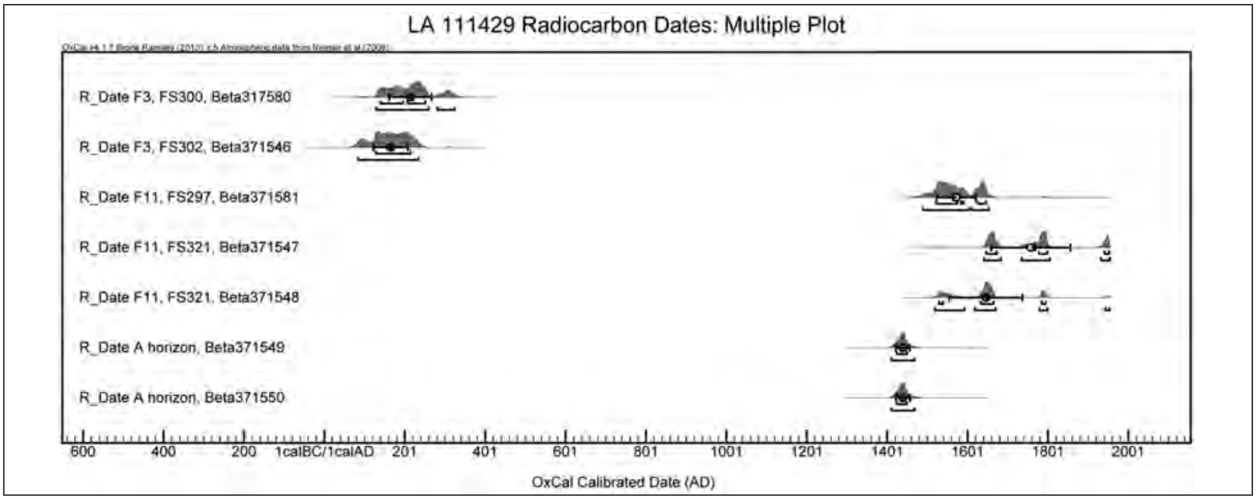

Figure 19.5. LA 111429, OxCal multiple plot of radiocarbon dates.

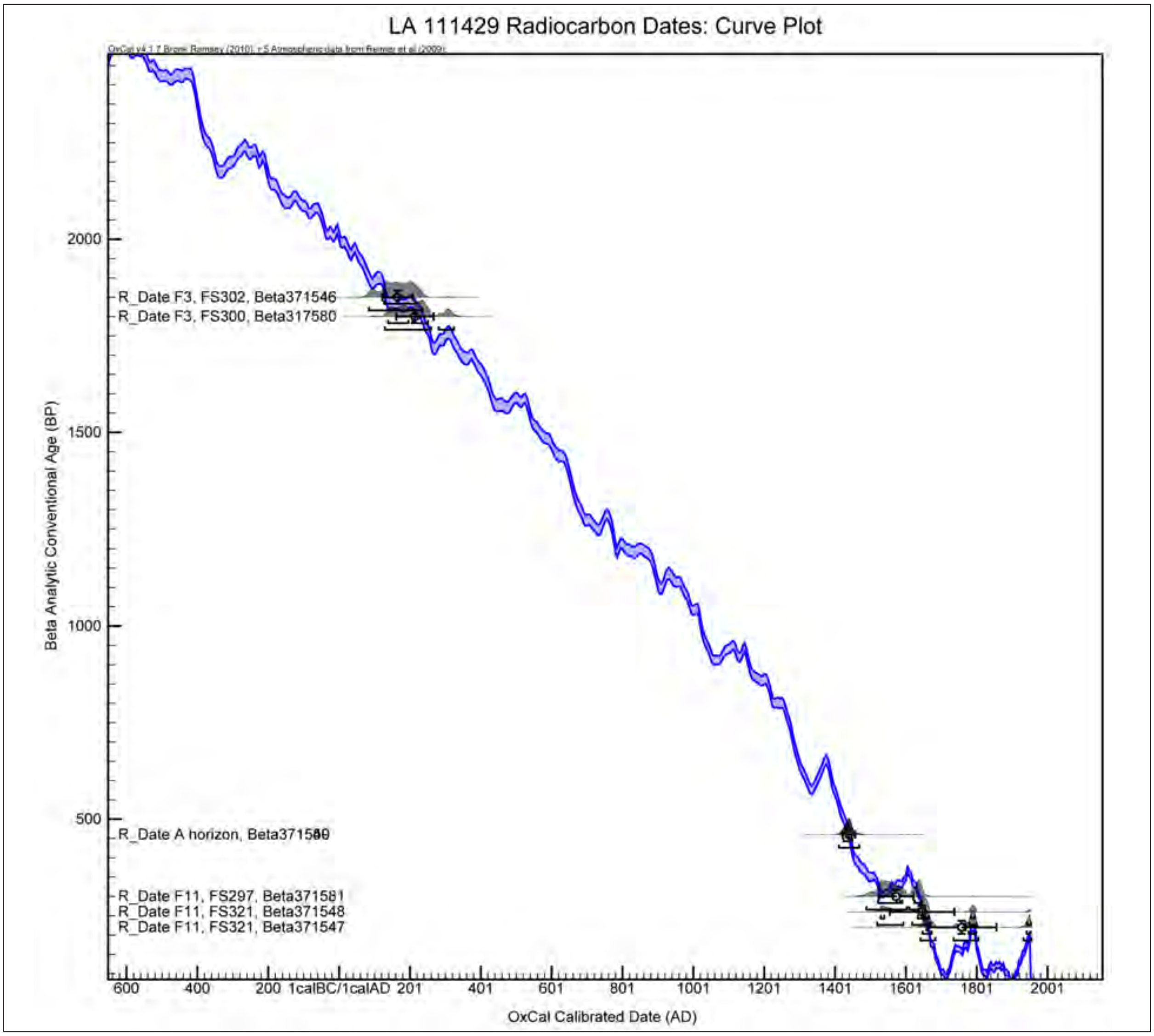

Figure 19.6. LA 111429, OxCal curve plot of radiocarbon dates.

Table 19.6. Radiocarbon dates, mean pooled radiocarbon ages, and Student T-test results.

Mean Pooled 14C Age				Standard Deviation	No. of Samples	Student's T-Test				Result Summary
Conven-tional (BP)	Uncali-brated (BC/AD)	Calibrated (BC/AD)				T Value	P Value (2-tail)	χ2 (0.05)	Degrees of Freedom	
		2–Sigma	1–Sigma							
LA 111422										
All samples										
1460 BP	AD 490	AD 565–644 (100.0%)	AD 585–586 (3.4%) AD 590–635 (96.6%)	21.213	2	0.889	0.537	3.84	1	Samples are the same at 95 % confidence level. They are a single group of dates.
LA 111429										
All samples										
768.57 BP	AD 1181.43	AD 1227–1276 (100.0%)	AD 1256–1273 (100.0%)	11.339	7	3539.206	NA*	12.60	6	Samples are different at 95 % confidence level. They are not a single group of dates.
Feature 3: 300-s and 302-y, 1st century samples										
1825 BP	AD 125	AD 130–239 (100.0%)	AD 138–159 (29.6%) AD 166–197 (42.8%) AD 207–227 (27.6%)	21.213	2	1.389	0.397	3.84	1	Samples are the same at 95 % confidence level. They are a single group of dates.
Feature 11 and A horizon samples										
346 BP	AD 1604	AD 1474–1525 (41.4%) AD 1556–1632 (58.6%)	AD 1490–1522 (45.3%) AD 1574–1584 (11.9%) AD 1589–1603 (31.7%) AD 1609–1625 (21.1%)	13.416	5	65.689	0.000	9.49	4	Samples are different at 95 % confidence level. They are not a single group of dates.
Feature 11: 297-m, 321-s, 321-y samples										
260 BP	AD 1690	AD 1529–1540 (3.5%) AD 1634–1666 (91.2%) AD 1784–1795 (5.3%)	AD 1643–1657 (100.0%)	17.321	3	3.556	0.071	5.99	2	Samples are the same at 95 % confidence level. They are a single group of dates.

(Table 19.6, continued)

Mean Pooled 14C Age				Standard Deviation	No. of Samples	Student's T-Test				Result Summary
Conventional (BP)	Uncalibrated (BC/AD)	Calibrated (BC/AD)				T Value	P Value (2-tail)	χ2 (0.05)	Degrees of Freedom	
		2–Sigma	1–Sigma							
A horizon samples: HALL 1 and HALL 2 samples										
475 BP	AD 1475	AD 1417–1447 (100.0%)	AD 1426–1442 (100.0%)	21.213	2	0.500	0.705	3.84	1	Samples are the same at 95 % confidence level. They are a single group of dates.
LA 111435										
All samples										
1986.667 BP	36.667 BC	37–27 BC (5.2%) 25–9 BC (10.5%) 3 BC–AD 55 (84.3%)	AD 1–29 (74.3%) AD 38–50 (25.7%)	10.000	9	9948.222	NA*	15.50	8	Samples are different at 95 % confidence level. They are not a single group of dates.
All dates except Feature 10 30-s sample										
1698.75 BP	AD 251.25	AD 261–282 (13.8%) AD 324–400 (86.2%)	AD 337–386 (100.0%)	10.607	8	3316.542	NA*	14.10	7	Samples are different at 95 % confidence level. They are not a single group of dates.
All dates except Feature 10 30-s and Feature 3 23-t samples (two oldest dates)										
1525.714 BP	AD 424.286	AD 443–454 (2.3%) AD 461–483 (6.9%) AD 534–592 (90.8%)	AD 539–564 (100.0%)	11.339	7	1453.524	NA*	12.60	6	Samples are different at 95 % confidence level. They are not a single group of dates.
All dates except Feature 10 30-s, Feature 3 23-t, and Feature 7 50-s samples (three oldest dates), only Feature 6 and 8 samples										
1375 BP	AD 575	AD 645–665 (100.0%)	AD 650–660 (100.0%)	12.247	6	393.500	0.000	11.10	5	Samples are different at 95 % confidence level. They are not a single group of dates.
Feature 6 samples										
1616.667 BP	AD 333.333	AD 398–466 (61.3%) AD 480–533 (38.7%)	AD 408–435	17.321	3	0.519	0.655	5.99	2	Samples are the same at 95 % confidence level. They are a single group of dates.

(Table 19.6, continued)

Mean Pooled 14C Age				Standard Deviation	No. of Samples	Student's T-Test				Result Summary
Conventional (BP)	Uncalibrated (BC/AD)	Calibrated (BC/AD)				T Value	P Value (2-tail)	χ2 (0.05)	Degrees of Freedom	
		2–Sigma	1–Sigma							
Feature 8 samples										
1133.333 BP	AD 816.667	AD 881–974 (100.0%)	AD 890–899 (2.0%) AD 919–954 (71.7%) AD 956–961 (8.2%)	17.321	3	3.630	0.068	5.99	2	Samples are the same at 95 % confidence level. They are a single group of dates.
LA 155963										
All samples										
925 BP	AD 1025	AD 1041–1108 (60.7%) AD 1116–1157 (39.3%)	AD 1045–1058 (19.5%) AD 1065–1068 (3.6%) AD 1071–1094 (33.6%) AD 1120–1141 (32.8%) AD 1148–1155 (10.6%)	8.660	12	4197.222	NA*	19.70	11	Samples are different at 95 % confidence level. They are not a single group of dates.
Feature 1 all samples										
390 BP	AD 1560	AD 1444–1518 (84.0%) AD 1594–1618 (16.0%)	AD 1449–1489 (91.8%) AD 1603–1608 (8.2%)	21.213	2	5.556	0.113	3.84	1	Samples are different at 95 % confidence level. They are not a single group of dates.
Feature 8 all samples										
725 BP	AD 1560	AD 1261–1292 (100.0%)	AD 1270–1284 (100.0%)	21.213	2	0.056	0.964	3.84	1	Samples are the same at 95 % confidence level. They are a single group of dates.
Feature 141 all samples										
1293.333 BP	AD 656.667	AD 666–725 (62.7%) AD 738–771 (37.3%)	AD 674–695 (43.4%) AD 697–708 (17.9%) AD 747–765 (38.6%)	17.321	3	11.135	0.008	5.99	2	Samples are different at 95 % confidence level. They are not a single group of dates.
Feature 141 618-s and 619-m samples										
1255 BP	AD 695	AD 676–782 (93.8%) AD 789–812 (5.0 %) AD 845–855 (1.2%)	AD 694–748 (84.5%) AD 765–775 (15.5%)	21.213	2	21.213	0.030	1.39	1	Samples are the same at 95 % confidence level. They are a single group of dates.

(Table 19.6, continued)

Mean Pooled 14C Age				Standard Deviation	No. of Samples	Student's T-Test				Result Summary
Conven-tional (BP)	Uncali-brated (BC/AD)	Calibrated (BC/AD)				T Value	P Value (2-tail)	χ2 (0.05)	Degrees of Freedom	
		2–Sigma	1–Sigma							
Feature 141 all samples and Feature 125 25-s sample										
1267.5 BP	AD 682.5	AD 685–774 (100.0%)	AD 690–725 (61.8%) AD 738–751 (22.6%) AD 762–771 (15.6%)	15.000	4	20.083	0	7.81	3	Samples are different at 95 % confidence level. They are not a single group of dates.
Feature 141 618-s and 619-m samples and Feature 125 25-s sample										
1233.333 BP	AD 716.667	AD 692–748 (38.6%) AD 764–870 (61.4%)	AD 713–745 (42.3%) AD 767–782 (23.8%) AD 789–811 (26.6%) AD 845–855 (7.3%)	17.321	3	4.518	0.046	5.99	2	Samples are the same at 95 % confidence level. They are a single group of dates.
LA 155964										
All samples										
112 BP	AD 1838	AD 1690–1730 (27.2%) AD 1809–1892 (61.9%) AD 1907–1926 (10.9%)	AD 1694–1707 (14.8%) AD 1719–1727 (9.4%) AD 1812–1825 (14.1%) AD 1832–1854 (32.3%) AD 1913–1926 (6.6%)	13.416	5	1.644	0.176	9.49	4	Samples are the same at 95 % confidence level. They are a single group of dates.
LA 155968										
All samples										
1266 BP	AD 684	AD 687–774 (100.0%)	AD 691–726 (63.8%) AD 737–750 (21.8%) AD 762–771 (14.4%)	13.416	5	6.800	0.002	9.49	4	Samples are the same at 95 % confidence level. They are a single group of dates.

*NA: Not applicable because p-value could not be calculated due to very large t-value.

Note: Conventional mean pooled ages (BP) are calculated by Calib 6.1.0 using conventional ages provided by Beta Analytic, Inc. Uncalibrated mean pooled ages (BC/AD) are calculated by subtracting conventional mean pooled ages from AD 1950. Calibrated mean pooled ages (BC/AD) are calculated by submitting conventional mean pooled ages to Calib 6.1.0 calibration.

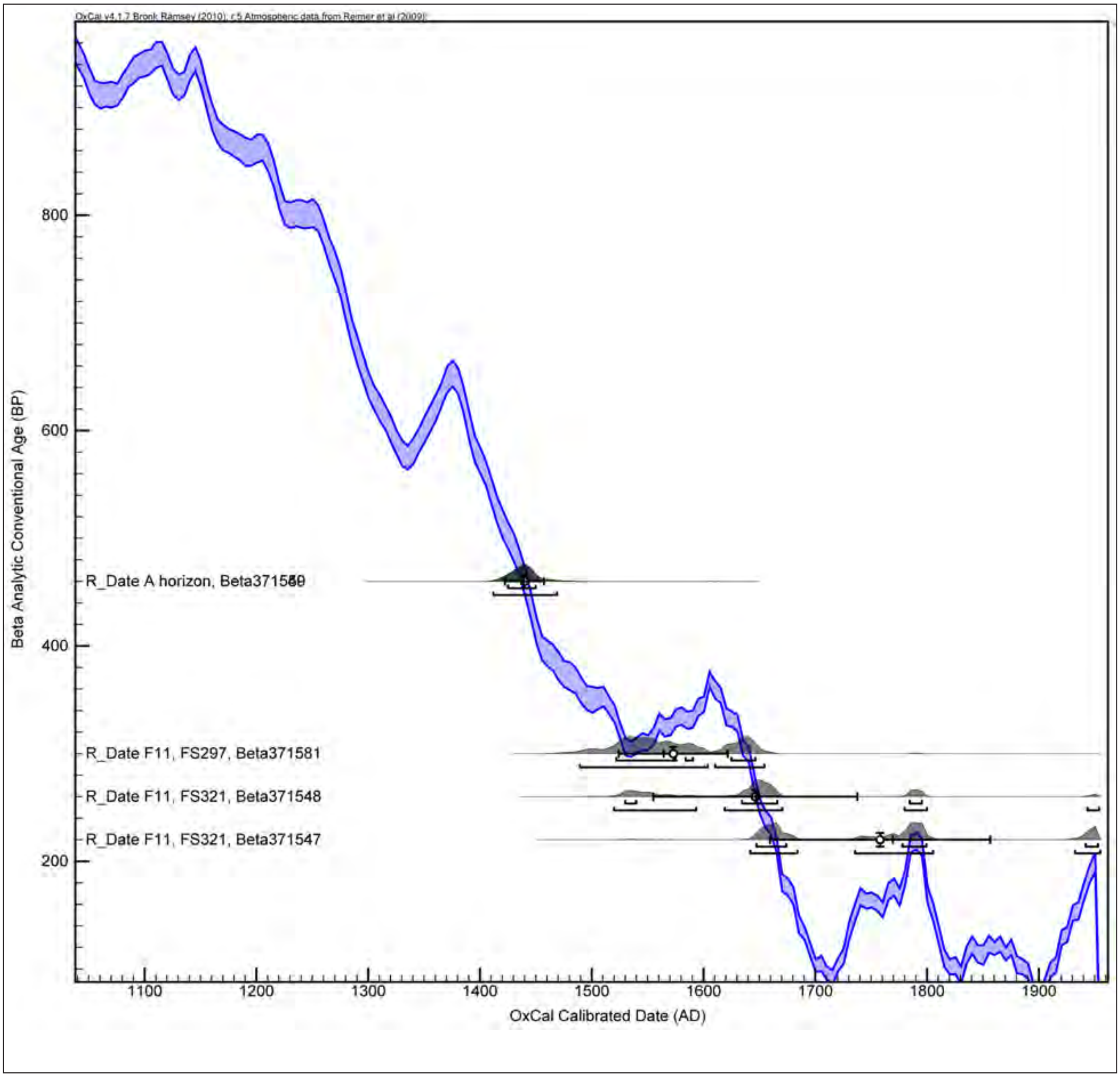

Figure 19.7. LA 111429, Feature 11 and Paleosol A horizon, OxCal curve plot of radiocarbon dates.

reasons, I then divided the five dates into a group of dates from Feature 11 and a group of dates from the paleosol A horizon.

Feature 11 (large roasting pit)

Dates
Most accurate: cal ca. AD 1620–1685
Most precise: cal ca. AD 1630–1675
Pooled mean: cal AD 1634–1666 (2 sigma); cal AD 1643–1657 (1 sigma)

Discussion: Grubb's outlier test shows that there are no outliers among the three dates from Feature 11 (Table 19.5) at LA 111429. Indeed, the oldest and youngest dates are the same distance from the group mean, which is, not surprisingly, the middle date. It should also not surprise us, then, that the 2-sigma pooled mean calibrated age is very similar, although somewhat shorter in length, to the middle (Beta-317548) date of the three. Student's t-test results confirm that a single group comprises the three dates (Table 19.6).

Interestingly, however, an examination of the 2-sigma calibrated dates (Table 19.3) shows that the date ranges with highest probability of accuracy are not only different for each sample from Feature 11, they also do not overlap. This could suggest that, in fact, the dates are individually different and outlier and t-test results simply confirm the long range of the dates, ca. 316 years (2 sigma) and 146 years (1 sigma). Closer assessment, however, shows that this is probably not the case and that material integrity probably influences the date of one sample.

Two Feature 11 samples, Beta-317581 and Beta-317548, yielded dating results in which a single range dominates their 2-sigma calibrated ranges: AD 1489 to 1603/1604 for the former and AD 1619/1626 to 1670/1680 for the latter (Table 19.3). In both cases, those dominate ranges make up over half of the percentage values, ca. 70 percent for the former and ca. 55 percent for the latter. In this situation, I might feel much more confident about the 2-sigma age of the former sample, which spans the sixteenth century AD.

The third sample, Beta-317547, yielded results in which the dominant ranges make up less than half of the percentage values. Indeed, both OxCal and Calib 2-sigma calibrated dates are similarly split between two ranges: AD 1642 to 1683/1684 (ca. 30 to 37 percent) and AD 1735 to 1805 (ca. 45 to 48 percent; Table 19.3), which are separated by about 50 years. Calibrated dates from sample Beta-317547 are considerably younger than those from Beta-317581 and younger, but less so, than those from Beta-317548.

Since the three Feature 11 samples are statistically the same, there is no value in separating the saltbush and yucca samples Beta-317547 and Beta-317548 from the older mesquite wood sample for additional statistical testing. How then to explain the older dates from mesquite wood? Two factors are involved in this situation.

First, I assert that the difference, to the extent that it is discernable, probably reflects different sample materials and integrity. Specifically, I suspect that, since sample Beta-317581 was burned mesquite wood, contrasting with saltbush wood and yucca stem that made up the younger samples (Tables 19.2a, 19.2b), the older date probably reflects an old-wood or cross-section situation in which the sample was charcoal from the interior of mesquite branches. That is, the integrity of the sample material is questionable because we cannot be certain about the following details regarding what was available and submitted for radiocarbon dating: which portion(s) of one or more mesquite branches (e.g., outer or inner parts) was used?; how thick was/were the branch(es) when collected for burning?; were one or more branches represented? We also cannot be certain of relationships between the dated material, as opposed to original material(s), and their archaeological contexts. This explains why all three dates make up a single group within which one date is discernibly but not statistically older than the other two.

The same pattern is apparent with 1-sigma dates (Table 19.4). Two samples, Beta-317581 and Beta-317548, yielded dating results in which a single range dominated their 1-sigma calibrated ranges: AD 1522 to 1574/1575 for the former and AD 1634/1639 to 1666/1668 (Table 19.4). In both cases, those dominant ranges, separated by about 60 years, make up about the same portions of the percentage values, ca. 46 to 67 percent for the former and ca. 50 to 72 percent for the latter. The pooled mean age for all three samples from Feature 11, AD 1634 to 1666, is the same as the Beta-317548 range.

The third sample, Beta-317547, yielded results in which the dominant ranges make up less than half of the percentage values. OxCal and Calib 1-sigma calibrated dates are similarly split between two ranges: AD 1646/1648 to 1672/1674 (ca. 30 to 46 percent) and AD 1778 to 1799 (ca. 27 to 42 percent; Table 19.4), which are separated by almost 100 years. The pooled mean age for all three samples, AD 1634 to 1666, overlaps with the younger end of the first range. Calibrated 1-sigma dates from sample Beta-317547 are considerably younger than those from Beta-317581 and younger, but still less so, than those from Beta-317548. These results support a conclusion that the burned mesquite wood making up sample Beta-317581 that yielded identifiably but not statistically older dates than the saltbush and yucca samples reflects old-wood conditions.

The second factor is the shape of the calibration curve where it is intersected by the conventional age curve of sample Beta-317581. While the calibration curve encompassing the range of all dates from LA 111429 is generally steep (Fig. 19.6), the location at which the sample Beta-317581 conventional age intersects the calibration curve, ca. cal AD 1500 to 1650, is relatively flatter (Figs. 19.7, 19.8). Consequently, the sample conventional age intersects the curve (Fig. 19.9) in the AD 1500s (cal AD 1489 to 1603/1604, 2 sigma, ca. 70 percent) and again in the early AD 1600s (cal AD 1610/1611 to 1654, 2 sigma, ca. 28 percent). The sample's OxCal mean and median dates (Tables 19.2a, 19.2b) confirm that the sample's age in the sixteenth century AD is most accurate.

We see, then, why the three Feature 11 dates are statistically a single group. The burned mesquite wood sample, Beta-317581, yielded results that best fit the calibration curve during the AD 1500s. These results probably reflect the nature and integrity of the burned material but are affirmed by the sample's OxCal mean and median dates. The sample date also intersects the calibration curve in the early AD 1600s, largely because of the curve shape. Although it appears to link the mesquite wood with dating results from the saltbush and yucca samples in the second and third quarters of the AD 1600s, it may be an artifact of the curve shape. This supports the position that the mesquite wood date reflects old-wood/cross-section integrity conditions.

We should also address the much younger dates from the saltbush and yucca samples (Tables 19.3, 19.4). Both samples yielded dates, with much lower probabilities of accuracy, in the late eighteenth century AD and the early to mid–twentieth century AD. In both cases these dates are, at least in part, a result of the relatively flat trend of the calibration curve between about AD 1700 and 1950 (Figs. 19.10, 19.11). As the conventional ages get younger, their distribution curves intersect more parts of the calibration curve and, in the part of the curve in the late AD 1700s, a flatter and thus longer part of the curve (compare Figs. 19.9, 19.10, and 19.11). It is for this reason that the OxCal mean and median dates for sample Beta-371547 are in the mid–AD 1700s: the curve shape tends to equalize intersections in the AD 1600s and 1700s (Fig. 19.11). If the trend of the curve were not as flat after about AD 1700, the sample would more clearly date in the AD 1600s.

For samples Beta-317547 and Beta-317548, the first locations of intersection are in the early to mid–AD 1600s, the steepest part of the calibration curve between about AD 1600 and 1700. The same is true for the second date range from sample Beta-317581. Together, the dates, all from a single feature, support each other and show that the later dates from the saltbush and yucca samples reflect calibration curve shape rather than the ages of the samples.

With these factors in mind, I conclude that the most accurate radiocarbon date for Feature 11 is ca. AD 1620 to 1685. This date range includes 2-sigma results from all three samples as well as the pooled mean age. The older date from the burned mesquite sample represents a material integrity issue and the younger dates from the saltbush and yucca samples represent the shape of the calibration curve. It may be possible, with lower statistical confidence, to increase the precision by about 10 years on the older and younger ends to ca. AD 1630–1675, which also includes the pooled mean age.

Paleosol A Horizon

<u>Dates</u>
Most accurate: cal AD 1405–1470
Most precise: cal AD 1405–1470
Pooled mean: cal AD 1417–1477 (2 sigma); cal AD 1426–1442 (1 sigma)

<u>Discussion</u>: Since there are two radiocarbon dates from the paleosol A horizon at LA 111429, I cannot test for outliers. Student's t-test results affirm that the two bulk soil samples make up a single group (Table 19.6; Fig. 19.7). Beta Analytic, OxCal, and

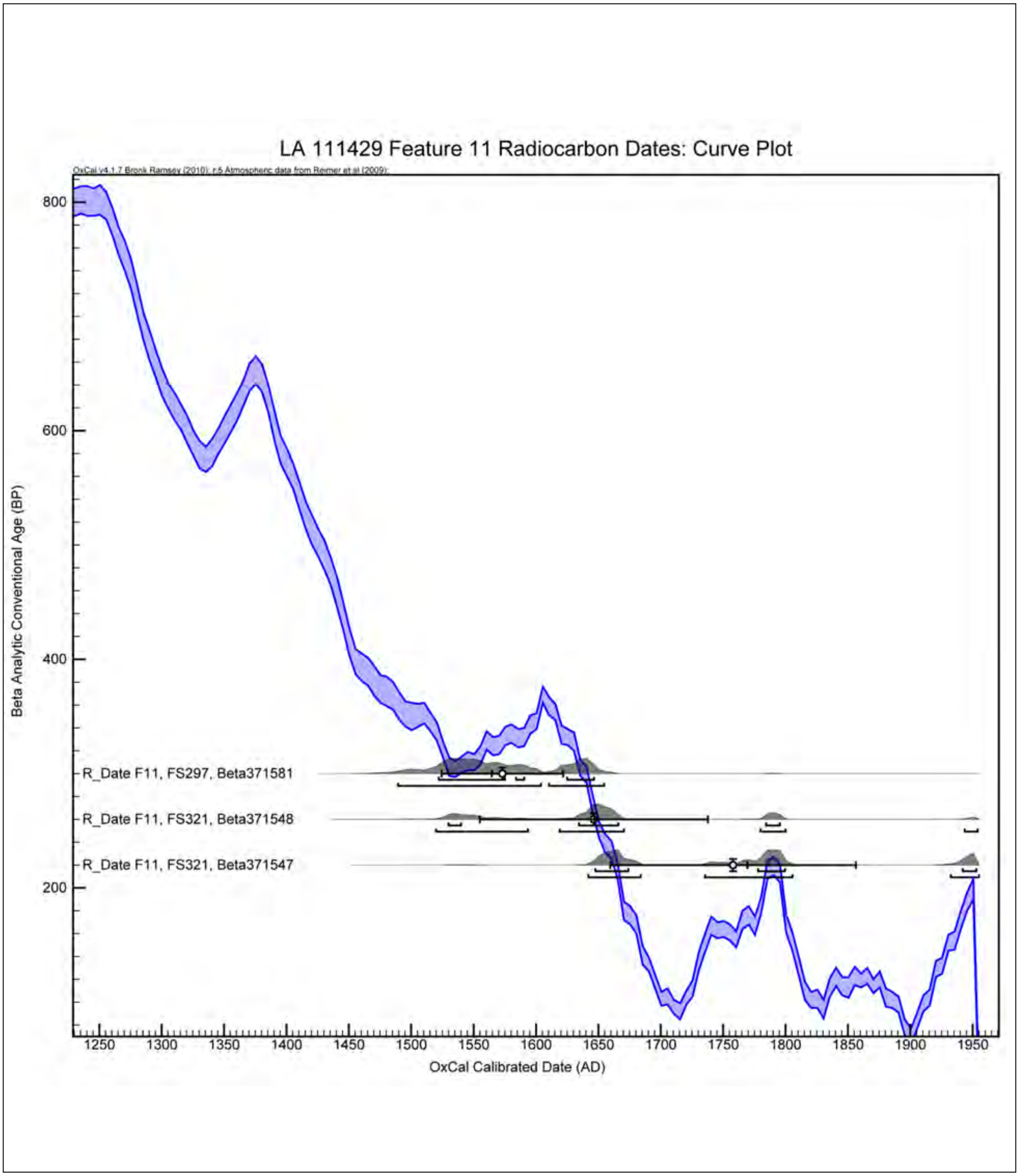

Figure 19.8. LA 111429, Feature 11, OxCal curve plot of radiocarbon dates.

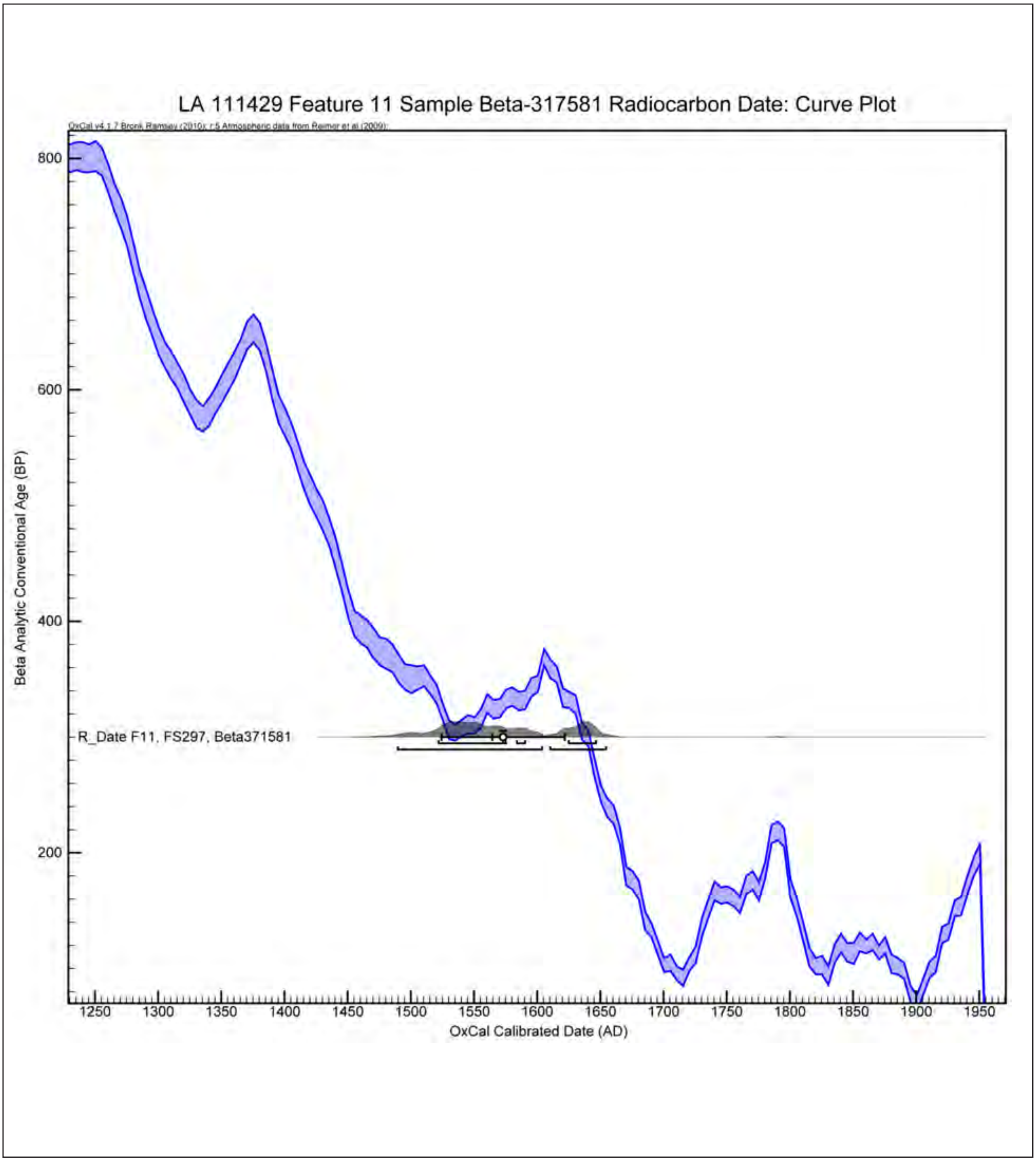

Figure 19.9. LA 111429, Feature 11, OxCal curve plot of radiocarbon dates (Beta-317581).

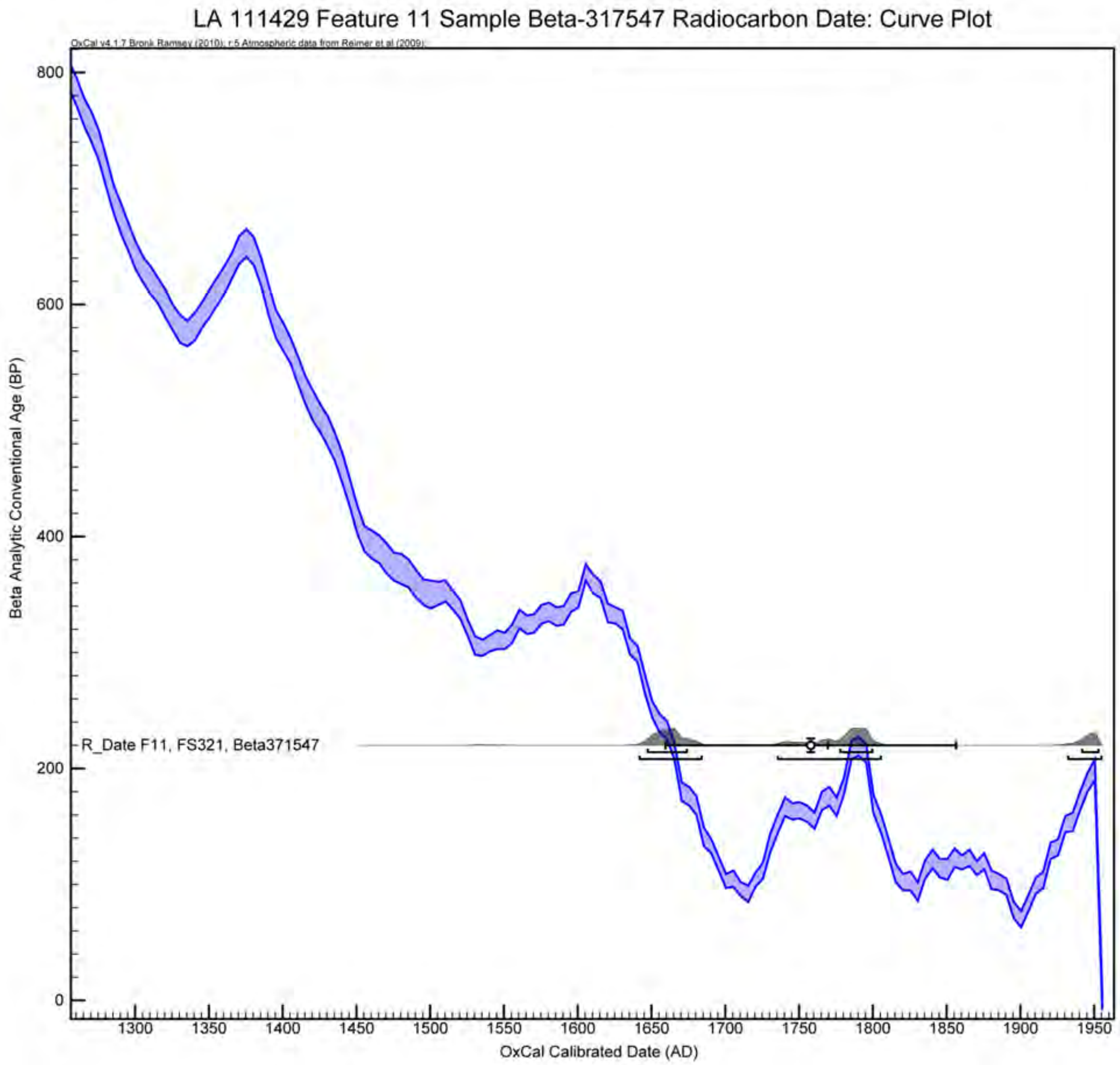

Figure 19.10. LA 111429, Feature 11, OxCal curve plot of radiocarbon date (Beta-317547).

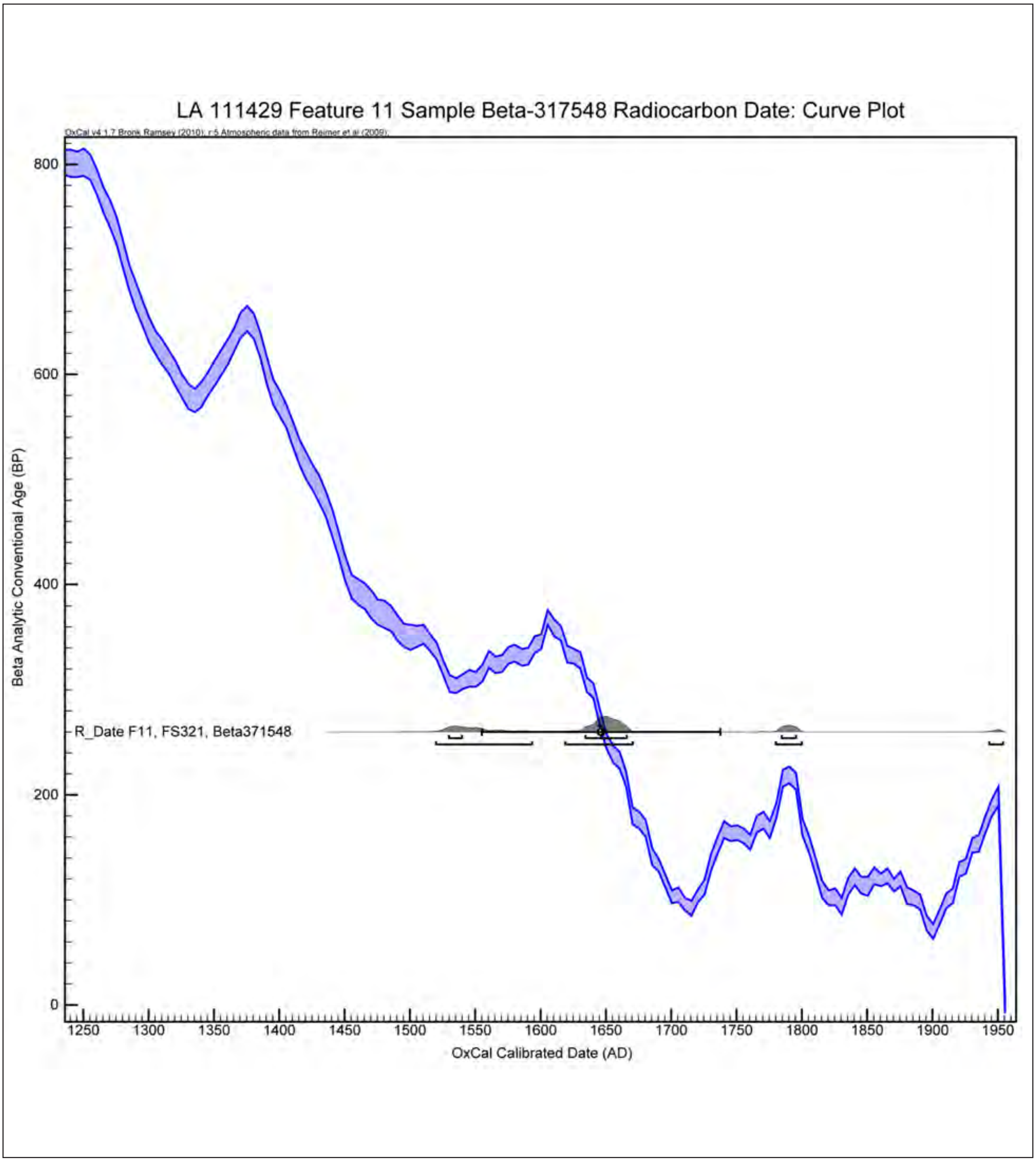

Figure 19.11. LA 111429, Feature 11, OxCal curve plot of radiocarbon date (Beta-317548).

Calib calibration analyses each produced a single 2-sigma and 1-sigma date range for each sample (Tables 19.3, 19.4). The most accurate radiocarbon date for the paleosol A horizon is AD 1405 to 1470, based on 2-sigma results. This range encompasses intercept, mean, and median dates for both samples (Tables 19.2a, 19.2b) as well as most of the 2-sigma pooled mean calibrated age and all of the 1-sigma pooled mean calibrated age (Table 19.6). It may be possible, with decreased statistical confidence, to increase precision to AD 1417 to 1450, shortening the 2-sigma range by 13 years on its older end and 20 years on its younger end. Indeed, this shortened range is the overlap period of the 2-sigma dates and also encompasses the 1-sigma pooled mean calibrated age and the older half of the 2-sigma pooled mean calibrated age. Still, the samples are soil collected from the A horizon of a paleosol found under a coppice dune and their dates derive from all organic material in the sampled portions of the horizon and also represent the potential effects of bioturbation in the A horizon. Consequently, there is no reason to opt for increased precision since I cannot be sure that it is meaningful.

A sample of the A horizon soil was also subjected to OSL analysis. The resulting date is 540 ± 20 BP or AD 1450 to 1490 (Hall, Chapter 21, this report). This range overlaps with the most accurate radiocarbon date for the samples and with the younger portion of their pooled mean radiocarbon age. Comparison of the radiocarbon and OSL dates points to a date of ca. AD 1405 to 1490 for the paleosol A horizon, and dates the formation of the A horizon to the fifteenth century AD. The horizon is only slightly older, in a relative sense, than Feature 11, which dates to the seventeenth century AD.

LA 111435

Site Assemblage

Date: Not applicable.

Discussion: Grubb's outlier test for the site assemblage revealed no outliers among the nine dates from LA 111435 (Table 19.5) and Student's t-test results show that the nine samples in the site assemblage are statistically different at a 95.4 percent confidence level (Table 19.6).

The oldest date in the site assemblage, from Feature 10, is furthest from the mean with the highest Z value that is very close to the critical Z value for the group of all samples (Table 19.5). When it is removed and the outlier test is run a second time, the next oldest date, from Feature 7, is identified as furthest from the mean with the highest Z value (Table 19.5). Student's t-test results show that the remaining eight dates are statistically different and do not make up a single group (Table 19.6). When the two oldest dates in the site assemblage are removed and the outlier test is run a third time, the third oldest date, from Feature 3, is identified as furthest from the mean with the highest Z value (Table 19.5). Again, Student's t-test results show that the remaining seven dates are statistically different and do not make up a single group (Table 19.6). The three oldest dates from LA 111435 are from three separate features (Figs. 19.12, 19.13).

Finally, when the three oldest dates are removed and the outlier test is run for a fourth time, the two youngest dates in the site assemblage, which are the same, are both identified as furthest from the mean (Table 19.5). The six dates in this assemblage are not a single group (Table 19.6) but there are two apparent groups of dates within it, one in the twelfth century AD and one in the seventeenth century AD (Fig. 19.12). Since the pattern of test results did not reveal a statistically secure group of remaining dates, and since the remaining assemblage of six dates apparently comprises two widely separated groups of dates, it made sense at this point to test those two groups for internal integrity. This decision was supported by the fact that the each of the two groups of dates is from a separate feature: the twelfth century AD dates are from Feature 8 while the seventeenth century AD dates are from Feature 6 (Tables 19.2a, 19.2b; Figs. 19.12, 19.13). I first discuss the three individual dates from LA 111435 Features 10, 3, and 7, followed by the Features 6 and 8 dates.

Feature 10 (fire-cracked rock scatter with charcoal stain)

Dates
Most accurate: 2940–2877 cal BC
Most precise and accurate: 2940–2877 cal BC

Discussion: Feature 10 at LA 111435 yielded the oldest radiocarbon date from the Spaceport America

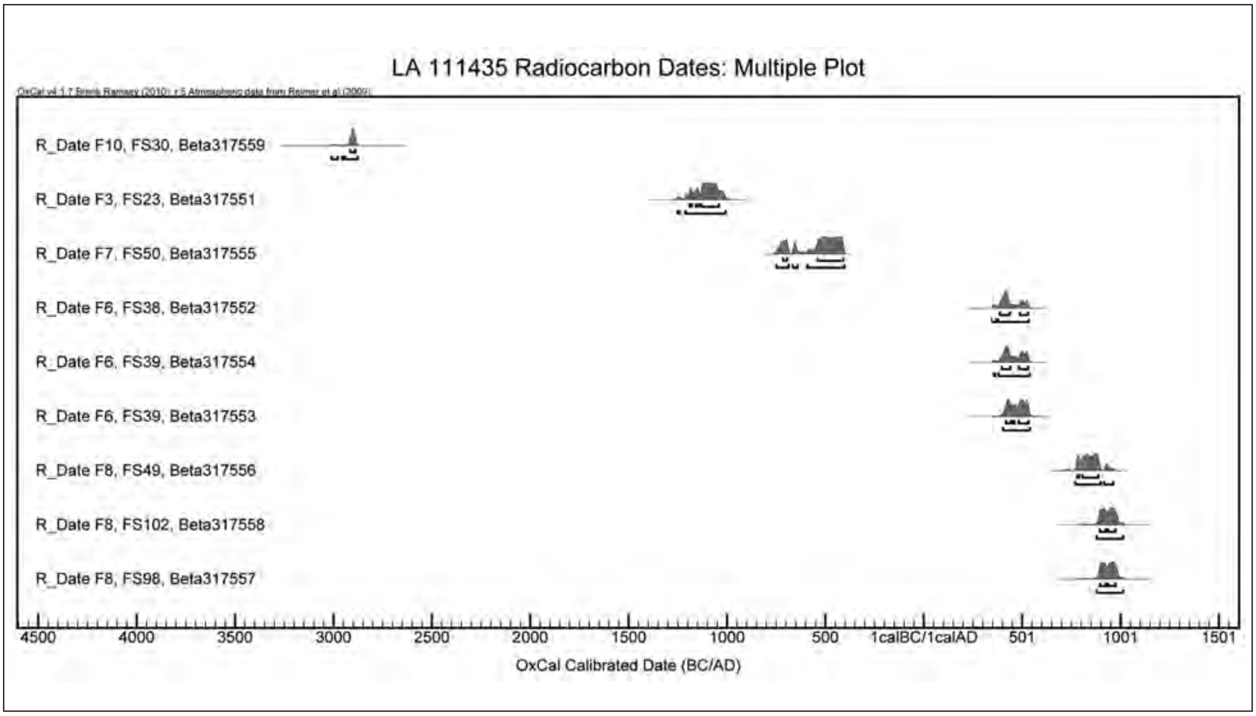

Figure 19.12. LA 111435, OxCal multiple plot of radiocarbon dates.

sites, obtained from a single sample of burned saltbush wood. The 2-sigma calibrated date is a very short range, 63 years, and this is the result of the steepness of the calibration curve between about 4400 and 4100 BP (Fig. 19.13). It is also for this reason that the intercept and calibrated mean and median dates fall between 2900 and 2900 BC (Tables 19.2a, 19.2b). That range is decreased—made more precise—by 40 years, with less confidence, using 1-sigma calibrated dates. Given the short range of the 2-sigma date and the decreased confidence in the 1-sigma range, I recommend that the 2-sigma date be considered the most accurate and precise for Feature 10.

Feature 3 (rock-lined fire pit)

Dates
Most accurate: 1213–1008 cal BC
Most precise: 1213–1008 cal BC

Discussion: Contrasting with the calibration curve in the location of the Feature 10 date, the trend of the curve is much flatter between about 3100 and 2700 BP. Consequently, the radiocarbon dates for Feature 3, from a single sample of burned wood resembling tarbush, have longer ranges than those for Feature 10. The 2-sigma calibrated range, ca. 1213/1212 to 1008 BC (Table 19.3), encompasses about 200 years. The 1-sigma calibrated range, ca. 1131 to 1042/1041 BC, spans 90 years (Table 19.4), primarily because, within the relatively flat curve in the late fourth millennium and early third millennium BC, there is a very flat area between about 2920 and 2850 BP. It is this characteristic of the calibration curve that changes the 2-sigma range to the 1-sigma range by 82 years on the older end and only 34 years on the younger end. Consequently, the most accurate and, likely, most precise radiocarbon date for Feature 3 is the 2-sigma calibrated range, ca. 1213 to 1008 BC.

Feature 7 (charcoal stain)

Dates
Most accurate: 592–403 cal BC
Most precise and accurate: 592–403 cal BC

Discussion: Like the dates for Feature 3, those for Feature 7, obtained from burned saltbush wood, fall in a relatively flat portion of the calibration curve,

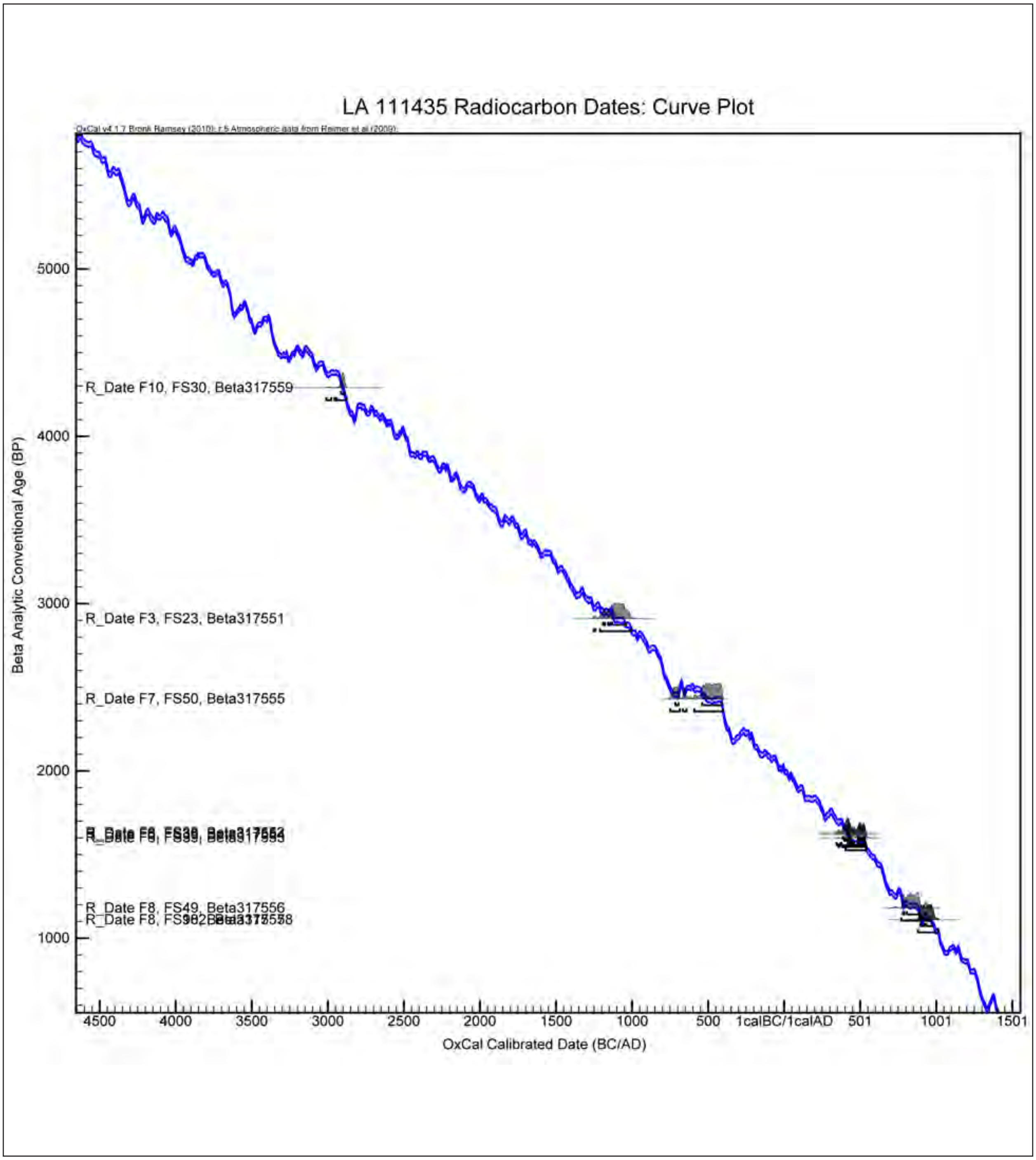

Figure 19.13. LA 111435, OxCal curve plot of radiocarbon dates.

this one between about 2500 and 2200 BP (Fig. 19.13) with a particularly flat portion between about 2460 and 2400 BP. Consequently, OxCal 2-sigma intersection of the conventional date curve and the calibration curve yields dates between about 750 and 687 BC and 592 and 403 BC, with the latter, spanning 189 years, much more likely to be accurate (Table 19.3). Calib 2-sigma calibration provides a somewhat shorter accurate range, 571 to 404 BC. However, Calib also identifies a short range of 592 to 576 BC that, if combined with the subsequent range, mirrors the OxCal range, 592 to 404/403 BC.

It is also the particularly flat portion of the curve in the late twenty-fourth century BP that produces a shorter 1-sigma calibrated range of 540 to 411 BC. The shape of the calibration curve results in a median date of 510 BC and a mean date of 542 BC with a very long 1-sigma standard deviation value of 105 years. Since the apparently increased 1-sigma precision of the radiocarbon date is a result of the shape of the calibration curve, the most accurate and precise date for Feature 7 is 592 to 403 BC.

Feature 6 (fire-cracked rock scatter)

<u>Dates</u>
Most accurate: cal ca. AD 378–540
Most precise: cal ca. AD 378–540
Pooled mean: cal AD 398–533 (2 sigma); cal AD 408-523 (1 sigma)

<u>Discussion</u>: Grubb's outlier test revealed no outliers in the Feature 6 assemblage, but the oldest date is furthest from the group mean (Table 19.5). This is simply because, of the three dates in this assemblage, the oldest one is only about three years further from the group mean than the youngest date. Student's t-test results confirm that the Feature 6 dates are a single group (Table 19.6).

While the 2-sigma calibrated dates are each clearly dominated by a single range (Table 19.3), the 1-sigma dates are less clear-cut (Table 19.4). This is the result of the shape of the calibration curve, which has a short, flat portion between about 1500 and 1600 BP (Fig. 19.14). The calibration curve shape and its intersection with the conventional ages also result in mean and median dates (Tables 19.2a, 19.2b) that fall into a short, shallow dip in the curve (Fig. 19.14).

The most accurate radiocarbon date for Feature 6 is AD 378 to 540, which also encompasses the 2-sigma and 1-sigma pooled mean ages. Slightly increased precision is provided by the 1-sigma range of AD 387 to 533, which shortens the 2-sigma range by nine years on the older end and seven years on the younger end. Because the shape of the calibration curve results in a long 2-sigma range, 162 years, shortening that range by 16 years with decreased confidence does not provide meaningfully increased precision. Consequently, the most accurate date is also the most precise date.

Feature 8 (possible structure)

<u>Dates</u>
Most accurate: cal ca. AD 771–1014
Most precise: cal ca. AD 807–976
Pooled mean: cal AD 881–974 (2 sigma); cal AD 890–961 (1 sigma)

<u>Discussion</u>: Three samples, one of burned saltbush wood and two of burned yucca caudex, were submitted from Feature 8. Grubb's outlier test shows that the Feature 8 date from sample Beta-317556, one of the two yucca samples, is a statistical outlier (Table 19.5). This is because the dates from the other two samples are the same, which places the mean group date much closer to those two dates than to the older date. Student's t-test results, however, confirm that the Feature 8 dates are a single group (Table 19.6). The shape of the calibration curve in the locations of the older date and the two younger dates results in the 243-year 2-sigma calibrated range, which is the most accurate date for Feature 8. The 1-sigma range encompasses the intercept dates, the mean and median dates, and the pooled mean age and is, therefore, the most precise date for Feature 8. Increased precision is not provided by the pooled mean age in the late ninth and tenth centuries AD because the mean age is skewed later by the Beta-317556 date.

LA 155963

Site Assemblage

<u>Date</u>: Not applicable.

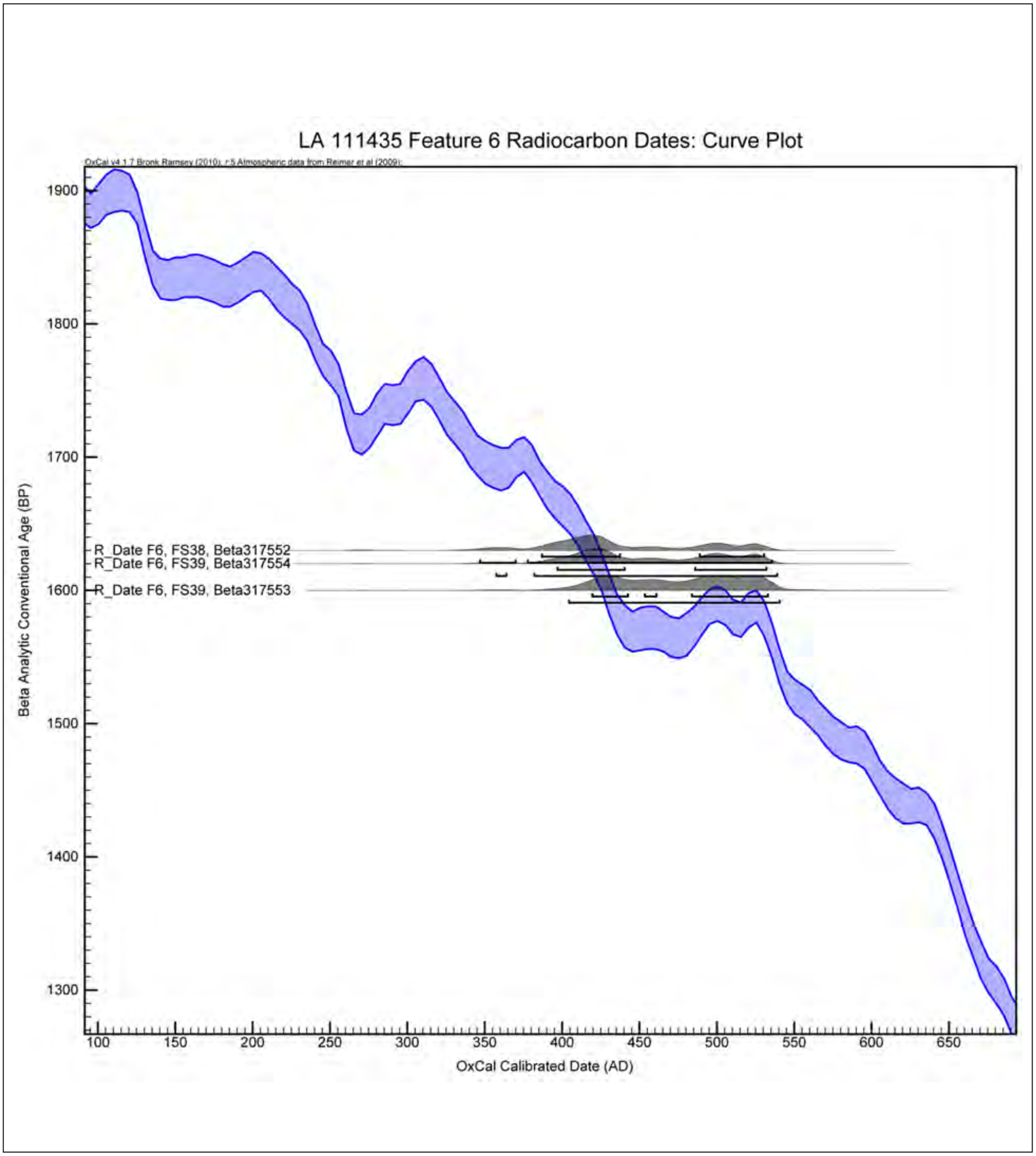

Figure 19.14. LA 111435, Feature 6, OxCal curve plot of radiocarbon dates.

Discussion: Twelve samples from eight features at LA 155963 were submitted for radiocarbon dating (Tables 19.2a, 19.2b). Figures 19.15 and 19.16 are the multiple and curve plots, respectively, of the site dates. Two-sigma calibrated dates from the samples range from 2 BC to AD 1919. It should, then, come as no surprise that, despite the fact that Grubb's outlier test identifies no statistical outliers within the assemblage (Table 19.5), Student's t-test results show that the assemblage is not a single group of dates (Table 19.6). As I noted earlier, the fact that there are no outliers in the LA 155963 assemblage is due both to the number of samples and the range of dates. The youngest and oldest dates in the assemblage are similar in distance from the group mean and neither is close to the critical Z value (Table 19.5).

The oldest date is identified as furthest from the group mean. When it is removed and the outlier test is run again, the youngest date is identified as furthest from the group mean (Table 19.5). When that date is removed, the next youngest date is identified as furthest from the group mean (Table 19.5). This pattern continues as each "furthest from group mean" date is removed in sequence until all dates younger than 1100 BP (AD 850) are gone. After that, the test identifies the second oldest date as furthest from the mean, then the third oldest date, and so on until only the middle date remains. Grubb's outlier test shows no groups of dates in the assemblage since each time the test is run another date is singled out as statistically furthest from the mean.

These results do not, however, demonstrate that there are no groups of dates in the LA 155963 assemblage. In the following discussion I use pooled mean ages and Student's t-test results to identify features in ascending order of dates.

Feature 15 (charcoal stain or small fire pit)

Dates
Most accurate: cal ca. 2 BC–AD 125
Most precise: cal ca. 2 BC–AD 125

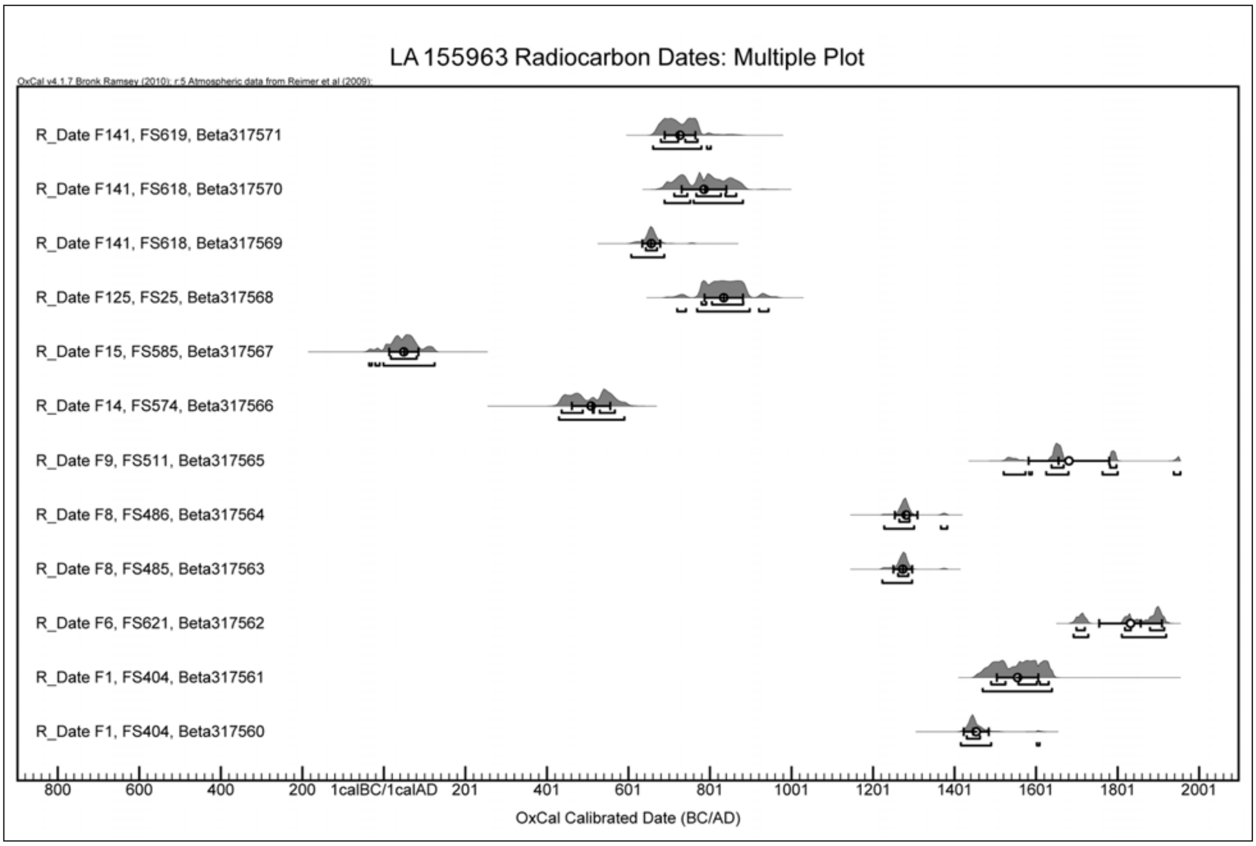

Figure 19.15. LA 155963, OxCal multiple plot of radiocarbon dates.

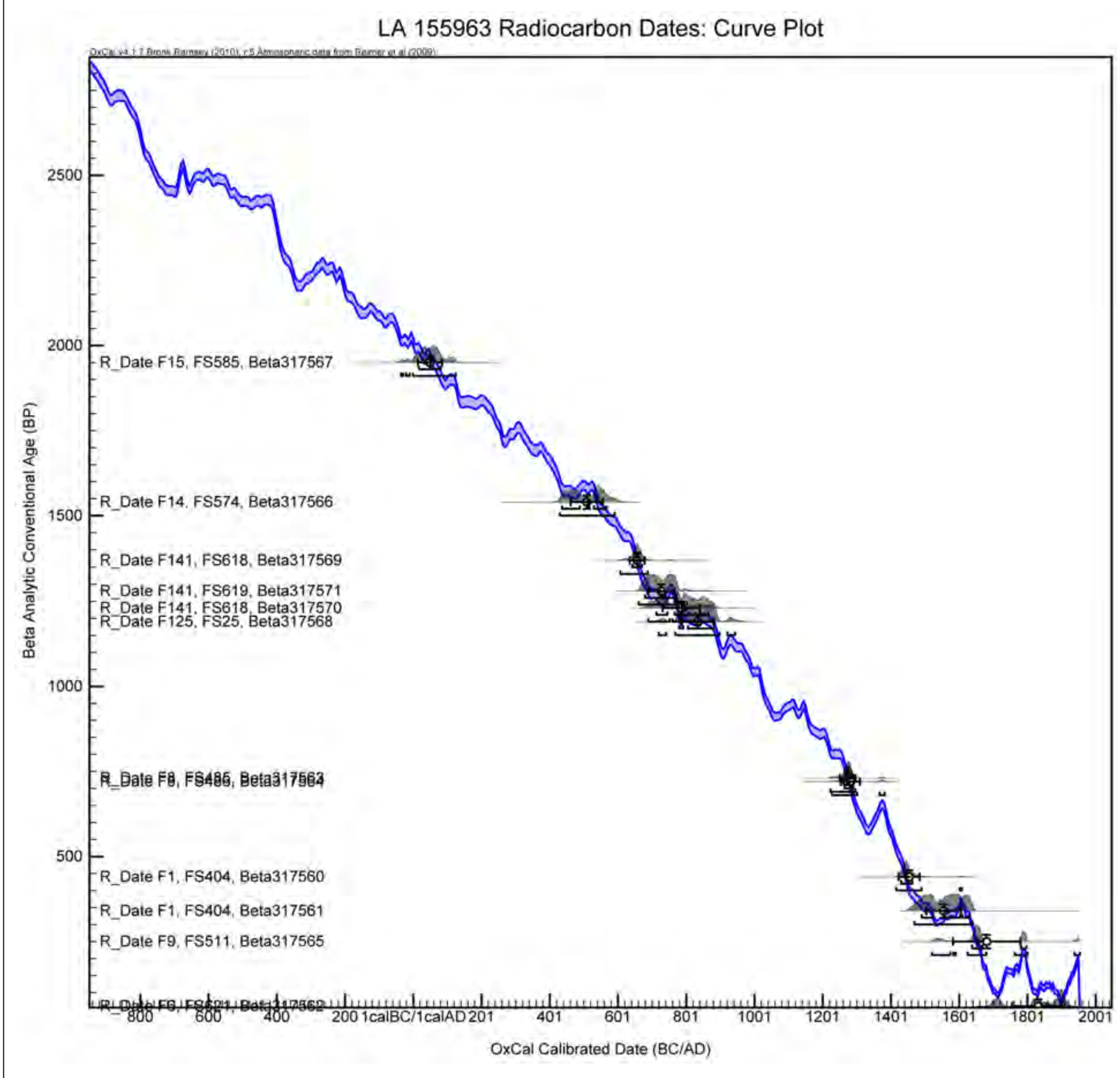

Figure 19.16. LA 155963, OxCal curve plot of radiocarbon dates.

Discussion: The Feature 15 sample at LA 155963 was a bulk sample of feature fill (Tables 19.2a, 19.2b). The OxCal 2-sigma calibrated date is 2 BC to AD 125 with a very low probability between 36 and 11 BC. The Calib 2-sigma calibrated date is 2 BC to AD 94, also with a very low probability between 37 and 11 BC. It also has a low (10.6 percent) probability between AD 96 and 125. Combined, however, the Calib 2-sigma dates between 2 BC and AD 125 have the same very high probability as the OxCal date of the same years (Table 19.3). Similarly, the OxCal and Calib 1-sigma calibrated dates point to a shorter range between AD 17/18 and 81 (Table 19.4). The 1 sigma range cuts 19 years from the older end of the 2-sigma range and 44 years from the younger end. OxCal mean and median dates fall at and very near the center of the 1-sigma range but are older than the center of the 2-sigma range, which is very near the Beta Analytic intercept date. The mean and median dates are likely to be more accurate single dates than the intercept date, while the mean date range, AD 49 ± 36, is very similar to the 1-sigma range. Still, the mean date range is a 1-sigma range and the date is essentially an average from a sample of feature fill rather than specifically identifiable charcoal. Consequently, the most accurate and precise date for Feature 15 is 2 BC to AD 125.

Feature 14 (roasting pit)

Dates
Most accurate: cal ca. AD 430–591
Most precise: cal ca. AD 430–591

Discussion: The Oxcal and Calib 2-sigma calibrated dates for this LA 155963 sample of burned saltbush are essentially the same (Table 19.3), and the relatively long range, 161 years, is due to a short, flat trend in the calibration curve during the 1500s BP (Fig. 19.16). The 1-sigma calibrated dates also reflect this flat trend and multiple intersections between the conventional age distribution and calibration curves. The highest probability, 1-sigma date is AD 437 to 489 in both the OxCal and Calib calibrations but that probability is just over half in both cases and is closely followed by the date of AD 530 to 567 (Table 19.4). Between those dates is a very low-probability date of AD 513 to 516. So, the two highest-probability, 1-sigma calibrated dates are separated by 41 years, the OxCal mean and median fall within that period, and the mean date range, AD 462 to 556, encompasses that period. Consequently, the most accurate and precise date for Feature 14 is AD 430 to 591.

Feature 125 (small fire pit)

Dates
Most accurate: cal ca. AD 769–898
Most precise: cal ca. AD 769–898

Discussion: Two-sigma calibrated dates for a sample of burned saltbush from Feature 125 at LA 155963 are decidedly dominated by the range of AD 769 to 898 (Table 19.3). Figure 19.17 shows that the Feature 125 conventional age intersects the calibration curve at a short, flat portion between about 1190 and 1240 BP. This period is about 100 years long, reflected in the length of the Feature 125 2-sigma date range and by three intercept dates for the sample. The 1-sigma calibrated dates are dominated by the range of AD 806/807 to 882 during the flattest part of the curve. Given the shape of the calibration curve at this location, the most accurate and precise date for Feature 125 is AD 769 to 898.

Feature 141 (fire pit)

Dates
Most accurate: cal ca. AD 662–882 (two youngest samples)
Most precise: cal ca. AD 662–882 (two youngest samples)
Pooled mean: cal AD 676–812 (2 sigma, two youngest samples); cal AD 694–775 (1 sigma, two youngest samples)

Discussion: Grubb's outlier test reveals no outliers in the LA 155963 Feature 141 assemblage but the oldest date, obtained from burned mesquite wood, is furthest from the mean (Table 19.5). The other two samples are from burned saltbush wood and burned mesquite seeds (Tables 19.2a, 19.2b). Student's t-test results confirm that the three dates are significantly different and not a single group (Table 19.6).

Since the oldest date, from sample Beta-317569, is furthest from the group mean, it was removed and the T-test was run again. The results show that the two remaining dates are a single group (Table 19.6).

As I discussed earlier, the burned mesquite

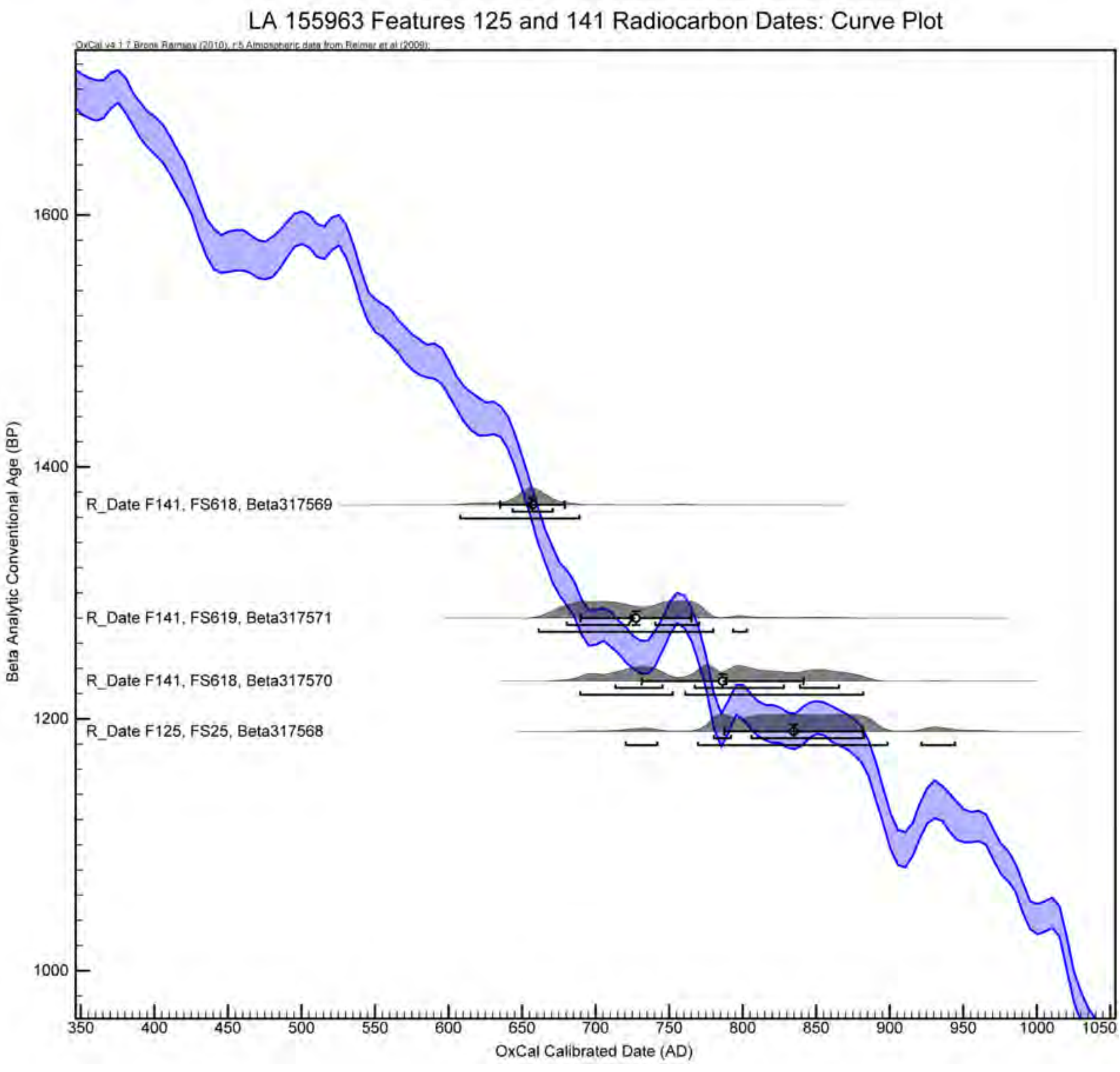

Figure 19.17. LA 155963, Features 125 and 141, OxCal curve plot of radiocarbon dates.

wood sample from Feature 11 at LA 111429 yielded dates older than burned saltbush wood and yucca stem samples from the same feature. I asserted that this discrepancy reflects a material integrity issue—old wood or cross-section effect—and that the dates reflect the shape of the calibration curve in the location of the conventional age of the mesquite wood sample. I believe that the material integrity factor also affects the burned mesquite wood sample, Beta-317569, from Feature 141. That is, the sample's date likely reflects inner wood or a cross-section of wood from a burned mesquite branch. Unlike the LA 111429 mesquite wood date, however, the shape of the curve at the location of the LA 155963 mesquite wood conventional age is uniformly steep (Fig. 19.17), resulting in a narrow range of values for the intersection of the conventional age distribution and calibration curves. This situation is reflected by the short ranges of 2-sigma and 1-sigma calibrated mesquite wood dates from Feature 141: AD 608/609 to 689 and AD 643/644 to 669/671, respectively (Tables 19.3, 19.4).

As Figure 19.17 also shows, the steepness of the calibration curve between about 1000 and 1500 BP is interrupted by a reversal and peak between about 1240 and 1300 BP that creates the potential for multiple curve intercepts, and by a flat portion of the curve between about 1190 and 1240 BP, which I discussed with regard to Feature 125. The two younger dates from Feature 141 result from the intersection of the conventional age distribution curve with the steep calibration curve, its reversal, peak, and subsequent drop, and the flat portion. Because of the multiple curve intercepts, those two samples yielded dates with multiple 2-sigma and 1-sigma ranges, each with different emphases. Sample Beta-317570, burned saltbush wood, was most affected by the curve reversal, peak, and subsequent drop (Fig. 19.17), shown by 2-sigma dates dominated (ca. 64 to 67 percent) by ranges between AD 761 and 882 in the curve peak and drop period but with relatively high-probability (ca. 31 to 33 percent) date ranges from AD 689 to 782 in the steep curve prior to the reversal. Three intercept dates for this sample (Tables 19.2a, 19.2b) reflect this situation. Had the calibration curve continued its steep shape rather than reversing and peaking, this sample might have had a short 2-sigma range in the late AD 600s, fitting more closely with the mesquite wood sample.

Sample Beta-317571, burned mesquite seeds, yielded a conventional age that intersects the calibration curve at the location of curve reversal and at the drop following the peak, and is affected by the subsequent flat portion of the curve (Fig. 19.17). The resulting 2-sigma calibrated dates are AD 681 to 780 (OxCal) and AD 662 to 779 (Calib). These dates are statistically the same as the older dates from the Feature 141 saltbush sample. It is this 2-sigma sameness and the younger dates from the saltbush sample that make these two samples statistically different from the slightly older mesquite wood sample. Again, had the calibration curve not reversed itself, peaked, and dropped between about 1240 and 1300 BP, the saltbush and mesquite seed dates might fit more closely with the mesquite wood dates, although the mesquite wood dates would still be older than the other two dates.

One-sigma dates from the Feature 141 samples more clearly reflect the impacts of the calibration curve reversal, peak, and drop. Because of the steepness of the curve, the older, mesquite wood sample, yielded 1-sigma dates between AD 643 and 671 (Table 19.4). Because of concerns for the material integrity of this sample, however, the most precise date for the sample is still the 2-sigma date, AD 608 to 689.

In contrast, 1-sigma calibrated dates for the saltbush wood include three (OxCal) or four (Beta Analytic, Calib) separate, short ranges reflecting multiple intersections with the calibration curve (Table 19.4). The dominant OxCal and Calib 1-sigma dates are AD 767 to 827/828 but the accuracy probability is just over half in both cases. The remainders comprise short date ranges in the early AD eighth and middle AD ninth centuries. Consequently, the 1-sigma dates do not provide increased precision for the saltbush sample.

Finally, the mesquite seed sample yielded 1-sigma dates with two short ranges that are dominated by the years between AD 680 and 723 (Table 19.4). As with the saltbush dates, however, accuracy probability is just over half for both OxCal and Calib dates and the remainders consist of the range of AD 740 to 770. The nearly even split in accuracy probability is also shown by the mean and median dates for this sample, which fall in the years between these two date ranges. These dates do not provide increased precision for the mesquite seed sample.

The most accurate and precise dates for Feature 141 are determined by the two samples of burned saltbush wood and mesquite seeds, ca. AD 662 to 882. The shape of the calibration curve precludes increased precision. While I suspect that the burned mesquite wood sample might have been contemporaneous with the other samples, material integrity does not allow us to confirm that possibility.

Features 125 and 141

Dates
Most accurate: cal ca. AD 662–898
Most precise: cal ca. AD 662–898
Pooled mean: cal AD 692–870 (2 sigma); cal AD 713–855 (1 sigma)

Discussion: Because of their apparent similarity, I tested LA 155963 Features 125 and 141 for contemporaneity. The four samples do not make up a single group (Tables 19.5, 19.6), which is not surprising since the three samples from Feature 141 are not a single group. Without the mesquite wood date from Feature 141, however, the remaining two Feature 141 dates and the Feature 125 date comprise a single group (Tables 19.5, 19.6).

Because the Feature 125 date overlaps with and extends beyond those from Feature 141, the most accurate date for this combined group is AD 662 to 898. As we have observed, the calibrated Feature 125 dates and the two younger Feature 141 dates are impacted by a reversal in the calibration curve, resulting in a peak and subsequent drop in the curve, followed by a relatively flat portion of the curve. Consequently, these three dates have long ranges because of multiple locations for intersection of their conventional ages with the calibration curve. The two younger 2-sigma dates from Feature 141, in fact, overlap only between AD 761 and 779/780, leaving about a century on either end of their joint 2-sigma range. Their 1-sigma dates do not overlap, which means that increased precision is not possible. Similarly, the Feature 125 2-sigma date overlaps with the younger Feature 141 dates between AD 769 and 882, leaving about a century on the older end of their joint range. Although the two younger dates from Feature 141 and the Feature 125 dates are statistically a single group, they do not have a clear center. Rather, the three samples provide dates that overlap with each other in a sequence with a long range, ca. 240 years, that is not made more precise using their 1-sigma dates (ca. 220 years).

Given these observations, while a single group comprises the three dates, I cannot be sure of their actual contemporaneity. On the other hand, as I have said for the Feature 141 dates, if the calibration curve were not disturbed between about 1240 and 1300 BP, it is possible that all three Feature 141 dates and the Feature 125 dates might have made up a single group, even with concerns for the material integrity of the Feature 141 mesquite wood sample.

Feature 8 (small fire pit)

Dates
Most accurate: cal ca. AD 1224–1302
Most precise: cal ca. AD 1262–1290
Pooled mean: cal AD 1262–1290 (2 sigma); cal AD 1270–1284 (1 sigma)

Discussion: One LA 155963 sample of burned yucca caudex and a bulk sample of the fill from Feature 8 were submitted (Tables 19.2a, 19.2b). Student's t-test results confirm that the two samples make up a single group (Table 19.6) dating to the late Doña Ana or early El Paso phase.

The most accurate date for Feature 8 is the 2-sigma range, AD 1224 to 1302 (Table 19.3). Because the curve in this location is steep (Fig. 19.16), the most precise date is the 1-sigma range, AD 1262 to 1290 (Table 19.4), which matches the 2-sigma pooled mean age (Table 19.6).

Feature 1 (large fire pit)

Date: Not applicable.

Discussion: Student's t-test results for the two Feature 1, LA 155963, samples, one of burned mesquite wood and the other of burned saltbush wood, show they are not a single group (Table 19.6). The curve is steep and narrow at the location of the mesquite wood conventional age, resulting in short 2-sigma and 1-sigma calibrated ranges (Tables 19.3, 19.4), ca. AD 1416 to 1491 and AD 1431 to 1460, respectively. The conventional age for the saltbush wood sample, in contrast, intersects the calibration curve where it reverses itself, peaks, and drops steeply. Consequently, its 2-sigma dates encompass a long range, about 170 years, between about AD 1470 and 1640.

The sample has three intercept dates (Tables 19.2a, 19.2b) and each calibration identified three 1-sigma date ranges spanning the years between about AD 1480/1490 and 1630 (Table 19.4). As I have noted with other series of dates impacted by calibration curve disturbances, it is possible that, had the curve not reversed about 300 BP, the saltbush sample conventional age intersection with the calibration curve might also have resulted in a short, narrow date that would have been more similar to the date from the Feature 1 mesquite wood sample. It is likely that the same old-wood, material integrity issue that impacted other mesquite wood samples from Spaceport America sites also affected the Feature 1 sample.

Under the circumstances, therefore, it is also likely that the Feature 1 samples are, in fact, a single group as I would expect from a single feature. If I focus on the 1-sigma dates from the two samples, I can speculate, but certainly not demonstrate, that the two samples point to a feature date between about AD 1430 and 1560. I cannot, indeed, demonstrate an accurate date for the feature. Given the probably material integrity issue for the mesquite wood sample, I assign Feature 1 to the saltbush sample 2-sigma range of AD 1470 to 1640.

Feature 9 (charcoal stain)

Dates
Most accurate: cal ca. AD 1626–1680
Most precise: cal ca. AD 1639–1668

Discussion: A single sample of burned mesquite wood was submitted from Feature 9 at LA 155963. Although Table 19.3 shows that 2-sigma calibrations identified five date ranges for the sample, one range is dominant, AD 1626 to 1680. Still, that range has an accuracy probability between 50 and 60 percent, and the ranges, together, span the calibrated years between AD 1521 and 1955. For those reasons, I cannot be sure of the age of the sample. The sample's conventional age, however, intersects a steep portion of the calibration curve in the seventeenth century AD (Fig. 19.16). The other date ranges reflect the effects of disturbances in the calibration curve before and after the steep curve, most noticeably the years between AD 1764 and 1800/1801 where the conventional age curve intersects a short, brief peak in the curve.

One-sigma dates for the sample show the same curve intersections (Table 19.4) with the seventeenth century range, AD 1639 to 1668, much more dominant than the eighteenth century range, AD 1782 to 1798, than is the case in the 2-sigma dates.

The sample's intercept, mean, and median dates are in the 1650s. The most accurate date for Feature 9 is AD 1626 to 1680, while the most precise date is AD 1639 to 1668.

Feature 6 (disturbed fire pit)

Dates
Most accurate: cal ca. AD 1811–1920
Most precise: cal ca. AD 1811–1920

Discussion: An LA 155963 sample of burned plant remains identifiable only as monocot stems (Tables 19.2a, 19.2b) yielded 2-sigma and 1-sigma calibrated dates in multiple ranges between about AD 1690/1700 and 1950, "present" in radiocarbon dating terms (Tables 19.3, 19.4). The years between about AD 1700 and 1950 are characterized by a series of disturbances in the shape of the calibration curve that create multiple locations for intersection with conventional age distribution curves. These intersections occur between 0 and about 220 BP. Feature 6 does not appear on Figure 19.16 because the sample's mean conventional age actually falls below the calibration curve; Figure 19.18 shows the sample's individual plot. The effects of calibration curve changes in the last three centuries are evident in that the sample's mean conventional age almost intersects the curve at about AD 1900 while its distribution curve intersects the curve between the late seventeenth century AD and the present. The mean conventional age also appears to intersect the curve at 1950, which is its "intercept date," but this is because the age is so young (late) that it can only intersect ("intercept") the calibration curve after 1950. There are, however, no values after 1950 so the curve simply drops to zero at that point, providing a misleading intercept value for this sample. It is this situation that results in OxCal and Calib 2-sigma calibrations that include one short range between the mid–AD 1690s and late 1720s, and a series of short ranges that begin about 80 years later, starting from the early AD 1810s and running to the present (AD 1950), that are separated from each other by about a decade. Given the inherent vari-

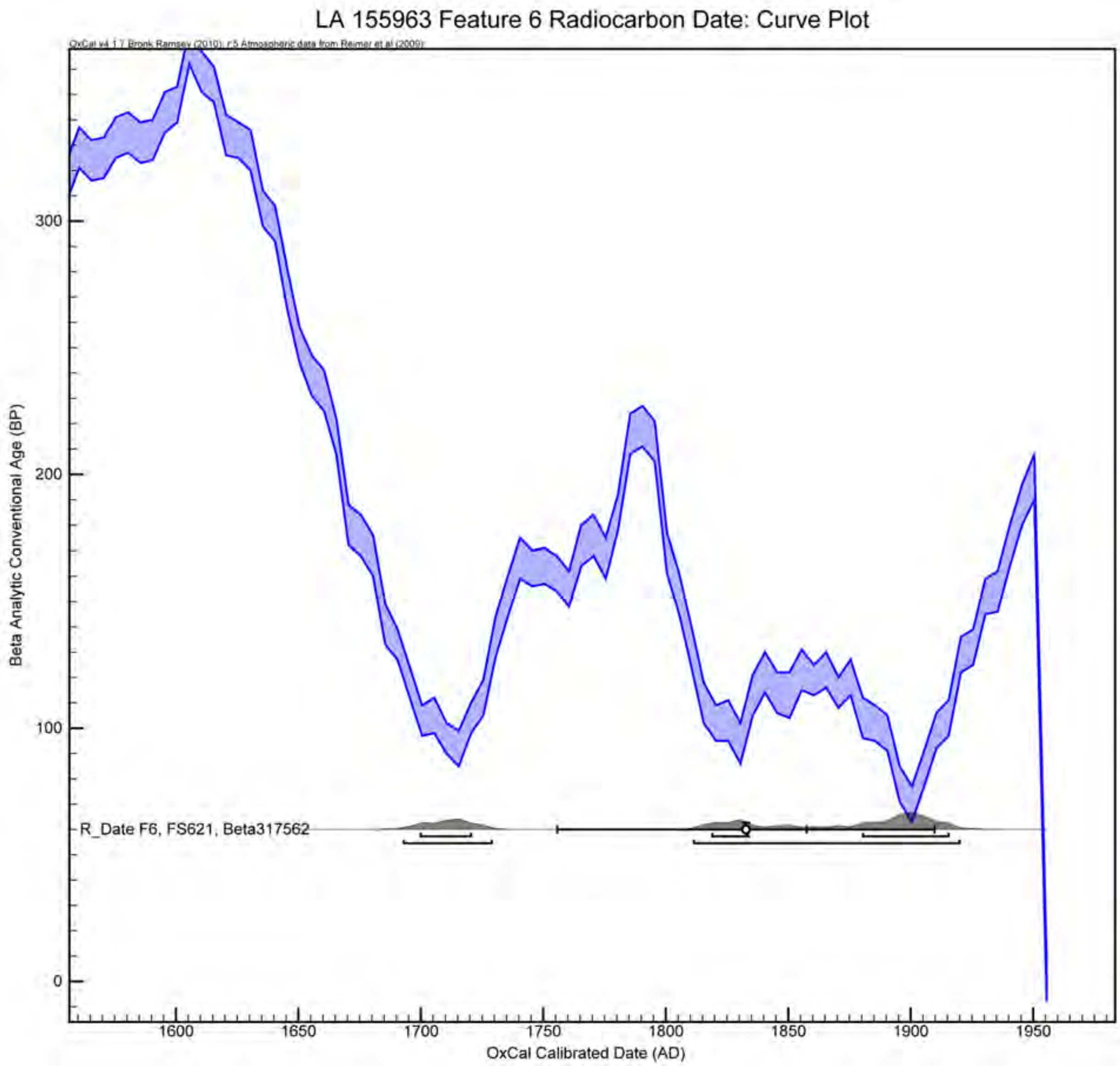

Figure 19.18. LA 155963, Feature 6, OxCal curve plot of radiocarbon date (Beta-317562).

ability in the dates and the nature of calibration processes, Beta Analytic calibration shows each short range, while OxCal and Calib calibrations combine them into a longer range between about AD 1811 and 1920, giving little possibility of accuracy to the older date (Table 19.3). One-sigma calibrations also acknowledge the ca. AD 1700 date and shorten the nineteenth century AD dates into a range between AD 1819 and 1833 and AD 1880 and 1915, with considerably higher probability of accuracy for the latter (Table 19.4), but with the associated decrease in statistical confidence.

As I have noted before, it is tempting to speculate that if the calibration curve had not reversed itself in the early AD 1700s, its intersection with the Feature 6 sample's conventional age distribution curve would provide an accurate and precise date at about that time. As that did not happen, though, the most accurate date for Feature 6 is the dominant 2-sigma range of AD 1811 to 1920. The relatively flat trend of the curve during the nineteenth century AD does not encourage use of the shorter 1-sigma range in the late nineteenth and early twentieth centuries for increased precision, so the 2-sigma range is also the most precise date for the sample. This range also encompasses the sample's mean and median dates because those dates are calculated from the largest range.

LA 155964

Site Assemblage: Feature 1 (large roasting pit)

Dates
Most accurate: cal ca. AD 1800–1940
Most precise: cal ca. AD 1800–1940
Pooled mean: cal AD 1809–1926 (2 sigma); cal AD 1812–1854 (1 sigma)

Discussion: Five samples of five different materials, making up the entire assemblage from LA 155964, were submitted from Feature 1 (Tables 19.2a, 19.2b). Grubb's outlier test results show that there are no outliers although the youngest date, conventional age 80 ± 30 BP, is furthest from the group mean (Table 19.5). Student's T-test results confirm that a single group comprises the five dates (Table 19.6).

As noted for Feature 6 at LA 155963, samples whose conventional ages intersect the calibration curve between about AD 1700 and 1950 typically yield multiple calibrated age ranges. The shape of the calibration curve between 0 and 220 BP also typically results in long overall date ranges often consisting of sequential series of shorter ranges. Table 19.3 shows that, depending on the calibration application, the samples from LA 155964, Feature 1 yield from two to five 2-sigma ranges spanning the years between AD 1670 and 1950+. They also yielded as many as 11 intercept dates between AD 1690 and 1950 (Tables 19.2a, 19.2b).

Consistently, the ranges with the highest probability of accuracy start at or near the beginning of the nineteenth century AD, AD 1799 to 1802—one starts at AD 1810—and end about AD 1939 to 1942—one ends at AD 1926 (Fig. 19.19). In most cases, this period is a single, long range with a greater than 60 percent probability of accuracy. In a few cases, it is made up of two ranges separated by only a few years at the turn of the twentieth century AD (Table 19.3; Fig. 19.20). In each case, a period of time between the mid– to late AD 1670s and the mid– to late AD 1700s (ca. AD 1764 to 1778; one date ends in AD 1725), has a lower but not inconsequential probability of accuracy, ca. 30 to 40 percent. OxCal mean dates range from AD 1810 to 1825, ± 77 to 81 years, and median dates range from AD 1832 to 1845, a period of time that also includes the 1-sigma pooled mean age of the samples. As I noted for Feature 6 at LA 155963, however, mean and median dates are calculated from the longest range of dates for each sample that are affected by the shape of the calibration curve, so they do not necessarily add increased precision or confidence to the actual age of the samples.

One-sigma dates (Table 19.4) confirm the effects of post–AD 1700 calibration curve changes that result in three to seven ranges of dates for the five samples. The highest probabilities of accuracy are for the years between about AD 1808/1812 and 1889/1891 but, given the shape of the calibration curve (Fig. 19.20), that is expected. One-sigma dates for the older range are between the early AD 1680s and the late AD 1730s.

As with Feature 6 at LA 155963, it is tempting to speculate that if the calibration curve had not reversed itself, its intersection with the sample's conventional-age distribution curves from LA 155964, Feature 1, would provide an accurate and precise date in the AD 1700s. The most accurate date for LA 155964, however, is the dominant 2-sigma

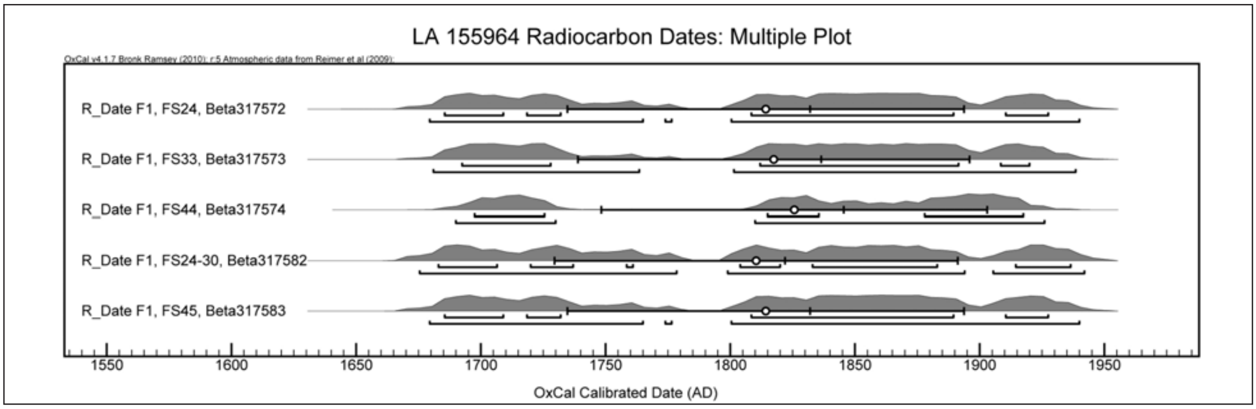

Figure 19.19. LA 155964, OxCal multiple plot of radiocarbon dates.

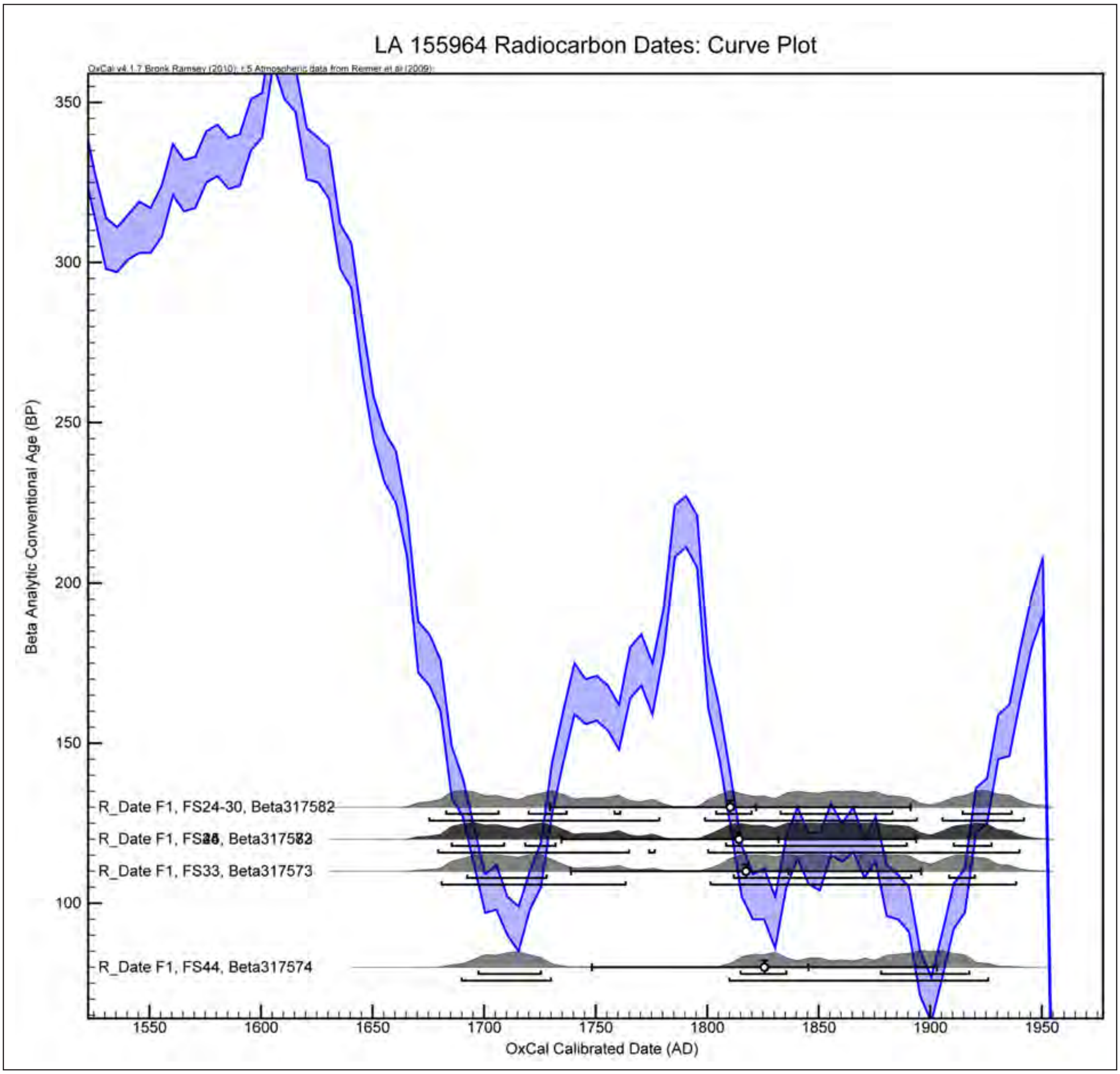

Figure 19.20. LA 155964, OxCal curve plot of radiocarbon dates.

range of AD 1800 to 1940. The relatively flat trend of the curve during the nineteenth century AD does not encourage use of the shorter 1-sigma range for increased precision, so the 2-sigma range is also the most precise date for the site.

LA 155968

Site Assemblage: Feature 1 (large roasting pit)

Dates
Most accurate: cal ca. AD 656–887
Most precise: cal ca. AD 656–779
Mean pooled: AD 684 ± 13.42

Discussion: Five samples of four different materials from Feature 1 made up the entire assemblage from LA 155968 (Tables 19.2a, 19.2b). Grubb's outlier test shows that there are no outliers in the assemblage, although the youngest date is the furthest from the group mean (Table 19.5). Student's T-test results confirm that a single group comprises the five samples (Table 19.6). Figures 19.21 and 19.22 are the OxCal calibration multiple and curve plots for the LA 155968 samples.

As I discussed regarding Features 125 and 141 at LA 155963, the steepness of the calibration curve between about 1000 and 1500 BP is interrupted by a reversal and peak between about 1240 and 1300 BP and by a flat portion of the curve between about 1190 and 1240 BP, all creating the potential for multiple curve intercepts. Figure 19.22 illustrates this situation as it impacts the sample dates from Feature 1 at LA 155968. Samples Beta-317575, 317578, and 317579 intersect the calibration curve in the late AD 600s and early AD 700s and again, because of the reversal peak, in the late AD 700s. Samples Beta-317576 and 317575 intersect the curve in the early AD 700s and the flat period between about AD 770 and 870. The site's multiple date plot, Figure 19.21, presents a clear picture of relationships between the dates.

Two-sigma calibrated dates for the five samples consistently fall into the years between AD 650 and 890 (Table 19.3), a long period of time resulting from the vacillations in the calibration curve. Three samples, however, securely date between AD 656 and 779 (Beta-317575, -317578, and -317579). Had the calibration curve not reversed itself, they would likely all date between about AD 656 and 750. Still, the reversal and its peak were relatively short-lived, adding only about 30 more years to the younger end of the ranges.

Two samples, Beta-317576 and Beta-317577, also intersect the calibration curve in the early AD 700s, ca. AD 690 to 750. This supports the expectation that samples from the same feature should yield approximately contemporaneous dates, taking into account factors such as material integrity and the type and complexity of the feature. These two samples also intersect the curve between about AD 760 and 890, encompassing the flat portion of the curve following the earlier curve reversal and peak. Because the flat portion is longer that the reversal and peak portion, its impact on dates is greater by providing more and longer locations for intersection. Their intercept, mean, and median dates are the youngest of the five samples (Tables 19.2a, 19.2b). Consequently, dates from these two samples between AD 760 and 890 have higher probabilities of accuracy (ca. 64 to 79 percent) than their older dates (ca. 20 to 33 percent). I suspect, nonetheless, that these two samples are probably contemporaneous with the other three samples from Feature 1 because their older dates fit with those of the other three samples, and that their younger dates, even with higher probabilities of accuracy, are not actually accurate dates for the samples.

The most accurate date for Feature 1 at LA 155968 is the 2-sigma calibrated range of AD 656 to 887. The shape of the calibration curve and its effects on samples Beta-317576 and Beta-317577 suggest that the most precise date for Feature 1 is AD 656 to 779.

Discussion

Table 19.7 summarizes the results of radiocarbon date assessments for each site and dated feature by arranging them from oldest to youngest according to most accurate and most precise dates. The sites and features are also listed by time period and phase (see Miller and Kenmotsu [2004] and Moore [2010] for discussions of current dates for the periods and phases).

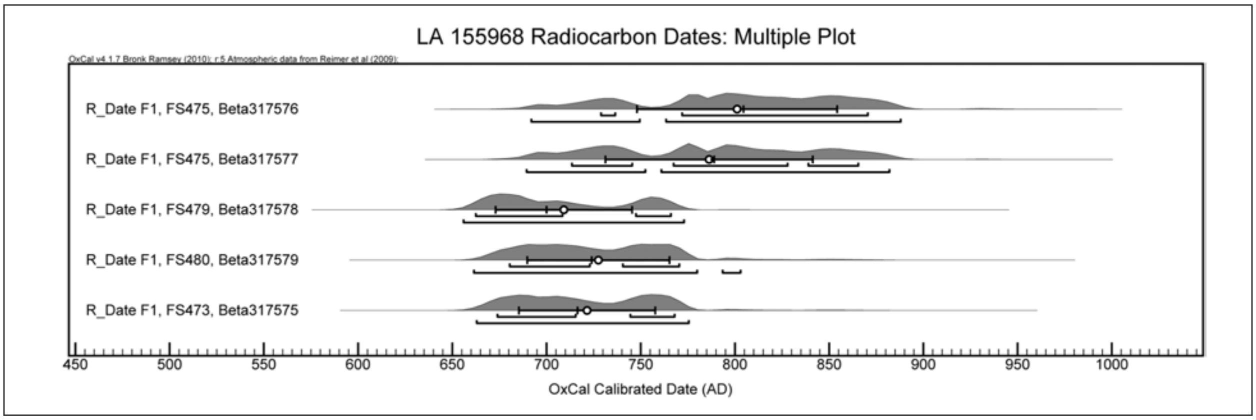

Figure 19.21. LA 155968, OxCal multiple plot of radiocarbon dates..

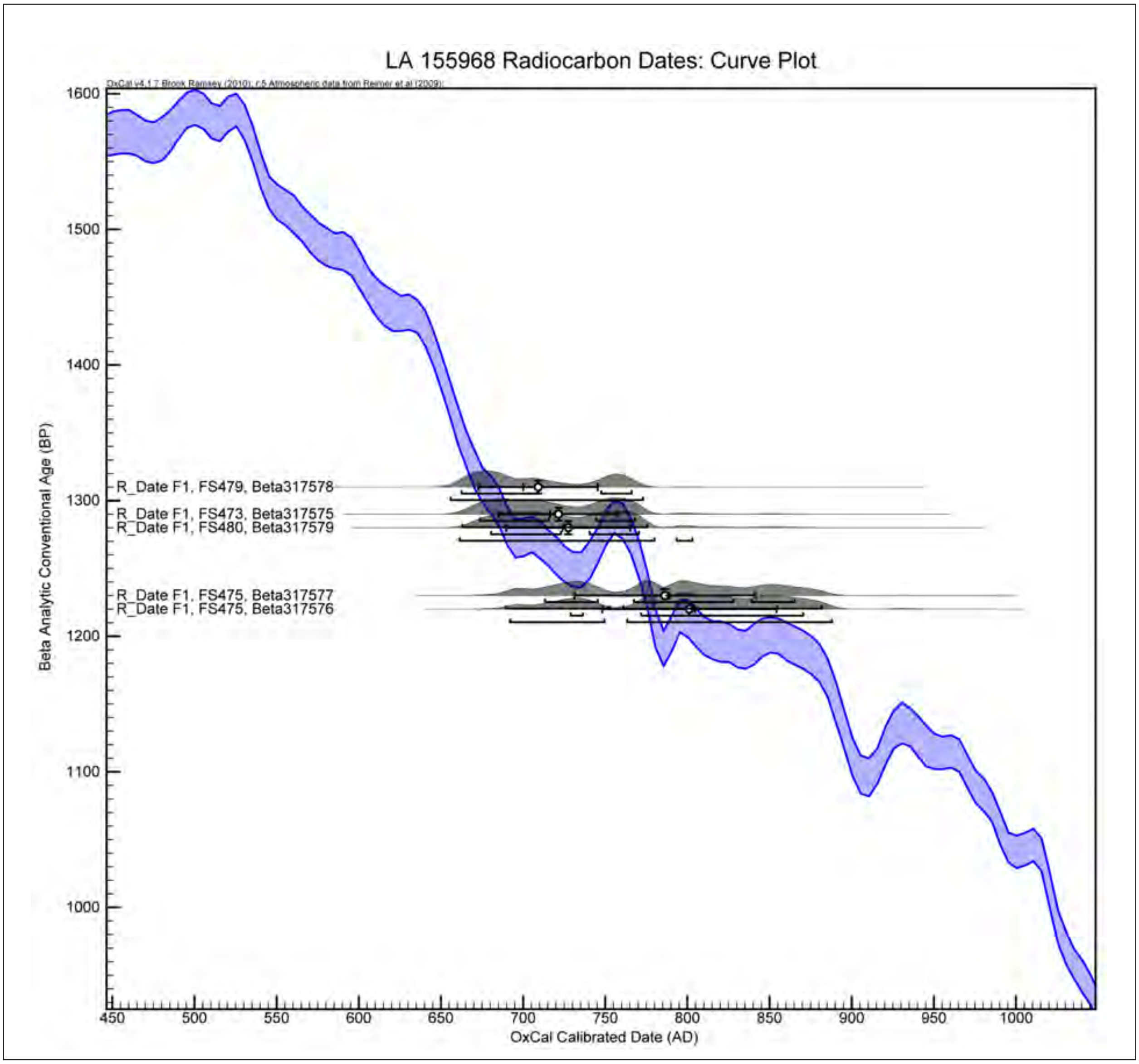

Figure 19.22. LA 155968, OxCal curve plot of radiocarbon dates..

Table 19.7. Sites and features by time period, phase, and radiocarbon dates.

Time Period and Phase	Site and Feature	Calibrated Radiocarbon Dates	
		Most Accurate	Most Precise
Archaic			
Middle Archaic	LA 111435, Feature 10	2940–2877 BC	2940–2877 BC
	LA 111435, Feature 3	1213–1008 BC	1213–1008 BC
Late Archaic	LA 111435, Feature 7	592–403 BC	592–403 BC
Late Archaic-Mesilla Phase transition	LA 111429, Feature 3	AD 85–260	AD 128–215
	LA 155963, Feature 15	2 BC–AD 125	2 BC–AD 125
Jornada Mogollon			
Mesilla Phase	LA 111435, Feature 6	AD 378–540	AD 378–540
	LA 155963, Feature 14	AD 430–591	AD 430–591
	LA 111422, entire site	AD 540–655	AD 540–655
	LA 155968, Feature 1	AD 656–887	AD 656–779
	LA 155963, Feature 141	AD 662–882	AD 662–882
	LA 155963, Feature 125	AD 769–898	AD 769–898
	LA 111435, Feature 8	AD 771–1014	AD 807–976
Dona Ana Phase			
Dona Ana-El Paso Phase transition	LA 155963, Feature 8	AD 1224–1302	AD 1262–1290
El Paso Phase			
Protohistoric Period	LA 111429, Paleosol A	AD 1405–1470	AD 1405–1470
	LA 155963, Feature 1	AD 1470–1640	AD 1470–1640
Historic Period	LA 111429, Feature 11	AD 1620–1685	AD 1630–1675
	LA 155963, Feature 9	AD 1626–1680	AD 1639–1668
	LA 155963, Feature 6	AD 1811–1920	AD 1811–1920
	LA 155964, Feature 1	AD 1800–1940	AD 1800–1940

Periods and Phases

Dated features from the Spaceport America sites range from ca. 3000 BC in the Middle Archaic period to the early twentieth century AD, spanning almost five millennia.

Archaic Period. Four features from two sites, LA 111435 and LA 155963, date to the Archaic period (ca. 6000 BC to AD 200), one from LA 111435 to the Middle Archaic (ca. 3500 ± 100 to 1200 BC), and two from LA 111435 and one from LA 1555963 to the Late Archaic (ca. 1200 BC to AD 200). The oldest feature, Feature 10 at LA 111435, was a fire-cracked rock scatter from which saltbush wood charcoal was recovered. LA 111435 also had the next two oldest features, Features 3 and 7, a formal, rock-lined fire pit and a charcoal stain, respectively, that are separated by about 400 to 600 years. The youngest Archaic feature was Feature 3 at LA 155963, which dates to the very late Late Archaic. As we will see, these two sites also produced the longest spans of radiocarbon dates.

Finally, Feature 3 at LA 111429, a formal, rock-lined fire pit, yielded a date at or near the temporal transition from the Late Archaic to the Mesilla phase of the Formative period. As Miller and Kenmotsu (2004) and Moore (2010) point out, Lehmer (1948) considered that transition to represent the addition of pottery and farming to evolving patterns of Archaic land-use, subsistence, and settlement, although his characterization is uncertain in light of subsequent research, particularly during the first quarter of the AD first millennium.

Formative Period (Jornada Mogollon). Fourteen dates from eight features from four sites show a sequence between AD 378 and 976/1014 during the Mesilla phase (ca. AD 300 ± 100 to 1000) of the Formative period, attributed to the Jornada Mogollon occupants of the region (Table 19.7). Because this time period has the most dates from the Spaceport America sites and because the calibrated dates are a sequence of adjacent and overlapping values, it is necessary to determine whether any of the Mesilla phase sites and features are statistically contemporaneous or if the dates represent a series of sites and features pointing to individual occupations or reoccupations. I used T-tests and F-tests to compare the means of and variances, respectively, within groups of Mesilla phase site groups. Table 19.8 shows the Mesilla phase, Beta-Analytic conventional age values from the sites and features, with group means and 1-sigma standard deviations for those sites or features with more than one date.

Table 19.9 presents the results of T-tests and F-tests for six pairs of sites and features. Comparisons of group means and for group internal variances between the six pairs show that none of the tested pairs can be identified as statistically contemporaneous. For some pairs, this observation seems obvious. For instance, conventional age mean values from Features 6 and 8 at LA 111435 are almost five centuries apart with relatively small standard deviation values, so we should not expect them to be contemporaneous. Indeed, T-test results show a 100 percent chance that their means are different and a greater than 84 percent chance that their internal variances are different. Similar results were obtained for the remaining five pairs, with one exception. Comparison of five Mesilla phase dates from LA 111968 and three dates from Feature 141 at LA 155963 revealed that there is only a 57.60 percent chance that the group means are different. Table 19.8 shows that the means of the two groups are in the late AD 1200s and their 1-sigma ranges overlap each other. That the LA 155963, Feature 141 group mean is slightly older than the LA 155968 group mean shows the impact of the 1370 BP date in the former group. It is likely that the T-test value is largely the result of differing numbers of values in the two groups; had the group from LA 155963, Feature 141 included two more dates, particularly if they were in the 1200s or early 1300s BP, the two groups, and therefore the features from which they were obtained, might be statistically contemporaneous, as is strongly suggested by their calibrated dates (Table 19.7).

F-test results (Table 19.9) show that internal variances within compared pairs of Mesilla phase date groups are overwhelmingly likely to be due to chance; only one pair produced F-test results showing variances that are less than 84 percent due to chance, and that one pair's F-test value is 71.36 percent due to

Table 19.8. Mesilla-phase radiocarbon dates.

	Site/Feature No.						
	LA 111435 F6	LA 155963 F14	LA 111422	LA 155968	LA 155963 F141	LA 155963 F125	LA 111435 F8
Beta-Analytic Conventional Age Mean Values (BP)	1600	1540	1440	1220	1230	1190	1110
	1620	–	1480	1230	1280	–	1110
	1630	–	–	1280	1370	–	1180
	–	–	–	1290	–	–	–
	–	–	–	1310	–	–	–
Mean	1616.667	–	1460.000	1266.000	1293.333	–	1133.333
Stan. Dev. (1σ)	15.275	–	28.284	39.115	70.946	–	40.415

Table 19.9. Mesilla-phase radiocarbon dates, T-test and F-test comparison results.

Compared Sites and Site Features	T-Test Results				F-Test Results		
	T-Test Value (α=0.05, 2-tail)	Degrees of Freedom	T-Test P Value	Result Summary	F-Test Value	F-Test P Value	Result Summary
LA 111435, F6 & LA 155968	0.0000039	7	1.0000000	100% chance that the two group means are different	0.2733613	0.8426052	>84% chance that the two group variances are different
LA 111435, F6 & LA 155963, F141	0.0126679	5	0.9903887	>99% chance that the two group means are different	0.0886076	0.9615587	>96% chance that the two group variances are different
LA 111435, F6 & LA 111435, F8	0.0007595	5	0.9994306	>99% chance that the two group means are different	0.2500000	0.8576215	>85% chance that the two group variances are different
LA 155968 & LA 155963, F141	0.5864197	7	0.5760134	>57% chance that the two group means are different	0.2859025	0.8943714	>89% chance that the two group variances are different
LA 155968 & LA 111435, F8	0.0092222	7	0.9929009	>99% chance that the two group means are different	0.8501784	0.9986214	>99% chance that the two group variances are different
LA 155963, F141 & LA 111435, F8	0.0391465	5	0.9702935	>97% chance that the two group means are different	0.4900000	0.7135705	>71% chance that the two group variances are different

chance. The value shows only that internal variances for the two groups are similarly narrow.

A single, small fire pit feature, Feature 8 at LA 155963, dates to the mid– to late AD 1200s near the transition from the Doña Ana phase (ca. AD 1000 to 1275 ± 50) to the El Paso phase (ca. AD 1275 ± 25 to 1450) as they are currently dated (Table 19.7). This is the only date from a Formative-period archaeological site that is not during the Mesilla phase.

A sample of soil from a Paleosol A horizon at LA 111429 yielded a calibrated date in the fifteenth century AD, ca. AD 1405 to 1470 (Table 19.7). This date falls near the end of the Formative period, El Paso phase as it is currently dated, although Moore (2010:37–38) states that, presently, the phase can best be described as ending after AD 1450. Archaeological features were not associated with the paleosol where it was sampled for radiocarbon dating; rather the date was obtained in order to confirm the age of the soil across the site. No dated archaeological features from the Spaceport America sites fall into the El Paso phase.

Protohistoric Period. A single feature, Feature 1 at LA 155963, provided a date during the Protohistoric period, currently dated between about AD 1450 (or after) and 1600. The feature was a large fire pit containing rocks.

Historic Period. Two features from two sites yielded radiocarbon dates in the seventeenth century AD (Table 19.7). Feature 11 at LA 111429 and Feature 9 at LA 155963 are contemporaneous, as their dates are almost identical in the mid– to late AD 1600s.

Two other features, Feature 1 at LA 155964 and Feature 6 at LA 155963, yielded dates spanning years between the late AD 1600s and the early 1900s, but with most accurate and precise dates between AD 1800 and 1940 because of the shape of the calibration curve in the nineteenth and twentieth centuries AD. I've speculated that, had the calibration curve not reversed itself and then settled into a long, flat portion, those two samples might date near or slightly after the AD 1600s features. The absence of Euroamerican artifacts in the vicinities of those features (Nancy Akins and James Moore, personal communication, 2012) might support interpreting the features as older than their nineteenth -and twentieth century AD dates.

Multiple-Occupation Sites

Three of the six Spaceport America sites yielded radiocarbon dates from multiple time periods or multiple dates from a single phase or period. Multiple occupations of those sites, spanning centuries and millennia, are demonstrated by the multiple dates. Detailed assessments of the dates show that, with the exception of dates derived from burned mesquite wood that point to material integrity circumstances, there are few reasons to question the accuracy of dates from different phases and periods for features from single sites. Where accuracy questions do arise, they are because of changes in the shape of the calibration curve that provide several locations for intersection with conventional age curves and are accounted for in the individual descriptions and in the discussion that follows.

LA 111435. Three features from LA 111435 date to the Archaic period. One, Feature 10, is very precisely dated to 2940 to 2877 BC during the early Middle Archaic period. The precision is due to the steep shape of the calibration curve in the area of this date. Two features, Features 3 and 7, on the other hand, date to parts of the Late Archaic period where the trend of the calibration curve is flatter, resulting in multiple locations for intersection with their conventional age curves. Consequently, their dates are much less precise: 205 years for Feature 3 and 189 years for Feature 7. Nonetheless, the dates show that LA 111435 was the location of multiple Archaic occupations spanning several centuries, indeed several millennia, beginning ca. 3000 BC. The Archaic features at LA 111435 included a fire-cracked rock scatter (Feature 10; Table 19.1), a rock-lined fire pit (Feature 3), and a charcoal stain (Feature 7).

Further, Features 6 and 8 at LA 111435 yielded dates in the early and late Mesilla phase of the Formative period, Jornada Mogollon occupation of the region. Feature 6 was a fire-cracked rock scatter, while Feature 8 might have been an ephemeral structure. With the Mesilla-phase dates, LA 111435 provided evidence of the longest sequence of reoccupation of the Spaceport America sites, ranging from about 3000 BC to AD 1000, based on five features. Indeed, each dated feature at LA 111435 yielded a very different date from this four thousand-year range (Table 19.7).

LA 155963. LA 155963 also provided a long range of dates (n = 12) between about 2 BC and AD 1920, from eight features, the most dated features of any Spaceport America site. Feature 15, a charcoal stain that might have been a small fire pit, yielded a Late Archaic date (Table 19.7), the youngest Archaic date from the Spaceport America sites. Most of the LA 155963 features date to the Mesilla phase (n = 3). One of those, Feature 14, was a roasting pit, while the other two, Features 141 and 125, were fire pits. The roasting pit was older than the fire pits, while close examination of the fire pits shows that they are statistically contemporaneous. The mesquite wood sample from Feature 141 yielded a date probably older than the use of the sample because of material integrity, specifically the loss of burned outer portions of the branch. Consequently, it is likely that the three samples from Feature 141 are actually, if not statistically, contemporaneous. On the other hand, Features 141 and 125, while statistically contemporaneous, might not be actually contemporaneous since there is little overlap of their dates. Nonetheless, the two fire-pit features probably date to the late eighth or ninth centuries AD, perhaps two centuries older than the roasting pit.

Feature 8 at LA 155963, a small fire pit, yielded dates in the thirteenth century AD, with a precise date in the second half of that century. This period is at the end of the Doña Ana phase and the beginning of the El Paso phase. A large fire pit from the site, Feature 1, dates to the Protohistoric period (ca. AD 1450 to 1600); the calibration curve at that location provided multiple locations for intersection with the sample's conventional age curve, so the feature's date spans 170 years covering the period and its overlap with the early years of the Historic period (ca. AD 1540 to the present).

Finally, two features at LA 155963 date to the Historic period. Feature 9, a charcoal stain, dates to the seventeenth century AD, most precisely to AD 1630 to 1675. Feature 6, a disturbed fire pit, provided a sample whose conventional age curve intersects the calibration curve between about AD 1690 and 1730 and about AD 1811 and 1920; the latter range results from the shape of the curve in the nineteenth century AD. As I discussed earlier, had the curve not briefly reversed its course, we might date the feature to ca. AD 1700, making it almost contemporaneous with Feature 9. A date in the nineteenth or early twentieth century AD is, however, statistically most accurate for Feature 6 given the shape of the curve.

The LA 155963 dates span nearly two millennia, the second-longest range of the Spaceport America sites. The site has the most Mesilla-phase features, which is probably expectable since it has the most dated features and most of the dated Spaceport America features are from the Mesilla phase. It also has the most Historic-period features and the only feature dated to the Doña Ana or El Paso phase.

LA 111429. In addition to the several multiple occupations shown at LA 111435 and LA 155963, the two dated features at LA 111429 are from very different time periods. As discussed earlier, Feature 3, a formal, rock-lined fire pit, yielded a date early in the first millennium AD, most precisely in the second or early third centuries. In contrast, Feature 11, a roasting pit, dates to the seventeenth century AD, most precisely between AD 1630 and 1675, some 14 centuries later.

Single-Occupation Sites

Sites LA 111422, LA 155968, and LA 155964 provided radiocarbon dates pointing to single occupations. Two features at LA 111422, Features 1 and 4, a charcoal stain and a small fire pit, date between AD 540 and 655 during the Mesilla phase. A single date from Feature 1 at LA 155968 yielded a date of AD 656–779, also during the Mesilla phase.

Finally, Feature 1 at LA 155964, a roasting pit, is most accurately dated between AD 1800 and 1940, making it approximately contemporaneous with Feature 6 at LA 155963. Like Feature 6 at LA 155963, however, LA 155964 Feature 1 sample's conventional age curve intersects the calibration curve in the late seventeenth and eighteenth centuries AD as well as in the nineteenth and early twentieth centuries because of the shape of the calibration curve. Had the curve not reversed itself and then become relatively flat during the nineteenth and twentieth centuries, Feature 1 at LA 155964 and Feature 6 at LA 155963 might be better dated as slightly later than the seventeenth century AD Feature 11 at LA 111429 and Feature 9 at LA 155963, resulting in a group of site occupations in the AD 1600s and 1700s.

20 | Modern Plant Survey

Pamela J. McBride

Introduction

A survey of the species characterizing the modern plant community in the Spaceport America project area was completed in September 2011, following the completion of fieldwork and the end of the rainy season. This survey was conducted by Pamela J. McBride, assisted and guided by Nancy J. Akins. With the exception of LA 155969, which could no longer be accessed because of its proximity to the Spaceport America runway, the vegetation on each site was examined, the general plant community was described, and identifiable species were recorded but were not quantified. In addition, two transects were walked across Jornada Draw. The first transect began at the north end of LA 111429, on the east side of the arroyo, and ran due west to LA 111435 on the west side. The second transect ran between LA 111422, on the west side of Jornada Draw, east to LA 111429.

The general area can be characterized as Chihuahuan Desertscrub (Brown 1994). Honey mesquite (*Prosopis glandulosa*) is the primary shrub species, particularly on dune ridges. Major winter die-off of mesquite was observed in low-lying areas of the east side of LA 111435. This may be due to the effects of cold air drainage. At the north end of LA 155963, creosotebush (*Larrea tridentata*) and honey mesquite were co-dominants, but in general, creosotebush was scattered or rare. The primary grass species is tobosa (*Pleuraphis mutica*) with black grama (*Bouteloua eriopoda*), muhlys (*Muhlenbergia torreyi, M. porteri*), vine mesquite (*Panicum obtusum*), purple three-awn (*Aristida purpurea* var. *perplexa*), alkali, spike, and mesa dropseed (*Sporobolus airoides, S. cantractus, S. flexuosus*), burro grass (*Scleropogon brevifolius*), desert lovegrass (*Eragrostis pectinacea* var. *miserrima*), and plains bristlegrass (*Setaria leucopila*) common to scattered.

LA 111422

This site is on a dune ridge where a large band of mesquite is present and interspersed with a considerable number of soaptree yucca (*Yucca elata*) and open areas of grassland where dropseeds, black grama, snakeweed (*Gutierrezia sarothrae*), at least two species of spurge, and a sprawling member of the amaranth family, espanta vaquero (*Tidestromia lanuginosa*) are common. Limoncillo (*Pectis angustifolia*), sageleaf bahia (*Bahia absinthifolia*), wild zinnia (*Zinnia grandiflora*), tall purple asters (*Dieteria* spp.), violet/pink globemallow that may be Wright's globemallow (*Sphaeralcea wrightii*), and chocolate flower (*Berlandiera lyrata*) also occur intermittently.

LA 111429

In the Archaic portion of the site there is lots of winter die-off of mesquite. Tobosa grass dominates with patches of purple three-awn, fluffgrass (*Dasyochloa pulchella*), dropseed, and mat grama (*Bouteloua simplex*). Concentrations of soaptree yucca and cholla (*Cylindropuntia* spp.) occur sporadically, while espanta vaquero is abundant. Other plants that occur infrequently include stunted Mormon tea (*Ephedra* spp.), an unknown composite, spike dropseed, nightshades (*Solanum* spp.), narrow leaf globemallow (*Sphaeralcea angustifolia*), possible Wright's globemallow, wild zinnia, dwarf desert holly (*Acourtia nana*), a member of the legume family, (twinleaf senna, *Senna bauhinioides*), a small morning glory with pink flowers (crestrib morning glory, *Ipomoea costellata*), another member of the legume family called hog potato (*Hoffmannseggia glauca*), a milkweed (cf. *Asclepias brachystephana*), purslane (*Portulaca* spp.), devil's claw (*Proboscidea parviflora*), and a four o'clock with tiny, dark pink flowers (Torrey spiderling, *Boerhavia torreyana*). Four-wing saltbush (*Atriplex canescens*) is rare, but can be found growing in mesquite. To the west, mesquite survived the winter on the dunes. This area is at a high spot, where a pretty good view of the surrounding grassland can be obtained. Purple three-awn, dwarf desert holly, nightshade, four-wing saltbush, and a few Mormon tea plants are present. A patch of leatherweed (*Croton potsii*) was distinctive to this part of the site.

One little-leaf sumac (*Rhus microphylla*) and another to the south was seen growing on the north end of the site, along with chocolate flower and the possible Wright's globemallow. The caliche field offered at least one unusual species, prostrate ratany (*Krameria lanceolata*), a plant with very lovely glossy burgundy flowers, but with nasty spiny fruits. Also growing in this area are: stunted indigobush (*Dalea Formosa*); Mormon tea; possible hog potato; a groundcherry with greenish-yellow flowers, possibly Sonora groundcherry (*Physalis virginiana* var. *sonorae*); a prostrate plant of the same family as Torrey spiderling with larger, dark pink flowers (combseed windmills, *Allionia choisyi*); and one cholla. Off-site, mesquite is either dead, plants are very stunted, or consist of root-sprouts. One creosotebush was observed in the area, along with wild zinnia, spiny dogweed (*Thymophylla acerosa*), sageleaf bahia, and purple three-awn.

Across the road on a dune ridge, large specimens of what may be slender amaranth (*Amaranthus viridis*) and what is probably western ragweed (*Ambrosia psilostachya*) are two taxa that were not noted as growing elsewhere. Also, one specimen of little bluestem (*Schizachyrium scoparium*) and patches of prostrate pigweed (*Amaranthus blitoides*) grow close to the roadside, perhaps taking advantage of runoff water.

LA 111435

LA 111435 is one of two sites where Wolfberry (*Lycium pallidum*) was identified, but the primary woody species is honey mesquite; soaptree yucca is also abundant. Taxa found at other sites are present, including: tobosa grass; hog potato; burro grass; limoncillo; one cholla; nightshade; purple three-awn grass; mat grama; spurges; scattered, very small mesquite; globemallow; milkweed; crest-rib morning glory; dwarf desert holly; western ragweed; black grama; struggling Mormon tea; prickly pear (*Platyopuntia* spp.); sageleaf bahia; and dropseed grass. Two plants that were somewhat unusual to the area were windmill grass (*Chloris* spp.) and a fungus that was in the spore stage. The fungus resembled a club with a stiff stem and a spore-laden head.

On the east side of the site, cowpen daisy (*Verbesina encelioides*) grew along the road. A succulent plant in the purslane family not encountered before was probably narrow-leaved fameflower (*Phemeranthus auriantiacus var. angustissimum*). Another member of the four o'clock family that was not in bloom and that also had not been seen elsewhere was growing on this side of the site, particularly clinging to mesquite trees. Wright's globemallow, devil's claw, warty carpetweed (*Kallstroemia parviflora*), combseed windmills, twinleaf senna, sageleaf bahia, and spurges were some of the plants found elsewhere that also occurred here. One creosote bush was observed growing within a mesquite and one tarbush was here as well. Yet another four o'clock was discovered with winged fruits (cf. *Acleisanthes diffusa*). This was difficult to identify, as there were no flowers. To the north can be found tobosa grass interspersed with black grama, and to the east with burro grass. An unknown was fairly common; this plant could be in the evening primrose or mint family.

LA 155963

This site covers nearly 124 acres and vegetation varies from the north end of the site, where creosotebush and yucca are prominent, to the southern end of the site, where mesquite-stabilized coppice dunes are found with four-wing saltbush growing within the mesquite shrubs and where the site generally lacks the diversity found on slightly higher ground, although a patch of tarbush (*Flourensia cernua*) occurred near Feature 51 and in the wash. A patch of groundcherry was observed, probably *Physalis hederifolia* var. *hederifolia*. Spiny dogweed, groundcherry, a spurge (*Euphorbia* spp.), prickly pear, and sageleaf bahia grow in the wash. Small thickets of little-leaf sumac are present at the northern end, where some specimens were observed to have grown to at least 6 ft (2 m) tall. Open expanses of tobosa grassland are present in the central portion of the site, where scattered four-wing saltbush, fluff grass, devil's claw, spiny dogweed, and stunted indigobush occur, along with Torrey spiderling and combseed windmills. Twinleaf senna is abundant in this area, as is dwarf desert holly.

LA 155964

Mesquite, dwarf desert holly, warty carpetweed, and silverleaf nightshade (*Solanum elaeagnifolium*) were abundant. At least three grasses occurred, with tobosa the most frequently encountered. Creosotebush was rare. Soaptree yucca and little-leaf sumac were scattered, while pockets of the spiny buckthorn family plant, graythorn (*Ziziphus obtusifolia*), were present. Single specimens of cholla, prickly pear, and Mormon tea were also observed. One species of spurge was fairly widespread (thymeleaf spurge, *Chamaesyce serphllifolia*), as was espanta vaquero. Another spurge, rattlesnake weed, (*Chamaesyce albomarginata*) was more restricted in distribution. Mesquites seemed to be acting as nurse trees for four-wing saltbush, which were otherwise scattered throughout the site.

LA 155968

The unknown plant described above for LA 111435 was also present on LA 155964. Creosotebush is scattered and is more compact than that found at more northerly sites. There were more patches of mesquite in the desert pavement. Another specimen of the fungus found at LA 11432 was found. This one is still viable and resembles an inky cap or shaggy mane with an elongated cap. Another four o'clock with beautiful long-tubular white flowers was present (cf. sweet four o'clock, *Mirabilis longiflora*). More of the cf. *Acleisanthes diffusa* was here as well. Otherwise, sageleaf bahia, cowpen daisy near the road, twinleaf senna, limoncillo, warty carpetweed, and scattered yucca were among several plants found elsewhere. A large patch of wolfberry was encountered along with one specimen of tarbush.

LA 156877

At this site there is a lot of bare ground in-between clumps of tobosa grass. Flora consists primarily of tobosa grass, mesquite, and soaptree yucca. Two taxa were found here and nowhere else: a dodder, which covered plants along the roadside, and one specimen of graythorn, which still retained the cups and disks that hold the ovary or fruit on the stem but are not adherent to it (Fig. 20.1). This specimen has been tentatively identified as *Ziziphus obtusifolia var. canescens*.

Figure 20.1. LA 156877, Possible graythorn Ziziphus obtusifolia var. canescens.

ACKNOWLEDGMENTS

I would like to thank field botanist extraordinaire Jim McGrath for his patient and persistent help with plant identifications, especially his valiant attempts to identify unknowns from photographs. His knowledge of grasses was particularly helpful.

21 | Late Quaternary Stratigraphy, Optical Geochronology, and Associated Prehistoric Sites

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Introduction

The goal of this investigation is to determine the relationship between the local surficial geology and the formation, preservation, and occurrence of prehistoric archaeological sites. To achieve that goal, we studied the stratigraphy, sedimentology, geochronology, and soils of the deposits associated with 14 prehistoric archaeological sites. The study area is in the center of the broad Jornada del Muerto valley with the Caballo Mountains to the west and the San Andres Mountains to the east (Fig. 21.1). The valley has a down-gradient slope from north to south and is drained by the ephemeral Jornada Draw and its tributaries that head in the adjacent mountains and uplands. In the past, tributary streams have transported and deposited materials from the mountains to the valley slopes with alluvial fans filling the valley and forming broad piedmont surfaces. Wind-deposited sand mantles the piedmont alluvium in many areas, especially the eastern piedmont slope.

Climate and Vegetation

The historic climate of the Jornada is moderately well documented. The closest weather station to our study area is Aleman Ranch located near the entrance to the new Spaceport America. The Aleman Ranch weather station was established in 1948 and closed in 2000. The mean annual temperature for that period is 58.3° F (14.6° C) and the mean annual precipitation is 9.98 inches (251 mm). Sixty-

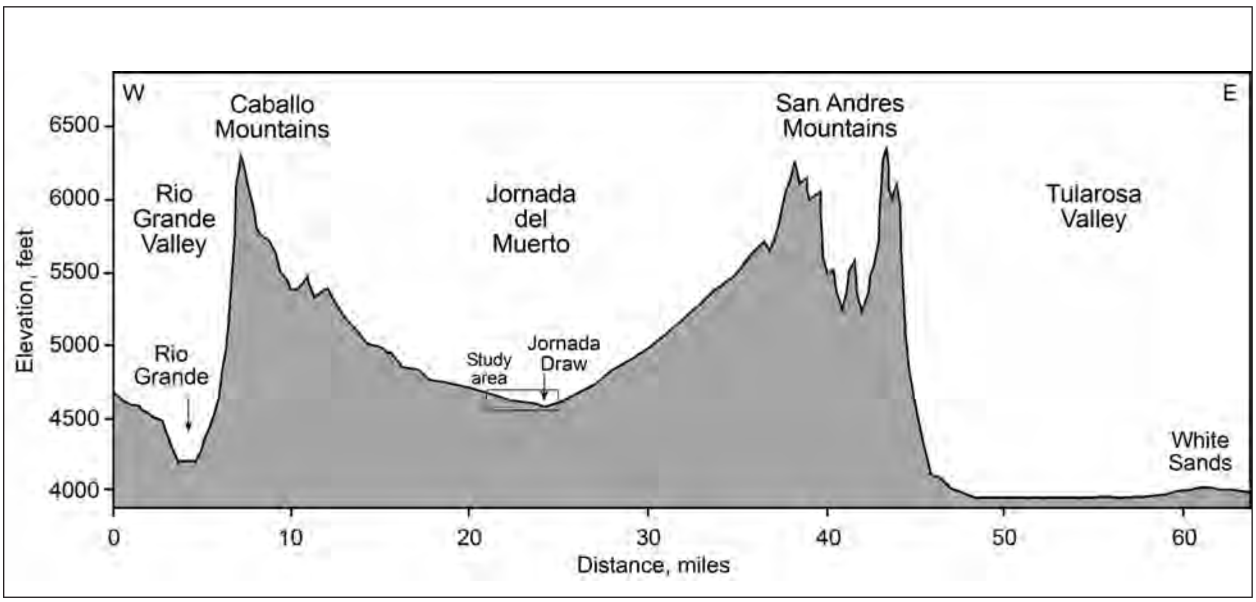

Figure 21.1. Topographic cross-section from Rio Grande Valley across the Jornada del Muerto to the Tularosa Valley at 33° north latitude; from USGS Las Cruces quadrangle, 1:250,000 scale, 1955, revised 1971.

four percent of the rainfall (6.36 inches, 162 mm) occurs during the summer monsoon July through October. Mean annual snowfall is 6.1 inches. An early weather station was established at the old railroad town of Engle in 1894 but was closed in 1961. Engle is about 13 miles north of Aleman Ranch. The average weather data from Aleman Ranch and Engle are similar (Table 21.1).

The climate of the Jornada is at the threshold of semiarid to arid. The vegetation of the Jornada is a desert grassland with scattered patches and areas of honey mesquite (*Prosopis glandulosa*) and creosotebush (*Larrea tridentata*) shrubs, depending on the substrate. Trees are absent. A vegetation map of New Mexico classifies the Jornada as "Chihuahuan Desert Scrub" (Dick-Peddie 1993). A potential natural vegetation map classifies the Jornada as the "creosotebush-bush muhly association" in the "Chihuahuan region" of the "desert shrub formation" (Donart et al. 1978). Donart et al. note on their map that "at one time these were predominantly grasslands with scattered creosotebush; principal grasses were black grama, bush muhly, scattered tobosa in rills, and creosotebush."

Geology

An important monograph on the geology of the Caballo Mountains summarizes the geologic history of the region (Seager and Mack 2003). Recent papers and discussions of the regional geology are included and cited in the New Mexico Geological Society guidebook to the Warm Springs region (Lucas et al., 2012). Our study area is located in the northwestern quarter of the Prisor Hill 7.5-minute quadrangle. The geology of the Prisor Hill quadrangle has been mapped by Seager (2005). The map is an open-file digital geologic map OF-GM 114 and is available on the web site of the New Mexico Bureau of Geology and Mineral Resources. Our study localities are shown on the northwest quarter of the Prisor Hill geologic map (Fig. 21.2).

Modern Soil Survey

The only comprehensive soil mapping in the Jornada is in the Sierra County soil survey report by the USDA (Neher 1984). The soils in our study area fall into the Dona Ana-Stellar-Wink Series. These soils occur on nearly level and gently sloping pediment surfaces and are deep, well drained, and formed in mixed alluvium, according to Neher (1984). Typical profiles show high clay content, characteristic of piedmont-slope alluvium, and a calcic B-horizon. The stratigraphy exposed in the backhoe trenches verifies the soil designations. However, some small areas of thin eolian sand sheet deposits that we document in several of our study trenches along the west side of Jornada Draw are not specifically mapped by either the Sierra County soil survey report (Neher 1984) or the Prisor Hill quadrangle geologic map (Seager 2005).

Table 21.1. Historic weather data from the Jornada del Muerto, New Mexico.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Aleman Ranch (290268); period of record: 6/1/1948 to 9/30/2000; 4530 ft elevation													
Avg. T (°F)	39.4	43.7	49.6	57.2	65.6	74.8	78	76	69.6	59.1	47.4	39.6	58.3
Avg. Total Precip. (in.)	0.44	0.35	0.31	0.21	0.4	0.69	2.04	1.99	1.4	0.91	0.5	0.74	9.98
Avg.Total Snowfall (in.)	1.9	0.8	0.4	0.1	0	0	0	0	0	0	0.5	2.5	6.1
Engle (292945); period of record: 12/1/1894 to 5/31/1961; 4770 ft elevation													
Avg. T (°F)	38.3	43.2	49.6	57.8	65.8	74.8	78.2	76.5	70.2	59.2	46.6	39.1	58.2
Avg. Total Precip. (in.)	0.34	0.5	0.34	0.33	0.54	0.63	1.76	2.02	1.26	0.84	0.27	0.49	9.32
Avg. Total Snowfall (in.)	1.1	1	0.2	0	0	0	0	0	0	0	0.4	1	3.7

Note : from NOAA, various sources

Methods

Field Methods

The fieldwork was conducted by Hall at the Spaceport America in the Jornada del Muerto, Sierra County, during September, November, and December 2010, and in June and July 2011. The evaluation of the surficial geology of the study area was based on a series of 18 backhoe trenches (Figs. 21.2, 21.2a, 21.2b) and several archaeological excavations (also Fig. 21.2). In the field, the stratigraphy of sedimentary deposits and associated soils is generally clear, based on lithology and color. A large effort was made to obtain sedimentology data from the stratigraphic units of alluvium and wind-deposited sand that make up the surficial geology of the Jornada. High-resolution particle-size and chemical information on the sediments and associated soils provide a firm documentation of the properties and characteristics of the stratigraphic units. In many cases, laboratory particle-size analytical data

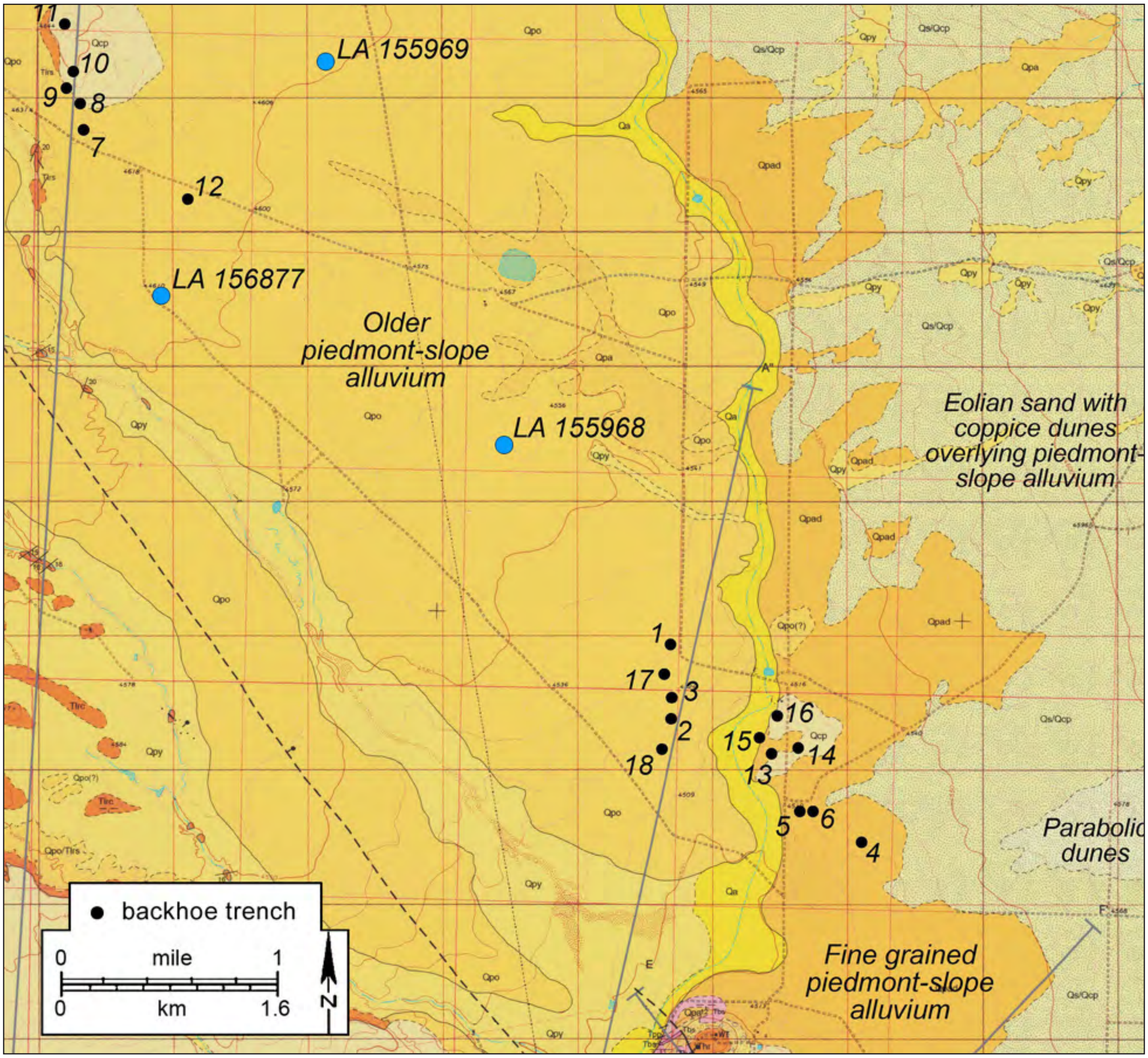

Figure 21.2. Geologic map of Prisor Hill Quadrangle, northwest corner, with locations of soil pits (BHT 1, etc.) and archaeological sites (map from Seager [2005]). Study localities "Paleoindian block," "vertical sample," and "Test Pit 3" at LA 111429 are located near BHT 13 and BHT 16.

showed a clear distinction between stratigraphic units. In a few cases where particle size was similar, carbonate content provided evidence of breaks in the stratigraphic sequences.

Sediment and Soil Analyses

Samples were collected from all sediments and soils for textural and chemical analysis. In most cases, the sampling was done continuously at 10 cm intervals of the exposed stratigraphic sequence. In two cases, sampling was done at every other 10 cm interval, and in one case samples were collected at 5 cm intervals. A total of 273 sediment samples were analyzed; each sample has a field number with a prefix SP, such as SP-1, and is listed in a series of tables in this chapter. Samples SP-1 through SP-42 were analyzed by the Milwaukee Soil Laboratory, Milwaukee, Wisconsin. All of the other samples, SP-43 through SP-273, were analyzed by the Pedology Laboratory, Department of Geography, University of Kansas, Lawrence, Kansas; the Pedology Laboratory provided the Munsell color of all 273 samples.

The Milwaukee Soil Laboratory conducted particle-size analysis of sand to 1-Φ intervals as percentages by dry weight using brass sieves (Wentworth 1922; Folk 1968). The Wentworth particle size limits, and those used in this study, are as follows: sand 2 to 1/16 mm, silt 1/16 to 1/256 mm, clay less than 1/256 mm. Sand is further broken down in the Wentworth scale as follows: very coarse sand 2 to 1 mm, coarse sand 1 to 1/2 mm, medium sand 1/2 to 1/4 mm, fine sand 1/4 to 1/8 mm, and very fine sand 1/8 to 1/16 mm. Percentages of silt and clay were determined by the hydrometer method; the silt-clay limit was fixed at 3.9 μm (1/256 mm), the limit used in geology and sedimentology. The percentages of organic carbon were determined by the Walkley-Black method; percentages of carbonate were determined by the Chittick method; iron (Fe) percentages were determined by the citrate-dithionite method.

The Pedology Laboratory, University of Kansas, conducted particle-size analysis with a Malvern Mastersizer 2000 laser diffractometer, resulting in percentages of particles by volume (instead of by weight). Although by volume, the particle sizes are set at the Wentworth size limits, such as described above, but with a slight variation for the very fine sand-silt grade limit: very coarse sand 1000–2000 μm, coarse sand 500–1000 μm, medium sand 250–500 μm, fine sand 125–250 μm, very fine sand 63–125 μm. An exception is the silt-clay size limit that was set at 2.0 μm, the value used by soil scientists: sand 63–2000 μm, silt 2–63 μm, clay < 2 μm. Organic carbon was determined by the Walkley-Black method; carbonate percentages were determined by elemental analyzer (pre- and post-acid treatment). Iron (Fe) in parts per million (ppm) was determined by mass spectrometer and the citrate-dithionite method. Munsell dry color for all 273 samples was determined by Konica-Minolta spectrophotometer and normalized to the categories in Munsell Color (2009; Table 21.2). The particle-size, chemical, and color data from the two laboratories are listed in various tables in this chapter.

The percentages of the clastic particles are presented in three different ways in the tables of sedimentary data and in the sediment diagrams. First, the percentages of sand, silt, and clay are given as a total of 100 percent. Second, the percentages of very coarse sand, coarse sand, medium sand, fine sand, and very fine sand are given as a total of 100 percent sand. In this regard, comparing the percentages of fine sand versus the percentages of silt would be independent of each other. Third, in a few cases where the amount of gravel was determined, the percentages of gravel are based on the sum of gravel, sand, silt, and clay by weight. In these cases, the percentages of sand, silt, and clay are calculated excluding gravel.

It should be pointed out that, in this study, the percentages of silt and clay determined by Milwaukee and Kansas are not based on the same criteria. Because of the differences in the silt-clay size limits utilized by the two laboratories, 3.9 μm by Milwaukee and 2.0 μm by Kansas, the percentage values of clay determined by Milwaukee may be slightly higher, theoretically, than those determined by Kansas. Likewise, the percentages values of silt determined by Milwaukee may be slightly lower than those determined by Kansas.

Laser diffraction versus dry sieving

As a footnote to the above, we are concerned about the use of laser diffraction for particle-size analysis. The reader should be aware that the newly developed volumetric laser diffraction methodologies do not produce the same results that are reported in the vast geologic and soil science literature where particle-size percentages are based on

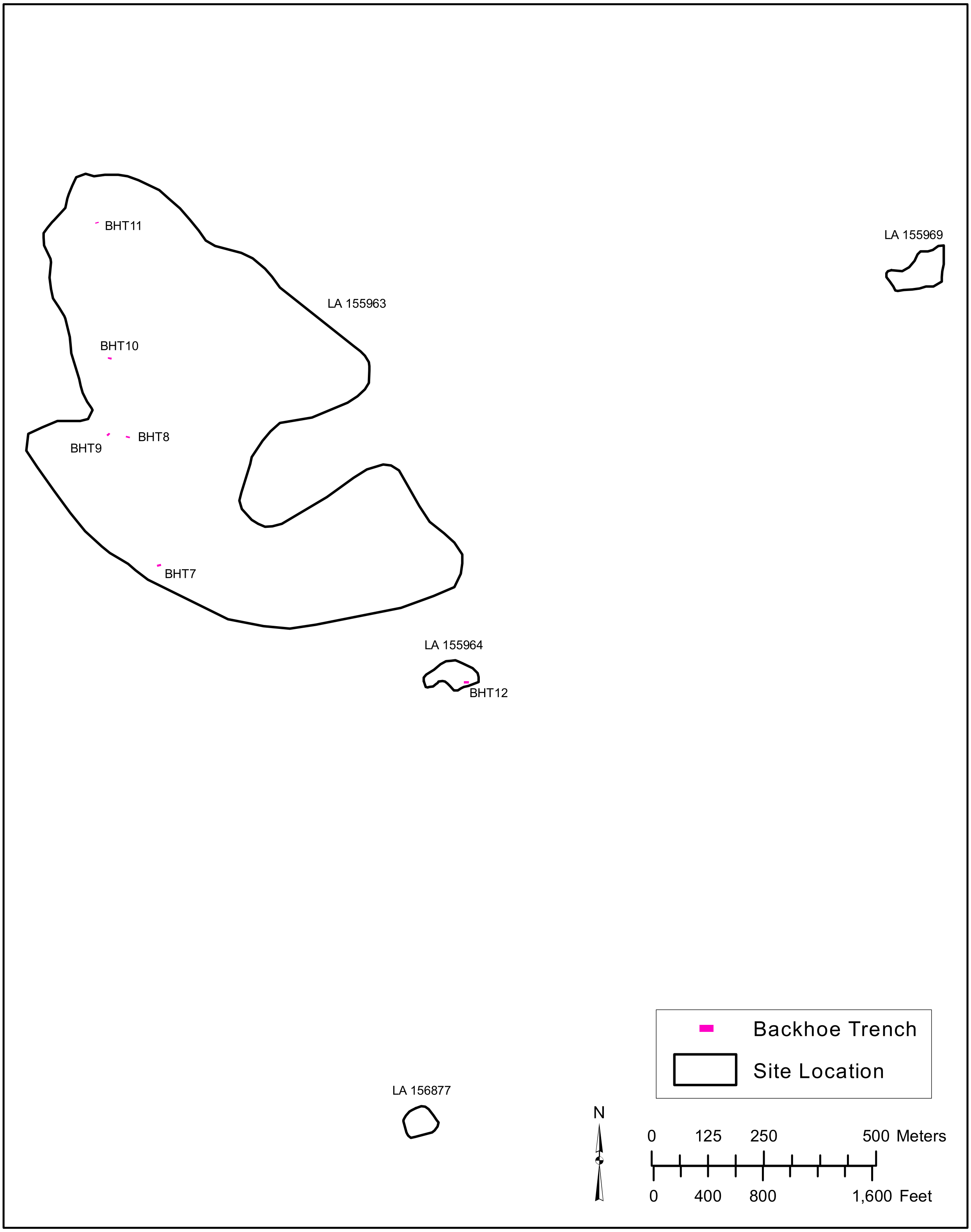

Figure 21.2a. Backhoe trenches (BHT), northern sites.

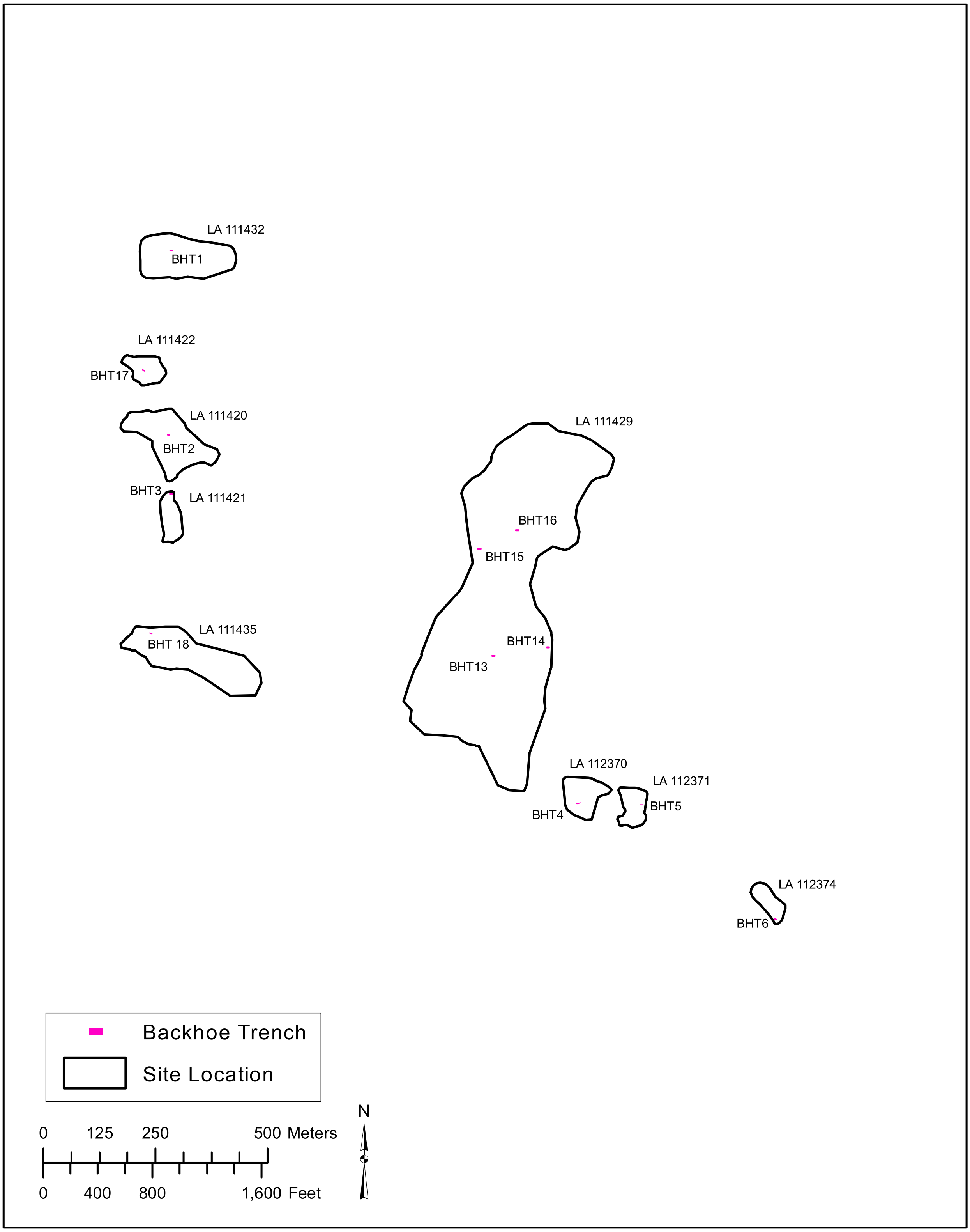

Figure 21.2b. Backhoe trenches (BHT), southern sites.

Table 21.2. Dry Munsell color of all 273 sediment samples, as determined by a Konica Minolta spectrophotometer.

Field/ Lab No.	Dry Munsell Hue	Dry Munsell Value	Dry Munsell Chroma	Field/ Lab No.	Dry Munsell Hue	Dry Munsell Value	Dry Munsell Chroma
SP-1	8.4YR	4.64	3.41	SP-138	7.8YR	5.18	3.37
SP-2	7.2YR	4.18	3.62	SP-139	7.6YR	5.16	3.41
SP-3	6.9YR	4.18	3.93	SP-140	7.5YR	5.38	3.39
SP-4	7.2YR	4.78	4.03	SP-141	7.5YR	5.45	3.42
SP-5	7.1YR	4.73	4.04	SP-142	7.6YR	5.5	3.35
SP-6	7.2YR	4.86	4.03	SP-143	7.6YR	5.5	3.32
SP-7	7.3YR	4.95	3.94	SP-144	7.5YR	5.45	3.48
SP-8	8.0YR	5.68	3.81	SP-145	7.5YR	5.61	3.47
SP-9	8.4YR	5.9	3.5	SP-146	7.5YR	5.63	3.46
SP-10	8.7YR	5.86	3.28	SP-147	7.3YR	5.54	3.49
SP-11	8.8YR	5.82	3.32	SP-148	7.2YR	5.4	3.57
SP-12	9.0YR	5.77	3.3	SP-149	7.5YR	5.43	3.49
SP-13	9.0YR	5.82	3.28	SP-150	7.6YR	5.63	3.54
SP-14	8.8YR	5.73	3.46	SP-151	7.7YR	5.98	3.37
SP-15	8.0YR	5.04	3.24	SP-152	8.0YR	6.35	3.01
SP-16	7.7YR	4.82	3.54	SP-153	8.1YR	6.35	3.01
SP-17	7.5YR	4.61	3.26	SP-154	8.2YR	6.17	3.02
SP-18	7.7YR	5.38	3.49	SP-155	8.1YR	6.05	3.13
SP-19	7.6YR	5.38	3.52	SP-156	7.8YR	5.45	3.3
SP-20	7.4YR	5.42	3.5	SP-157	7.8YR	5.79	3.3
SP-21	7.6YR	5.74	3.39	SP-158	7.6YR	5.55	3.32
SP-22	8.0YR	5.79	3.14	SP-159	7.5YR	5.58	3.4
SP-23	7.9YR	5.45	3.06	SP-160	7.5YR	5.3	3.39
SP-24	7.8YR	5.46	3.25	SP-161	7.5YR	5.54	3.23
SP-25	8.0YR	5.53	2.95	SP-162	7.6YR	6.04	3.1
SP-26	8.0YR	5.79	3.08	SP-163	7.8YR	6.45	2.75
SP-27	8.0YR	5.93	3.19	SP-164	7.8YR	5.13	3.72
SP-28	8.2YR	5.76	2.77	SP-165	8.1YR	5.7	3.86
SP-29	7.9YR	4.63	3.63	SP-166	8.4YR	5.89	3.59
SP-30	7.6YR	4.31	3.45	SP-167	8.6YR	5.89	3.46
SP-31	7.6YR	4.33	3.69	SP-168	8.8YR	5.97	3.33
SP-32	7.8YR	4.3	3.44	SP-169	8.9YR	5.9	3.44
SP-33	8.0YR	4.54	3.62	SP-170	9.0YR	5.91	3.26
SP-34	7.8YR	4.3	3.6	SP-171	8.9YR	5.48	3.38
SP-35	8.6YR	4.64	3.4	SP-172	9.0YR	5.81	3.35
SP-36	8.4YR	4.47	3.38	SP-173	9.0YR	5.52	3.47
SP-37	8.7YR	4.46	3.24	SP-174	9.1YR	5.44	3.57
SP-38	8.8YR	4.66	3.36	SP-175	9.4YR	5.32	3.46
SP-39	8.3YR	4.73	3.54	SP-176	9.0YR	5.49	3.6
SP-40	7.7YR	4.41	3.62	SP-177	9.0YR	5.4	3.58
SP-41	7.5YR	4.32	3.65	SP-178	8.9YR	5.2	3.52
SP-42	8.1YR	7.97	2.11	SP-179	9.3YR	5.17	3.57
SP-43	8.9YR	4.87	3.54	SP-180	8.7YR	5.52	3.69
SP-44	8.6YR	4.54	3.45	SP-181	9.0YR	5.19	3.54
SP-45	8.3YR	4.5	3.45	SP-182	8.9YR	5.26	3.6
SP-46	6.7YR	4.94	3.35	SP-183	8.8YR	5.37	3.64

(Table 21.2, continued)

Field/ Lab No.	Dry Munsell Hue	Dry Munsell Value	Dry Munsell Chroma	Field/ Lab No.	Dry Munsell Hue	Dry Munsell Value	Dry Munsell Chroma
SP-47	7.0YR	5.16	3.13	SP-184	7.8YR	5.33	3.25
SP-48	6.7YR	5.22	3.14	SP-185	7.4YR	5.02	3.48
SP-49	6.4YR	5.59	3.36	SP-186	7.4YR	5.14	3.35
SP-50	7.0YR	6.18	3.38	SP-187	7.3YR	5.18	3.32
SP-51	6.7YR	6.15	3.48	SP-188	7.1YR	5.08	3.46
SP-52	6.8YR	6.02	3.43	SP-189	7.0YR	5.16	3.38
SP-53	6.7YR	6.04	3.46	SP-190	7.1YR	5.45	3.39
SP-54	6.9YR	5.98	3.63	SP-191	7.0YR	5.29	3.43
SP-55	7.1YR	6.18	3.5	SP-192	6.9YR	5.23	3.57
SP-56	6.9YR	6	3.55	SP-193	7.0YR	5.14	3.58
SP-57	6.9YR	5.95	3.62	SP-194	6.8YR	5.04	3.59
SP-58	7.0YR	6.14	3.49	SP-195	6.7YR	5.11	3.64
SP-59	4.7YR	4.8	3.21	SP-196	7.1YR	5.28	3.54
SP-60	7.7YR	4.81	3.79	SP-197	7.5YR	5.88	3.35
SP-61	7.6YR	4.89	3.53	SP-198	7.6YR	5.65	3.27
SP-62	7.6YR	4.48	3.3	SP-199	7.8YR	5.34	3.18
SP-63	7.6YR	4.54	3.32	SP-200	7.9YR	5.08	3.01
SP-64	7.4YR	5	3.49	SP-201	7.6YR	5.1	3.07
SP-65	7.4YR	5.06	3.36	SP-202	7.4YR	5.11	3.24
SP-66	7.5YR	5.36	3.34	SP-203	7.6YR	5.61	3.24
SP-67	7.7YR	5.35	3.48	SP-204	7.6YR	5.61	3.21
SP-68	7.5YR	5.23	3.58	SP-205	7.4YR	5.44	3.33
SP-69	7.7YR	5.86	3.25	SP-206	7.5YR	6.16	3.03
SP-70	7.5YR	5.69	3.31	SP-207	7.5YR	6.23	3.02
SP-71	7.6YR	5.57	3.29	SP-208	7.2YR	6.04	3.02
SP-72	8.1YR	5.17	3.27	SP-209	7.2YR	5.94	3.04
SP-73	8.1YR	5.89	2.87	SP-210	7.3YR	5.51	3.16
SP-74	8.0YR	5.82	3.1	SP-211	7.0YR	5.78	3.24
SP-75	8.2YR	5.8	3.08	SP-212	7.0YR	5.87	3.31
SP-76	7.7YR	5.32	3.55	SP-213	6.9YR	5.77	3.29
SP-77	7.9YR	5.11	3.49	SP-214	7.0YR	5.76	3.29
SP-78	8.2YR	5.19	3.57	SP-215	6.4YR	5.8	3.47
SP-79	8.2YR	5.33	3.54	SP-216	6.2YR	5.71	3.66
SP-80	8.4YR	5.5	3.58	SP-217	7.2YR	5.98	3.04
SP-81	9.1YR	5.34	3.43	SP-218	6.5YR	5.97	3.69
SP-82	9.4YR	5.24	3.33	SP-219	6.2YR	5.64	3.77
SP-83	9.4YR	5.45	3.44	SP-220	6.8YR	6.26	3.59
SP-84	7.8YR	5.57	3.01	SP-221	6.9YR	6.33	3.38
SP-85	7.4YR	4.92	3.49	SP-222	7.9YR	6.15	3.36
SP-86	8.1YR	4.09	2.82	SP-223	8.0YR	6.4	3.1
SP-87	8.3YR	4.04	2.15	SP-224	7.9YR	6.1	2.97
SP-88	7.3YR	4.88	3.53	SP-225	7.8YR	5.83	3
SP-89	7.4YR	4.69	3.62	SP-226	7.9YR	5.67	3.12
SP-90	7.4YR	4.51	3.32	SP-227	8.2YR	5.72	3.1
SP-91	7.1YR	4.68	3.24	SP-228	8.4YR	5.76	3.2
SP-92	6.9YR	4.73	3.37	SP-229	8.7YR	5.7	3.34
SP-93	6.9YR	4.77	3.42	SP-230	8.6YR	5.68	3.32
SP-94	7.0YR	5.05	3.46	SP-231	8.5YR	5.66	3.37
SP-95	6.9YR	5.23	3.31	SP-232	8.7YR	5.37	3.22
SP-96	7.0YR	5.27	3.32	SP-233	8.6YR	5.41	3.21

(Table 21.2, continued)

Field/ Lab No.	Dry Munsell Hue	Dry Munsell Value	Dry Munsell Chroma	Field/ Lab No.	Dry Munsell Hue	Dry Munsell Value	Dry Munsell Chroma
SP-97	6.9YR	5.02	3.67	SP-234	8.5YR	5.4	3.17
SP-98	6.9YR	5.13	3.45	SP-235	8.4YR	5.77	3.46
SP-99	6.8YR	5.02	3.46	SP-236	8.1YR	5.41	3.22
SP-100	6.7YR	5.04	3.64	SP-237	8.4YR	5.77	3.36
SP-101	6.8YR	5.06	3.59	SP-238	8.4YR	5.83	3.44
SP-102	7.9YR	5.19	3.44	SP-239	8.1YR	5.68	3.4
SP-103	7.8YR	5.03	3.53	SP-240	7.9YR	5.47	3.52
SP-104	7.8YR	5.16	3.03	SP-241	8.0YR	6.01	3.03
SP-105	7.8YR	5.31	3.05	SP-242	7.2YR	5.55	3.28
SP-106	7.6YR	5.24	3.16	SP-243	7.1YR	5.72	3.35
SP-107	7.6YR	5.19	3.29	SP-244	7.0YR	6.07	3.29
SP-108	7.5YR	5.44	3.44	SP-245	6.9YR	6	3.23
SP-109	7.5YR	5.58	3.46	SP-246	6.8YR	5.79	3.23
SP-110	7.5YR	5.75	3.29	SP-247	6.9YR	5.79	3.24
SP-111	7.6YR	5.62	3.15	SP-248	6.8YR	5.69	3.19
SP-112	7.6YR	5.74	3.22	SP-249	6.8YR	5.55	3.24
SP-113	7.6YR	5.91	3.12	SP-250	6.3YR	5.66	3.54
SP-114	7.4YR	5.88	3.29	SP-251	6.2YR	5.33	3.68
SP-115	7.8YR	5	3.98	SP-252	6.5YR	5.72	3.62
SP-116	6.5YR	4.47	4.12	SP-253	6.6YR	5.69	3.56
SP-117	6.4YR	4.64	4.21	SP-254	6.7YR	5.77	3.54
SP-118	7.7YR	5.57	3.81	SP-255	6.4YR	5.22	3.52
SP-119	8.6YR	5.81	3.21	SP-256	7.6YR	5.54	3.72
SP-120	8.9YR	5.79	3.28	SP-257	7.2YR	5.59	3.68
SP-121	9.0YR	5.44	3.22	SP-258	7.8YR	6.09	3.36
SP-122	9.1YR	5.65	3.14	SP-259	7.9YR	6.27	3.08
SP-123	9.2YR	5.87	3.2	SP-260	8.1YR	5.91	2.94
SP-124	9.4YR	5.7	3.24	SP-261	8.1YR	5.96	3.06
SP-125	9.4YR	5.44	3.27	SP-262	8.2YR	5.99	3.01
SP-126	8.0YR	5.29	3.19	SP-263	8.1YR	5.92	3.16
SP-127	8.0YR	5.46	3.27	SP-264	7.8YR	5.51	3.22
SP-128	8.0YR	5.76	3.29	SP-265	7.6YR	5.41	3.2
SP-129	8.0YR	5.65	3.35	SP-266	7.5YR	5.27	3.3
SP-130	8.1YR	5.47	3.13	SP-267	7.4YR	5.26	3.34
SP-131	7.9YR	5.96	3.07	SP-268	7.6YR	5.48	3.28
SP-132	7.8YR	6.07	3.1	SP-269	8.0YR	5.53	3.3
SP-133	7.9YR	5.81	3.09	SP-270	8.1YR	5.29	3.38
SP-134	7.8YR	6.08	3.21	SP-271	7.6YR	5.23	3.54
SP-135	6.9YR	5.78	3.45	SP-272	7.9YR	5.37	3.44
SP-136	6.9YR	5.96	3.32	SP-273	8.4YR	7.72	2.17
SP-137	7.1YR	6.42	3.19	–	–	–	–

Samples listed by Field/Lab number SP-1 through SP-273; data from Pedology Laboratory, University of Kansas.

weight as determined by sieving, hydrometer, and pipette (Folk 1968; Burt 2009; Soil Survey Staff 2010).

In the present study at the Spaceport, five sediment samples were split and sent to the Milwaukee Soil Laboratory and the Pedology Laboratory, University of Kansas. The particle-size analyses were conducted by experienced staff at both laboratories, the Milwaukee lab using dry sieving and hydrometer and the Kansas lab using laser diffraction. We compare the results of the coarse sand, medium sand, fine sand, and very fine sand percentages; the laser diffractometer did not register very coarse sand in four of the five samples, so the very coarse sand fraction was omitted from our statistical analysis of the data (Table 21.3).

A linear regression of the sand grades shows a good correlation between dry sieving and laser diffraction percentage values with an $r^2 = 0.967$ (Fig. 21.3). However, close inspection of the plotted data shows systematic differences between the sieving and laser methods with the laser method registering lower percentage values of high-abundant sand particles and higher percentages of low-abundant sand particles. Particle size does not seem to influence the results in this case; very fine sand and medium sand are in both the high-abundant and low-abundant groups.

More striking are the differences in total sand percentage values (sieving and laser methods in this study utilize essentially the same size limits) (Table 21.3). Laser diffraction consistently measured lower percentage values of sand, ranging from 12.0 to 20.7 percentage values less than measured by sieving. It is unclear why the particle-size values of sand differ so radically in this case.

A number of studies have documented a variety of problems with the results of laser diffraction methods in particle-size analysis: (a) different brands and models of commercial instruments yield dissimilar particle-size results; (b) all laser studies systematically underestimate the amount of clay; (c) clay mineralogy affects volume estimates; (d) volume overestimates may be caused by overestimated particle size or by overestimated number of particles; (e) variability of particle size and shape affects volume estimates; (f) non-uniform particle mineralogy and density affects volume estimates; (g) non-sphericity of particles produces overestimated volume; (h) different sediment types, such as from fluvial, eolian, lacustrine, and marine deposits, yield different levels of numerical bias between laser and pipette particle size information (Di Stefano et al. 2010; Loizeau et al. 1994; Eshel et al. 2003; Campbell 2003; Buurman et al. 2000; Beuselinck et al. 1998; Konert and Vandenberghe 1997).

The bottom line regarding the different results of laser diffraction versus sieving is that, in any study, either one or the other should be applied throughout the investigation so that the particle sizes are comparable in a relative sense. Even though laser diffraction has technological problems that result in biased analytical results, it also has a few advantages over sieving, such as utilizing small samples and providing rapid analysis with a continuous estimated volume curve. However, a century of particle-size information in the literature is based on sieving-hydrometer-pipette analysis, and at this time the standard for soil characterization is a combination of sieving-hydrometer-pipette particle-size analysis by weight (Burt 2009). Eventually, if laser diffraction becomes the standard method and replaces sieving and hydrometer use, a standardized technology within the wide range of laser diffraction methodologies will have to be chosen, and a series of equations will have to be developed that can convert weight-based particle-size values from different types of sedimentary deposits to volumetric laser diffraction values. In the meantime, the classic traditional methodology of sieving-hydrometer-pipette will continue to be the standard methodology, as well as the methodology of choice, until laser diffraction techniques and instrumentation become more mature.

OSL Sample Collection, Analysis, and Preparation

Sample collection

Fifty-four samples for OSL dating were collected from sediments at the Spaceport. OSL-dating sampling points were selected after a field study of the stratigraphy of the deposits that were exposed in trenches and at archaeological sites. Once the stratigraphy of the deposits was determined, OSL-dating samples were chosen that would provide age information on the stratigraphic units as well as on the associated archaeology.

OSL dating samples were collected by hammering aluminum sampling tubes into the sediment

Table 21.3. Particle-size data, by dry sieving and laser diffractometry.

Field/ Lab SP-No./ Stratigraphic Unit	Analytical Method	Very Coarse Sand (%)	Coarse Sand (%)	Medium Sand (%)	Fine Sand (%)	Very Fine Sand (%)	Sand (%)	Silt (%)	Clay (%)
Sieve Grade Limits		1000–2000 µm	500–1000 µm	250–500 µm	125–250 µm	62.5–125 µm	62.5–2000 µm	3.9–62.5 µm	<3.9 µm
Laser Diffraction Grade Limits		1000–2000 µm	500–1000 µm	250–500 µm	125–250 µm	63–125 µm	63–2000 µm	(?) µm	<2
7	Sieves	0.4	1.1	15.2	46.4	36.9	41.0	26.0	33.0
Qpc2	Laser diff.	0.0	6.9	17.4	40.0	35.8	23.0	67.9	9.1
8	Sieves	0.8	1.4	15.5	45.7	36.6	31.0	34.0	35.0
Qpc2	Laser diff.	0.0	2.4	18.0	43.6	35.9	19.0	69.9	11.2
9	Sieves	0.5	0.8	18.3	44.0	36.4	28.0	39.0	33.0
Qpc2	Laser diff.	0.0	2.9	17.7	41.8	37.6	16.0	71.5	12.5
32	Sieves	0.9	6.2	37.1	45.2	10.6	78.0	8.0	14.0
Qay	Laser diff.	0.0	11.6	33.3	40.7	14.3	57.3	35.9	6.8
33	Sieves	1.5	8.9	42.4	39.3	7.9	80.0	8.0	12.0
Qay	Laser diff.	0.8	19.4	37.2	34.4	8.2	61.8	31.8	6.3

Note : Dry sieving by Milwaukee Soil Laboratory; laser diffractometry by Pedology Laboratory, Department of Geography, University of Kansas.

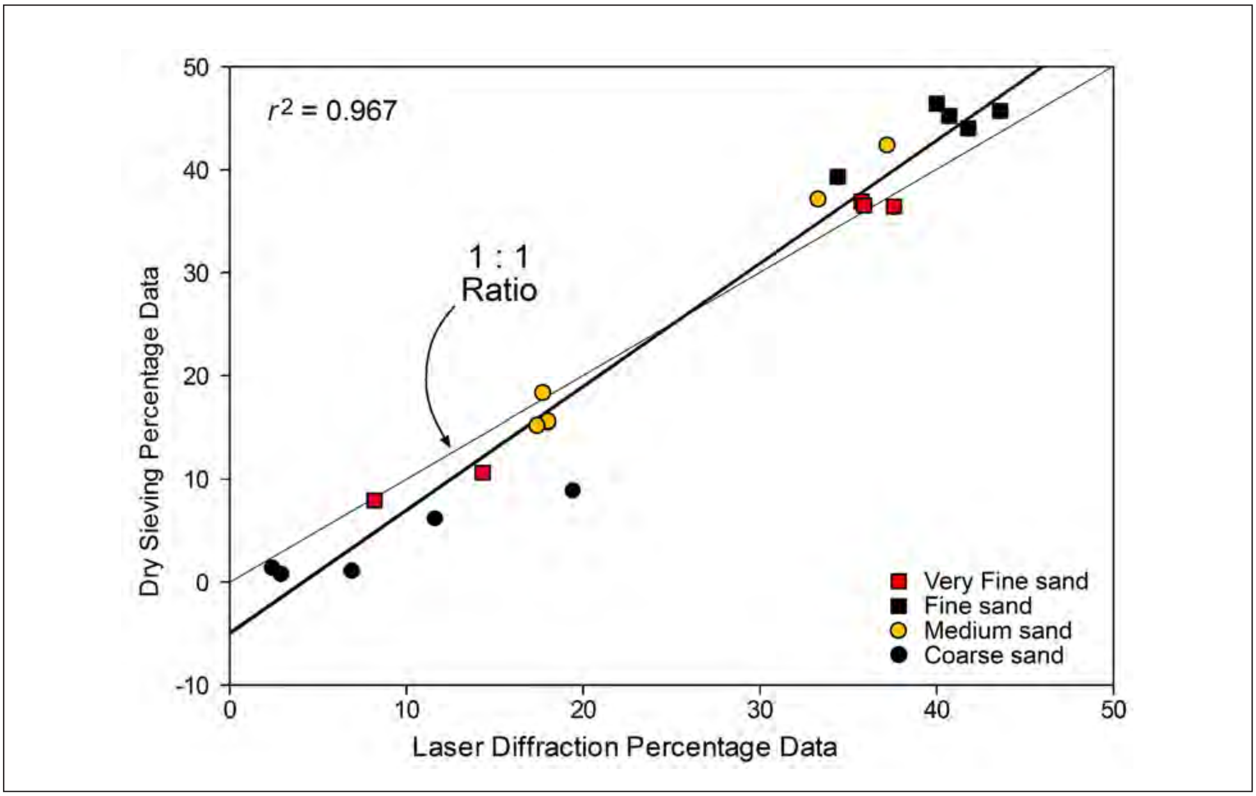

Figure 21.3. Linear regression comparison of sand percentage data of five samples as determined by dry sieving and laser diffraction. High-percentage particles (> 30%) are under-estimated by laser diffraction and low-percentage particle amounts (< 20%) are over-estimated by laser diffraction (data in Table 21.3); regression by SigmaPlot 12.

using a short-handled 3-pound sledge. The tubes are 7 inches long and 2 inches outside diameter (about 1 3/4-inch inside diameter). A sampling tube was hammered into the sediment until the end of the tube was flush with the cleaned outcrop and completely hard-packed with sediment. With each OSL dating sample, about 400 grams of sediment were collected for chemical analysis; about 100 grams of sediment were also collected in sealable plastic containers for soil moisture analysis. Prior to sample collection, the outcrop was cleaned off and cut back about 10 cm. Additional details and recommendations concerning OSL sample collection in the field are presented and discussed by Hall and Rittenour (2010).

In a few cases, the sediment is very hard and it was not possible to hammer an aluminum sampling tube into the sediment. In these cases, a block of sediment was excavated from the outcrop. The sediment blocks were generally about 25 by 25 cm and about 20 cm thick. The sediment blocks were wrapped in aluminum foil and then wrapped in duct tape; the foil reduces further exposure of the sediment to light, and the tape holds the block together so that it doesn't crumble during transport and shipping. In the OSL laboratory, the tape and foil were peeled away and the outer layer of sediment was removed from the block. Sand grains for OSL dating were extracted from the interior of the block that had not been exposed to light.

Sample preparation/dose-rate determination

Sample preparation was carried out under amber-light conditions. Samples were wet sieved to extract the 90–150 μm fraction (very fine to fine sand), and then treated with HCl to remove carbonates, hydrogen peroxide to remove organics, and CBD solution to remove iron coatings. Quartz and feldspar grains were extracted by flotation using a 2.7 g/cc sodium polytungstate solution, then treated for 75 minutes in 48 percent HF, followed by 30 minutes in 47 percent HCl. The sample was then resieved and the < 90 μm fraction discarded to remove residual feldspar grains. The etched quartz grains were mounted on the innermost 2 mm or 5 mm of 1 cm aluminum disks using Silkospray.

Chemical analyses were carried out using a high-resolution gamma spectrometer. Dose-rates were calculated using the method of Aitken (1998) and Adamiec and Aitken (1998). The cosmic contribution to the dose-rate was determined using the techniques of Prescott and Hutton (1994).

Optical measurements

Optically stimulated luminescence analyses were carried out on a Riso Automated OSL Dating System Models TL/OSL-DA-15B/C and TL/OSL-DA-20, equipped with blue and infrared diodes, using the Single Aliquot Regenerative Dose (SAR) technique (Murray and Wintle 2000). Preheat and cutheat temperatures were based upon preheat plateau tests between 180° and 280° C. Dose-recovery and thermal transfer tests were conducted (Murray and Wintle 2003). Growth curves were examined to determine whether the samples were below saturation ($D/D_o < 2$; Wintle and Murray 2006). Optical ages are based upon a minimum of 50 aliquots (Rodnight 2008). Individual aliquots were monitored for insufficient count-rate, poor quality fits (i.e., large error in the equivalent dose, D_e), poor recycling ratio, strong-medium versus fast component (Durcan et al. 2009), and detectable feldspar. Aliquots deemed unacceptable based upon these criteria were discarded from the dataset prior to averaging. Averaging was carried out using the Central Age Model (Galbraith et al. 1999) unless the D_e distribution (asymmetric distribution; skew $> 2\sigma_c$, decision table of Bailey and Arnold 2006), indicated that the Minimum Age Model (Galbraith et al. 1999) was more appropriate. The OSL ages are reported with a 1σ error (Table 21.4).

Radiocarbon Dating

Radiocarbon samples were collected from two A-horizon soils that occur in eolian sand deposits. In each case, the soils are associated with OSL-dated stratigraphy and archaeology. The radiocarbon samples were about 200 grams of bulk sediment from a 5 cm thick layer from the center of the thin A-horizon soils. The samples were sent to Beta Analytic, Inc., Miami, Florida, where they were pretreated with hot HCl to remove carbonate. The organic fraction was radiocarbon-dated by accelerator mass spectrometry (AMS). The radiocarbon ages were corrected for isotopic fractionation using $\delta^{13}C$ values. The $\delta^{13}C$ values were determined by isotope ratio mass spectrometry (IRMS) using a Thermo DeltaPlus, measurements good to 0.2‰ and calculated relative to the PDB-1 standard. The

Table 21.4. OSL ages and laboratory data.

UNL No.	Field No.	Burial Depth (m)	H_2O Content (%)	K_20 (%)	U (ppm)	Th (ppm)	Cosmic (Gy)	Dose Rate (Gy/ka)	D_e (Gy) b	No. Aliquot	Age (ka) c
3159	12	0.78	3.6	1.05 ± .03	1.48 ± .09	5.68 ± .24	0.24	1.80 ± .04	4.77 ± 0.53	51	2.65 ± 0.32
[d] MAM									0.59 ± 0.06	51	0.33 ± 0.04
3160	13	0.19	2.4	1.23 ± .04	1.77 ± .10	6.59 ± .32	0.27	2.12 ± .08	3.29 ± 0.45	52	1.55 ± 0.22
[d] MAM									0.53 ± 0.11	52	0.25 ± 0.05
3161	14	1.22	3.6	1.71 ± .05	2.48 ± .12	8.15 ± .35	0.23	2.70 ± .09	116.6 ± 3.5	50	43.2 ± 2.30
3162	15	0.26	2.1	1.33 ± .04	1.84 ± .10	6.64 ± .26	0.27	2.22 ± .08	0.90 ± 0.01	52	0.41 ± 0.02
[d] MAM									0.32 ± 0.10	52	0.15 ± 0.05
3163	17	0.39	3	1.95 ± .05	2.39 ± .12	9.39 ± .40	0.26	3.01 ± .10	25.62 ± 0.70	51	8.51 ± 0.45
3164	18	1.72	1.6	1.32 ± .04	2.19 ± .11	6.83 ± .32	0.22	2.28 ± .08	112.5 ± 3.4	50	49.3 ± 2.70
3165	19	0.25	5	1.51 ± .05	2.19 ± .12	7.51 ± .35	0.26	2.43 ± .09	23.44 ± 1.49	54	9.65 ± 0.75
3166	20	0.18	1.6	1.47 ± .04	2.16 ± .11	7.38 ± .31	0.27	2.48 ± .09	1.08 ± 0.15	56	0.44 ± 0.07
[d] MAM									0.36 ± 0.09	56	0.15 ± 0.04
3167	21	1.16	2.8	1.31 ± .04	2.06 ± .10	7.23 ± .33	0.23	2.25 ± .08	111.2 ± 3.5	51	49.5 ± 2.70
3168	22	0.81	1.1	0.19 ± .03	0.99 ± .09	1.72 ± .18	0.23	0.74 ± .04	46.93 ± 3.75	30	63.7 ± 6.60[e]
3211	27	0.22	0.9	1.27 ± .04	1.51 ± .10	5.95 ± .27	0.27	2.08 ± .07	0.51 ± 0.07	51	0.24 ± 0.04
[d] MAM									0.20 ± 0.02	51	0.10 ± 0.01
3212	28	0.12	0.6	1.26 ± .04	1.53 ± .09	7.55 ± .30	0.27	2.20 ± .08	0.35 ± 0.27	58	0.16 ± 0.12
[d] MAM									0.27 ± 0.02	58	0.12 ± 0.01
3213	29	0.46	1.8	1.36 ± .04	1.79 ± .10	6.37 ± .31	0.25	2.22 ± .08	3.05 ± 0.15	51	1.38 ± 0.08
3214	30	0.66	1.9	1.30 ± .04	1.76 ± .10	5.94 ± .26	0.25	2.12 ± .08	5.44 ± 0.09	52	2.57 ± 0.10
3215	31	0.97	2.1	1.18 ± .04	1.69 ± .09	5.54 ± .26	0.24	1.96 ± .07	9.51 ± 0.18	55	4.85 ± 0.20
3216	32	1.2	2.3	1.43 ± .04	1.65 ± .10	6.02 ± .26	0.23	2.18 ± .08	11.32 ± 0.19	57	5.20 ± 0.21
3217	33	1.43	3.6	1.49 ± .04	1.87 ± .12	7.23 ± .29	0.22	2.32 ± .08	14.14 ± 0.07	50	6.09 ± 0.23

(Table 21.4, continued)

UNL No.	Field No.	Burial Depth (m)	H_2O Content (%)	K_20 (%)	U (ppm)	Th (ppm)	Cosmic (Gy)	Dose Rate (Gy/ka)	D_e (Gy) b	No. Aliquot	Age (ka) c
3218	34	1	2.8	1.64 ± .04	1.79 ± .10	7.13 ± .31	0.23	2.44 ± .09	15.05 ± 0.30	56	6.17 ± 0.26
3219	35	0.79	1.5	1.33 ± .04	1.71 ± .10	6.45 ± .29	0.24	2.17 ± .08	12.65 ± 0.22	50	5.82 ± 0.24
3220	36	0.32	1.4	1.40 ± .04	1.61 ± .09	5.91 ± .29	0.26	2.19 ± .08	10.31 ± 0.24	59	4.72 ± 0.24
3221	37	0.59	2.2	1.26 ± .04	1.88 ± .11	6.11 ± .26	0.25	2.12 ± .08	11.46 ±0 .38	56	5.40 ± 0.27
3222	38	0.21	1.3	1.34 ± .04	1.60 ± .10	5.53 ± .25	0.27	2.12 ± .08	2.03 ± 0.17	52	0.96 ± 0.09
[d] MAM									1.05 ± 0.04	52	0.50 ± 0.03
3223	39	0.94	3.8	1.25 ± .04	1.88 ± .12	5.75 ± .29	0.24	2.00 ± .07	78.83 ± 6.00	58	39.5 ± 3.50
3224	40	0.18	0.7	1.16 ± .04	1.52 ± .09	5.35 ± .24	0.27	1.96 ± .07	0.50 ± 0.65	65	0.26 ± 0.33
								[d] MAM	0.20 ± 0.01	65	0.10 ± 0.01
3225	41	0.44	3.1	1.55 ± .04	1.84 ± .13	6.80 ± .33	0.26	2.38 ± .09	4.06 ± 0.18	50	1.71 ± 0.10
3226	42	1.05	5.3	1.78 ± .05	2.32 ± .14	7.29 ± .36	0.24	2.62 ± .10	23.28 ± 0.59	57	8.89 ± 0.40
3342	43	0.24	2.5	1.26 ± .05	1.57 ± .10	6.10 ± .28	0.27	2.06 ± .09	18.14 ± 0.58	55	8.83 ± 0.44
3343	46	0.45	2.8	1.22 ± .04	2.88 ± .13	7.12 ± .33	0.25	2.39 ± .09	112.5 ± 5.4	50	47.1 ± 2.80
3344	47	0.29	1.9	0.98 ± .03	1.69 ± .09	4.65 ± .24	0.26	1.77 ± .06	82.03 ± 4.04	52	46.3 ± 2.80
3345	48	0.16	1.1	1.32 ± .04	1.80 ± .12	6.28 ± .28	0.27	2.21 ± .08	6.75 ± 0.27	57	3.06 ± 0.17
3346	49	1.2	2	1.50 ± .04	2.01 ± .12	6.76 ± .35	0.23	2.38 ± .09	24.41 ± 0.55	54	10.3 ± 0.40
3347	50	0.48	2.3	1.30 ± .04	1.85 ± .10	6.37 ± .28	0.25	2.17 ± .08	13.06 ± 0.23	52	6.02 ± 0.24
3348	51	0.76	1.7	1.44 ± .04	1.95 ± .11	6.58 ± .27	0.24	2.33 ± .08	15.21 ± 0.06	61	6.52 ± 0.23
3349	52	1.63	2.3	1.51 ± .05	2.35 ± .14	7.65 ± .36	0.22	2.51 ± .09	109.8 ± 2.8	54	43.7 ± 2.00
3350	53	0.24	2.1	1.48 ± .04	2.05 ± .11	8.16 ± .37	0.27	2.50 ± .09	55.51 ± 2.90	52	23.4 ± 1.40
3351	54	0.71	1.3	1.18 ± .04	2.03 ± .11	6.71 ± .28	0.25	2.15 ± .08	96.94 ± 3.07	51	45.0 ± 2.20
3352	1	1.69	3.3	1.86 ± .04	3.29 ± .14	8.35 ± .36	0.21	3.05 ± .11	148 ± 13	5	48.5 ± 4.50[f]
3353	2	0.94	1.3	1.60 ± .04	2.29 ± .12	6.67 ± .30	0.24	2.58 ± .09	135 ± 6	5	52.3 ± 3.10[f]
3354	3	1.94	2.5	1.59 ± .04	2.37 ± .12	7.56 ± .30	0.21	2.58 ± .09	134 ± 6	5	51.7 ± 3.10[f]

(Table 21.4, continued)

UNL No.	Field No.	Burial Depth (m)	H_2O Content (%)	K_20 (%)	U (ppm)	Th (ppm)	Cosmic (Gy)	Dose Rate (Gy/ka)	D_e (Gy) b	No. Aliquot	Age (ka) c
3355	4	0.12	4	1.66 ± .05	1.76 ± .11	7.08 ± .36	0.27	2.45 ± .09	27.59 ± 1.83	59	11.3 ± 0.90
3356	6	1.69	1.5	1.95 ± .04	2.35 ± .12	5.19 ± .26	0.21	2.75 ± .09	173 ± 12	5	62.8 ± 4.90[f]
3357	7	2.45	1.3	1.78 ± .04	2.45 ± .12	5.07 ± .26	0.19	2.61 ± .09	128 ± 10	5	49.2 ± 4.20[f]
3358	10	0.88	3.5	1.61 ± .04	2.11 ± .12	5.32 ± .28	0.24	2.39 ± .08	157 ± 15	5	65.6 ± 6.80[f]
3359	11	1.57	0.5	1.65 ± .04	1.61 ± .09	3.80 ± .22	0.22	2.25 ± .08	149 ± 16	5	66.2 ± 7.40[f]
3360	16	0.14	1.8	1.35 ± .04	1.93 ± .11	6.44 ± .29	0.27	2.26 ± .08	16.65 ± 0.79	56	7.37 ± 0.44
3361	24	0.82	2.4	1.32 ± .04	1.70 ± .10	5.71 ± .26	0.24	2.09 ± .07	10.71 ± 0.23	62	5.12 ± 0.22
3362	25	0.25	1.5	1.38 ± .04	1.54 ± .10	6.05 ± .29	0.26	2.17 ± .08	0.66 ± 0.07	58	0.30 ± 0.04
[d] MAM									0.32 ± 0.04	58	0.15 ± 0.02
3363	26	0.33	1.8	1.28 ± .04	1.56 ± .09	5.98 ± .25	0.26	2.08 ± .07	1.84 ± 0.11	55	0.89 ± 0.06
[d] MAM									1.13 ± 0.03	55	0.54 ± 0.02
3364	44	0.15	1.1	1.09 ± .04	1.71 ± .11	5.89 ± .27	0.27	1.97 ± .07	11.97 ± 0.28	54	6.06 ± 0.27
3365	45	0.09	0.6	1.15 ± .04	1.69 ± .10	5.64 ± .27	0.27	2.02 ± .07	10.10 ± 0.35	62	5.00 ± 0.25
3450	5	1.19	5	1.52 ± .04	2.94 ± .14	6.15 ± .29	0.23	2.51 ± .09	140 ± 6	15	55.7 ± 3.10[f]
3451	8	0.36	1.5	1.43 ± .05	1.96 ± .12	6.79 ± .34	0.26	2.35 ± .09	131.2 ± 5.0	29	51.6 ± 2.90[f]
3452	9	0.48	2.7	1.60 ± .05	2.80 ± .16	8.25 ± .34	0.25	2.75 ± .10	41.02 ± 2.18	58	14.9 ± 1.00
3453	23	0.9	0.5	0.11 ± .02	0.96 ± .09	1.46 ± .16	0.24	0.66 ± .04	114.3 ± 5.7	35	173.1 ± 12.9

Note: UNL 3159-3168, 3352-3363, and 3450-3453 were collected in the field in 2010; UNL 3211-3226, 3342-3351, and 3364-3365 were collected in the field in 2011; sample collection by S. A. Hall.

[a] In-situ moisture

[b] Error on D_e is 1 standard error.

[c] Error on age includes random and systematic errors calculated in quadrature; Ages with 1 σ error.

[d] Minimum Age Model (Galbraith et al. 1999)

[e] Minimum age; 42 aliquots discarded because D_e >2D_o (Wintle and Murray 2006)

[f] Ages should be regarded as minimum values; D_e values calculated from the minimum of the observed De and the calculated value of 2Do.

AMS radiocarbon ages are calibrated to calendar years AD using the InCal09 calibration dataset (Stuiver and Reimer 1993; Reimer et al. 2009). The radiocarbon ages are reported with a 1σ error and calibrated with a 2σ error (Table 21.5).

Stratigraphy

The late Quaternary stratigraphy of the project was determined largely by the study of deposits exposed in 18 backhoe trenches and in archaeological testing. Natural exposures of the surficial geology in the area are uncommon to non-existent. A sequence of 12 stratigraphic units are recognized and defined in this study. The units are informal and are for use only in this report although future investigations inside and outside of our study area may find some of them applicable. Our 12 units are discussed in the context of the stratigraphic units described and mapped by Seager (2005). However, the symbols we use for our 12 units in this report are deliberately distinct from those in Seager. Some of the deposits that we define as units are thin, discontinuous, and have limited geographic extent; units such as these are inappropriate for geologic mapping. Some of our units are subdivisions of broader categories of deposits recognized and mapped by Seager; our units that are subdivisions of Seager's units are also inappropriate for geologic mapping. Since our units are based on trench exposures, some units that are well exposed in the near subsurface are unrepresented at the surface. Our stratigraphic units are presented below, oldest first. OSL and radiocarbon ages are presented with 1σ error. An outline summary of the stratigraphic units, backhoe trenches, associated archaeological sites, and OSL and AMS ages is presented in Table 21.6 and Figure 21.4.

Qcc, Camp Rice Formation, Calcrete, and La Mesa Surface

The oldest unit observed in trench exposures is calcrete with a stage III–IV carbonate morphology at the top of the Camp Rice Formation. The localities with *Qcc* are BHTs 8, 10, and 11 that occur on a low hill in the northwestern corner of the Prisor Hill quadrangle (Fig. 21.2). The hill is mapped as Camp Rice Formation (*Qcp*) by Seager (2005). A locality marked as a gravel pit on the east side of Jornada Draw in north-central sec. 3 is actually a caliche pit with a stage IV calcrete and mapped as Camp Rice Formation by Seager.

The Camp Rice Formation was named for sequences of fluvial deposits in the axis of the Rio Grande valley and representing the Ancestral Rio Grande. A map of the Ancestral Rio Grande deposits in southern New Mexico is illustrated in Mack and Seager (1990), Seager and Mack (2003), and Seager (2005). The Ancestral Rio Grande occupied the present-day Rio Grande valley from Truth or Consequences southward, following the west flank of the Caballo Mountains to Hatch where the ancestral river turned eastward into the southern part of the Jornada. From there, the ancestral river flowed southward again to the Mesilla basin, paralleling the present-day Rio Grande valley. Axial fluvial gravel was deposited south of the Point of

Table 21.5. AMS radiocarbon dates from A-horizon soils.

Lab No.	Field No.	Material Dated	Measured Age	$\delta^{13}C$ (‰)	Corrected Age (^{14}C Years BP)	Calibrated Age (Calendar Year AD)[a]
Test Pit (TP)-3, LA 111429						
Beta-317549	Hall-1	Bulk sediment	350 ± 30	-18.4	460 ± 30	AD 1413–1467
BHT-18, LA 111435						
Beta-317550	Hall-2	Bulk sediment	340 ± 30	-15.7	490 ± 30	AD 1405–1449

[a] 2-σ, from InCal09 calibration data set (Stuiver and Reimer, 1993; Reimer et al., 2009)

Table 21.6. Summary of dated stratigraphy for this study.

Unit Symbols	Unit Description	Occurrences of Dated Units	Associated Archeological Sites	OSL Ages (ka)	Lab No. UNL-
Qec	Coppice dunes	BHT 7	LA 155963	0.15 ± 0.04	3166
		W of BHT 9	LA 155963	0.15 ± 0.05	3162
Qe	Young eolian sand	BHT 14	LA 111429	0.10 ± 0.01	3224
		BHT 18	LA 111435	0.10 ± 0.01	3211
		BHT 18	LA 111435	0.12 ± 0.01	3212
		TP 3	LA 111429	0.15 ± 0.02	3362
Qay	Young alluvium	BHT 9	LA 155963	0.25 ± 0.05	3160
		BHT 9	LA 155963	0.33 ± 0.04	3159
Qah	A horizon soil	TP 3	LA 111429	460 ± 30*	Beta-317549
		BHT 18	LA 111435	490 ± 30*	Beta-317550
		BHT 16	LA 111429	0.50 ± 0.03	3222
		TP 3	LA 111429	0.54 ± 0.02	3363
Qes	Eolian sand sheet	BHT 18	LA 111435	1.38 ± 0.08	3213
		BHT 14	LA 111429	1.71 ± 0.10	3225
		BHT 18	LA 111435	2.57 ± 0.10	3214
		BHT 13	LA 111429	3.06 ± 0.17	3345
		BHT 17	LA 111422	4.72 ± 0.24	3220
		BHT 18	LA 111435	4.85 ± 0.20	3215
		TP 3	LA 111429	5.12 ± 0.22	3361
		BHT 18	LA 111435	5.20 ± 0.21	3216
		BHT 16	LA 111429	5.40 ± 0.27	3221
		BHT 17	LA 111422	5.82 ± 0.24	3219
		BHT 13	LA 111429	6.02 ± 0.24	3347
		BHT 18	LA 111435	6.09 ± 0.23	3217
		BHT 17	LA 111422	6.17 ± 0.26	3218
		BHT 13	LA 111429	6.52 ± 0.23	3348
		BHT 14	LA 111429	8.89 ± 0.40	3226
		BHT 13	LA 111429	10.3 ± 0.40	3346
Qcs	Cover sediment	PaleoIn.	LA 111429	5.00 ± 0.25	3365
		PaleoIn.	LA 111429	6.06 ± 0.27	3364
		Vertical	LA 111429	7.37 ± 0.44	3360
		PaleoIn.	LA 111429	8.83 ± 0.44	3342
		BHT 7	LA 155963	9.65 ± 0.75	3165
		BHT 3	LA 111420	11.3 ± 0.9	3355
		BHT 4	LA 112374	14.9 ± 1.0	3452
Qaj	Jornada Draw alluvium	BHT 15	LA 111429	46.3 ± 2.8	3344
		BHT 15	LA 111429	47.1 ± 2.8	3343
Qpc2	Piedmont alluvium from Caballo Mountains	BHT 9	LA 155963	8.51 ± 0.45	3163
		BHT 12	LA 155964	23.4 ± 1.4	3350
		BHT 9	LA 155963	43.2 ± 2.3	3161
		BHT 12	LA 155964	45.0 ± 2.2	3351
		BHT 7	LA 155963	49.3 ± 2.7	3164
		BHT 7	LA 155963	49.5 ± 2.7	3167

(Table 21.6, continued)

Unit Symbols	Unit Description	Occurrences of Dated Units	Associated Archeological Sites	OSL Ages (ka)	Lab No. UNL-
Qpc1	Piedmont alluvium from Caballo Mountains	–	–	(Not dated)	–
Qps2	Piedmont alluvium from San Andres Mountains	BHT 16	LA 111429	39.5 ± 3.5	3223
		BHT 13	LA 111429	43.7 ± 2.0	3349
		BHT 4	LA 112374	>49.2 ± 4.2	3357
		BHT 3	LA 111420	>51.6 ± 2.0	3451
		BHT 2	LA 111421	>52.3 ± 3.1	3353
		BHT 4	LA 112374	>55.7 ± 3.1	3450
		BHT 4	LA 112374	>62.8 ± 4.9	3356
		BHT 4	LA 112374	>65.6 ± 6.8	3358
Qps1	Piedmont alluvium from San Andres Mountains	BHT 1	LA 111432	>48.5 ± 4.5	3352
		BHT 3	LA 111420	>51.7 ± 3.1	3354
		BHT 5	LA 112370	>66.2 ± 7.4	3359
Qcc	Camp Rice Formation with stage IV calcrete	BHT 8	LA 155963	>63.7 ± 6.6	3168
		BHT 10	LA 155963	173.1 ± 12.9	3453

* AMS radiocarbon ages from Beta Analytic, ^{14}C years

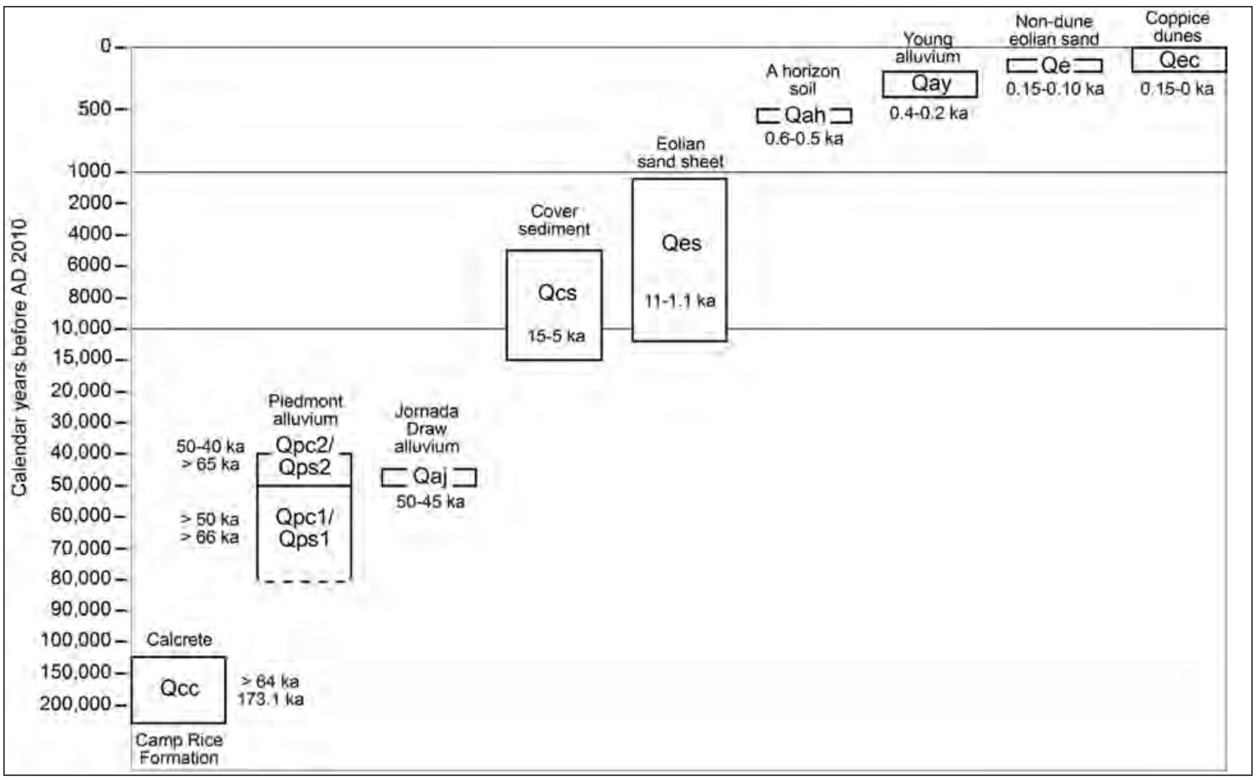

Figure 21.4. Summary of the 12 stratigraphic units recognized and discussed in this chapter; most of the geochronology is provided by OSL dating (see Table 21.6).

Rocks in the Jornada, about 10 to 15 miles south of our study area.

In our Jornada study area, older piedmont alluvial gravel from the Caballo and San Andres mountains grades to the axial/fluvial gravel and is considered by Seager (2005) to be a local equivalent of the Camp Rice. The top of the Camp Rice Formation is characterized by a stage IV petrocalcic paleosol and has been named the La Mesa surface elsewhere (Seager 2005). The *Qcc* unit of this study is the calcrete paleosol of the La Mesa surface at the top of the Camp Rice. Younger piedmont-slope alluvium and eolian sand overlie and bury the La Mesa surface in the Jornada. The weathered surface of the calcrete paleosol, where the Camp Rice is mapped on the Prisor Hill quadrangle, is overlain by thin eolian-colluvial silt and sand that is called the cover sediment (*Qcs*) in this report and discussed later.

It should be noted that the fluvial gravel of the Camp Rice Formation in the axis of the Rio Grande valley contains well-rounded pebbles of granite, quartzite, chert, and obsidian from distant upstream sources. These and other rock types in the Camp Rice gravel have been utilized as lithic resources and collected by prehistoric inhabitants for millennia. The Camp Rice Formation in our study area in the Jornada, however, does not incorporate these rock types but instead contains limestone, andesite, and ash-flow tuffs derived from the nearby Caballo and San Andres mountains (Seager 2005).

The upper 1.5m of the *Qcc* calcrete is exposed in BHT 8, 10, and 11; the base of the petrocalcic horizon and the underlying Camp Rice are not exposed in the trenches or elsewhere in the project area. The calcrete is pinkish white (7.5YR 8/2) and occurs in hard, but not dense, masses. It has 80 percent carbonate; the carbonate content of the calcrete at the caliche pit is 87 percent. The upper part of the weathered calcic horizon incorporates a single thin discontinuous laminar structure; three thin discontinuous laminar bands are present in the upper 16 cm at BHT 11. In most of these exposures, the upper part of the calcic horizon is strongly weathered and isolated blocks and caliche pebbles occur in the overlying cover sediment. Large burrows are also exposed in the calcrete. The burrow fill is loose, unconsolidated powdery-granular-pebbly caliche. The burrows are 30 cm across and extend to 1 m depth. The uppermost Camp Rice Formation in which the calcrete is formed consists of sandy silt to coarse sand. Below 50 to 90 cm depth, the sediment contains gravel with pebbles of gray limestone and red sandstone. The pebbles generally have a 2 mm thick carbonate coat.

OSL ages from *Qcc*. Two OSL ages were obtained on sand grains from blocks of the calcrete; Camp Rice sediments below the calcrete were not exposed. One OSL age from BHT 8 is >63,700 years (UNL-3168), and an OSL age from BHT 10 is 173,100 ± 12,900 years (UNL-3453). The ages are from 43 cm and 46 cm below the top of the exposed calcrete, respectively. The 63.7 ka (thousand years ago) age is a minimum age. The 173.1 ka age is considered finite, although it too may be a minimum age. With UNL-3453, a large amount of data was discarded because of saturation, but less than the 50 percent cutoff, although even that cutoff can produce age under-estimation (Duller 2012). However, in this case, the main uncertainty is in using the current chemistry without adjusting the dose rate for chemical changes associated with the development of the calcic paleosol. The addition of calcite will dilute the potassium (K), uranium (U), and thorium (Th), thus lower the calculated dose rate and increase the apparent age. The uncertainty and possible OSL minimum ages from the *Qcc* are consistent with the age of the Camp Rice Formation determined elsewhere as being deposited during the period from about 5 Ma (million years ago) to 0.78 Ma (Seager and Mack 2003; Mack 1997).

Piedmont Alluvium

Piedmont-slope alluvium forms the surficial geology of most of the Jornada except where covered by younger eolian sand deposits and a thin mantle of eolian-colluvial sand. In this study, we describe four units of piedmont-slope alluvium, separate from the Camp Rice Formation. Two piedmont units (*Qpc1* and *Qpc2*) are derived from the Caballo Mountains on the western flank of the Jornada and two units (*Qps1* and *Qps2*) are derived from the San Andres Mountains on the eastern flank of the Jornada. The two sets of units correspond in general to the older piedmont-slope alluvium (*Qpo*) and fine-grained piedmont-slope deposits (*Qpad*), respectively, described and mapped by Seager (2005). Seager's younger piedmont-slope alluvium (*Qpy*) that fills the drainages of some larger tributaries to Jornada Draw was not investigated.

Qps1, Piedmont Alluvium from San Andres Mountains

The *Qps1* piedmont alluvium is derived from the nearby San Andres Mountains. It occurs only in the subsurface, as far as can be determined in our investigation, and is exposed in BHTs 1, 2, 3, 5, and 6. The upper 1 m of the unit is present, the top occurring at about 80 cm depth and the alluvium extending to 220 cm depth at its greatest exposure; the base of *Qps1* was not observed. Where the unit is present, it is buried by the *Qps2* alluvium.

Qps1 is brown to light-brown silty sand to sandy silt. It is generally massive but may have thin sand beds with laminar or cross-bed structures. Isolated pebbles are generally absent although a bed of small pebble gravel occurs near the base of the exposure in BHT 2. The gravel consists of rounded to angular clasts of black limestone, sandstone, siltstone, and volcanic rock. Soils are generally absent in *Qps1*. Even though the amount of carbonate can be as great as 20 to 40 percent, only a few weak carbonate filaments are present in some places. The high percentages of carbonate in some zones may be related instead to high percentages of clay instead of to soil formation. Neither calcic or argillic soil horizons are present in *Qps1*.

OSL age of *Qps1*. Three OSL ages were obtained on sandy beds in the fine-textured alluvium at BHTs 1, 2, and 3. All three ages are minimum ages, the sand grains exceeding the 50 percent threshold for saturation (Duller 2012). The greatest minimum age is > 66,200 ± 7400 years (UNL-3359). The greatest minimum age of the overlying *Qps2* alluvium is > 65,600 ± 6800 years. Neither of these ages is definitive, although a Pleistocene age of greater than 65,000 years is indicated for *Qps1*.

Qps2, Piedmont Alluvium from San Andres Mountains

Qps2 piedmont alluvium is fine-textured sediment derived from the San Andres Mountains and overlies the *Qps1* piedmont alluvium. The basal contact between the two units is sharply defined; the base of *Qps2* is a thin bed of alluvial gravel and sand in three sections. The unit is exposed in nine trenches (BHTs 1, 2, 3, 4, 5, 6, 13, 16, 17). In two cases the unit is covered by 25–80 cm of sandy silt (*Qcs*) and in three places the unit is buried by 70–130 cm of the eolian sand sheet (*Qes*). In the remaining four exposures, *Qps2* extends to the surface. The unit is 45 to 115 cm thick where its base is exposed, although in BHT 4 it is greater than 180 cm thick and its base there is not exposed.

Qps2 is light-brown to brown sandy silt; the quartz sand is fine to very fine; very coarse sand is generally absent. The silt content ranges from 50 to 70 percent, and clay averages 9 to 15 percent. Small pebbles are rare to absent. The fine-textured alluvium is massive, very hard, and characterized by numerous small, rounded insect burrow fills 6 to 12 mm diameter. The burrows are formed by cicada-insect nymphs. The borrow fills comprise more than 80 percent of the sediment column in the fine-textured sandy silt. Carbonate has accumulated inside the burrow fills, giving the appearance of soil carbonate nodules. Carbonate averages from 20 to 35 percent and up to 44 percent in the zone of burrows. Carbonate filaments around the burrows are rare and faint. The nodule-like concentration of carbonate in the burrows and the high percentages of carbonate produce the appearance of a calcic soil horizon with stage II carbonate development. Whether the concentration of carbonate is a Bk soil horizon or a result of the presence of the fine-textured sediment with cicada burrows is uncertain. Other soil horizons, such as A, Bt, or Btk, are absent in *Qps2*.

OSL age of *Qps2*. Eight OSL ages were obtained from the piedmont alluvium that directly overlies the *Qps1* alluvium. Two of the ages are finite: 39,500 ± 3500 and 43,700 ± 2000 years. The others are minimum ages and the greatest is > 65,600 ± 6800 years. Thus, the age of the *Qps2* piedmont alluvium is about 40,000 to greater than 65,000 years.

Qpc1, Piedmont Alluvium from Caballo Mountains

Qpc1 alluvium is derived from the Caballo Mountains and is exposed only in the lower half of BHT 9. *Qpc1* and the overlying *Qpc2* occur in the large area mapped as *Qpo*, "older piedmont-slope alluvium" (Seager, 2005) in the northwestern corner of the Prisor Hill quadrangle. The upper 140 cm of *Qpc1* is exposed in BHT 9; the base of the unit is not exposed.

Qpc1 piedmont alluvium is brown to light-brown fine- to very fine-textured quartz sand with 19–28 percent silt and 21–35 percent clay. It also contains granules and small, subrounded pebbles, generally less than 40 mm diameter, scattered throughout the alluvium and not concentrated in beds or lenses; the gravel comprises up to 20 percent of the texture. The pebbles are mostly black limestone and have 2 mm thick carbonate coats; the carbonate coats may have formed on the clasts in an older deposit upslope on the piedmont, the carbonate-coated clasts reworked into *Qpc1*.

The *Qpc1* alluvium is characterized by a moderately developed argillic-calcic paleosol. The upper 50 cm is a Bt-horizon with 35 percent clay and 0.43 percent iron (Fe). The lower 90 cm has up to 25 percent carbonate in a Bk-horizon; the lower part of the Bk is not exposed. Carbonate nodules are absent, and carbonate filaments are weak and uncommon. The carbonate occurs as coats on sand grains, resulting in a zone of weak whitening. Carbonate also forms soft irregular concentrations 3–8 mm in diameter associated with small soil pores and cicada burrow fills. The Bk-horizon has a carbonate morphology of stage I or I+.

OSL age of *Qpc1*. *Qpc1* is not directly dated, although the overlying *Qpc2* is OSL-dated at three localities. The earliest age of the overlying *Qpc2* is 49,500 ± 2700 years and thus is a minimum age for *Qpc1*. The age of *Qpc1* is greater than 50 ka.

Qpc2, Piedmont Alluvium from Caballo Mountains

The *Qpc2* alluvium is derived from the Caballo Mountains and exposed in three trenches (BHT 7, 9, 12) and at archeological sites LA 155968, LA 155969, and LA 156877. It overlies the *Qpc1* alluvium in BHT 9 where it is 130 cm thick; it is 170 cm thick in BHT 7 although the base is not exposed. *Qpc2* is mantled by the cover sediment (*Qcs*) and coppice dunes (*Qec*).

Qpc2 is a pale brown to brown to light-brown to yellowish-brown silty sand to sandy silt. The quartz sand is fine- to very fine-textured and massive without bedding. It has 24 to 64 percent silt and 4 to 35 percent clay. Gravel is rare to absent.

A moderately well-developed soil occurs throughout the *Qps2* sediment column. The upper 60 cm at BHT 9 is a Bt-horizon with 35 percent clay and 0.8 percent iron (Fe). The lower 70 cm is a Bk-horizon with small carbonate nodules 6 to 22 mm diameter; the nodules have a soft outer layer and a hard interior. The maximum amount of carbonate is 24 percent. The Bk has weak stage II carbonate morphology.

OSL age of *Qpc2*. Six OSL ages have been obtained from *Qpc2* alluvium. Four of the ages from three stratigraphic sections range from 43,200 ± 2300 to 49,500 ± 2700 years. Two ages, 23,400 ± 1400 and especially 8510 ± 450 years, seem too young for the level of argillic soil development observed in the alluvium. The two younger sediment samples brought up no problems during laboratory analysis and dating that would indicate the ages are incorrect; indeed, laboratory data show that the ages are sound and reliable. However, we tentatively set aside the younger ages based on soil development in *Qpc2*, that the ages are too young to take into account the amount of time required for pedogenesis. It is possible that the OSL sampling intersected a filled burrow that was not exposed in the trench wall, thereby resulting in ages that are too young. Also, an OSL age from the cover sediment (*Qcs*) overlying *Qpc2* is 9.65 ka, slightly older than the 8.51 ka age from the *Qpc2*. Thus, the age of *Qpc2* is about 40 to 50 ka and correlates with the late stage of deposition of *Qps2* alluvium and the accumulation of the Jornada alluvium (*Qaj*).

Qaj, Jornada Draw Alluvium

The eastern edge of the alluvial valley of Jornada Draw mapped as *Qa* by Seager (2005) was trenched for study (BHT 15). The locality selected for trenching is west of a local exposure of the top of the Camp Rice Formation calcrete (*Qcc*). The calcrete is eroded and missing from the axial drainage of Jornada Draw and locally forms a low-relief bench on the east side of the draw.

The upper 130 cm of the exposed *Qaj* alluvium is composed of alternating beds of sandy silt and gravel capped by a 20 to 40 cm thick bed of brown sandy silt. The silt bed is massive and contains many insect burrow fills; the lower part exhibits some whitening due to the presence of carbonate coats on sand grains. The sand fraction is fine- to very fine-textured with some coarsening upwards. Silt is 45–60 percent, and clay is 5–8 percent. Carbonate content is 9–23 percent with higher amounts with greater depth. A sharp local erosional unconformity separates the silt bed from the underlying silt-gravel beds.

The alternating sandy silt and gravel beds are light brown, and the silt beds are 50–69 percent silt, 16–42 percent sand, and 8–15 percent clay. The sand is fine- to very fine-textured. The silt is massive to laminar, and the lower silt beds have some whitening due to carbonate coats. Carbonate content ranges from 16 to 30 percent. Except for the weak carbonate coats on sand grains that could be attributed to pedogenesis, soils are absent in *Qaj*. The gravel is formed mostly by granule (2–4 mm) and small pebble size (4–16 mm) clasts, and 88–98 percent of the small pebbles are dense caliche (*see* Table 21.15). The fill sediments in the central axis of Jornada Draw were not studied; it is possible that those sediments are much younger than the *Qaj* alluvium along the edge of the draw.

OSL age of *Qaj*. Two OSL ages were obtained from the fluvial sandy silt at the eastern edge of the Jornada Draw alluvial deposits. The ages are 46,300 ± 2800 and 47,100 ± 2800 years and are statistically the same; the age of *Qaj* alluvium is rounded to 45 to 50 ka. Both ages are from the upper 50 cm of the alluvium, and deeper *Qaj* alluvial deposits may be significantly older than these ages. The deposition of silt and gravel beds along Jornada Draw correlates with the late stage of accumulation of fine-textured alluvium (*Qps2*) on the nearby piedmont slope coming out of the San Andres Mountains and with the silty sandy alluvium (*Qpc2*) on the piedmont slope derived from the Caballo Mountains.

Qcs, Cover Sediment

Everywhere across the Jornada, Pleistocene piedmont alluvium is mantled by a thin veneer of silty sand. The sediment is probably a mix of eolian sand and weathered material from the piedmont alluvium. The result is a mix of eolian-colluvial sediment. The cover sediment is exposed at BHT 3, 4, 7, 8, 10, 11, 12, Surface Strip 6, and the "Vertical" sampling localities. The thickness of *Qcs* ranges from 12 to 75 cm, averaging 36 cm in thickness. In some areas, *Qcs* is buried by young non-dune eolian sand (*Qe*) and coppice-dune sand (*Qec*).

Overall at the various localities across the study area, *Qcs* is brown silty sand with about 8 percent clay and 10 to 20 percent carbonate. Sand ranges widely from 13 to 70 percent; sand texture is generally fine to very fine. A Bw-horizon soil occurs in the upper 15 cm of the cover sediment in exposures in the northwest corner of the quadrangle. Visible carbonate in the form of filaments or grain coats is absent. Where it overlies the calcrete of the Camp Rice Formation, *Qcs* incorporates large blocks as well as granule and pebble-sized clasts of calcrete. The presence of calcrete clasts throughout *Qcs* is probably a result of coarse-scale bioturbation of the *Qcc* calcrete by large carnivores such as badgers (discussed later).

OSL age of *Qcs*. Seven OSL ages define the age of the thin cover sediment and range from 14,900 ± 1000 to 5000 ± 250 years. It is significantly younger than the Pleistocene piedmont alluvium and Camp Rice Formation calcrete that it overlies and mantles. However, it overlaps in time with the early stage of deposition of the *Qes* eolian sand sheet, although the *Qcs* and *Qes* do not appear to be related. Overall, the *Qcs* formed during the period 15 to 5 ka. The presence of the Bw-horizon soil at the top of the *Qcs* indicates that the unit has not been forming during the late Holocene, at least in some areas.

Qes, Eolian Sand Sheet

The eolian sand sheet occurs over a broad area in the Jornada valley; in our study area it mantles the distal piedmont slopes of the San Andres Mountains. The sand sheet is shown on the Prisor Hill geologic map as "*Qs*, eolian sand, coppice dunes" and "*Qsp*, eolian sand, parabolic dunes" (Seager 2005). Our study trenches document the presence of the sand sheet about one mile farther west from that shown on the geologic map, although the sand sheet at our study localities may be thin and less continuous than where it is mapped east of Jornada Draw. The Qes sand sheet is exposed in six of our study localities: BHTs 13, 14, 16, 17, 18, and Test Pit 3. At two localities, BHTs 13 and 17, *Qes* overlies *Qps2* piedmont alluvium where the sand sheet thickness is 118 and 95 cm, respectively. The top of the sand sheet may be eroded in places where it is not buried and protected by younger eolian sand such as *Qe* and *Qec* coppice dunes.

The *Qes* sand sheet is brown silty sand with fine to medium and fine to very fine texture. The stratigraphic columns generally show a coarsening upwards in texture, and in a couple of cases the basal 20 cm is sandy silt. Silt averages 31 to 44 percent and clay 5 to 8 percent; carbonate is 6 to 10 percent. The sand is massive everywhere with many small insect burrow fills up to 16 mm diameter as well as large burrow fills 20 to 25 mm diameter. Pebbles are not present in *Qes*. Visible carbonate such as filaments and soft concentrations in borrow and pore fills are absent. In a few cases where carbonate content increases with greater depth, a faint whitening of the sand is present, a result of carbonate coats on sand grains. The whitening qualifies as a weak Bk soil horizon.

OSL age of *Qes*. Sixteen OSL ages from six stratigraphic sections define the period of accumulation of the *Qes* sand sheet from 10,300 ± 400 to 1380 ± 80 years, almost the entire Holocene. Given the error of the OSL ages, the age of the *Qes* eolian sand sheet is rounded to 11 to 1.1 ka. The sedimentation rate of the *Qes* sand sheet is discussed later.

Qah, A-horizon Soil

Only one A-horizon was observed in the sequences of surficial deposits in the Jornada. It occurs at the top of the *Qes* eolian sand sheet where the soil is preserved because it has been buried by more recent *Qe* eolian sand and *Qec* coppice dunes. The A-horizon soil is present at BHTs 14, 16, 18, and Test Pit 3. At BHT 13, the A-horizon soil occurs at the present-day surface and but is very weak and mostly eroded.

The A-horizon soil is generally 10 to 20 cm thick. It is a brown fine- to very fine- and fine- to medium-textured quartz sand. It has 26 to 37 percent silt and 3 to 8 percent clay, reflecting the *Qes* eolian sand sheet substrate. B-horizon development is absent; *Qah* has 1 to 4 percent carbonate and 0.1 to 0.2 percent organic carbon. Its color is generally somewhat darker than the non-soil sand below and above. The top of the soil is probably missing in all cases due to erosion.

OSL and AMS radiocarbon age of *Qah*. Two OSL and two AMS ages have been obtained from three localities of the *Qah* A-horizon soil. The OSL ages on sand from the soil are 540 ± 20 and 500 ± 30 years. The AMS ages on organic carbon from the soil are 490 ± 30 and 460 ± 30 ^{14}C years BP. The calibrated-calendar year of the four ages is AD 1470, 1511, 1427, and 1440, respectively. The AD 1470 OSL age and the AD 1440 AMS age are from the same level of the A-horizon soil at the Test Pit 3 locality. The ages overlap at 2σ error and are statistically the same. Overall, the A-horizon soil formed during a period of at least 100 years from about AD 1400 to 1500, or about 500 to 600 calendar years ago. Because of erosion that has removed the soil at many locations, the top of the A-horizon soil that is preserved may be missing, even at localities where it is buried by younger sediments. Thus, the ages we have obtained may not reflect a late stage of soil formation and, accordingly, the ages may be unrepresentatively early. Regardless, *Qah* is buried by *Qe* and *Qec* eolian sand, the earliest of which is 150 years, marking the latest time that the A-horizon soil could have formed in the Jornada.

Qay, Young Alluvium

Deep gullies are not common across the low-relief piedmont surface in the Jornada. A gully and its alluvial deposits were intersected by BHT 9. The gully channel is eroded into Qpc1 piedmont alluvium, and the sides of the gully are cut into the Qpc2 piedmont alluvium. The channel fill alluvium is about 80 cm in thickness and was sampled for OSL dating and textural analysis. Based on the OSL age of the channel fill, the gully eroded to its deepest level by about 400 years ago (about AD 1600).

The gully alluvium is fine- to medium-textured sand with small amounts of silt (6–10 percent) and clay (9–15 percent); gravel is uncommon although the percentages were not determined. Coarse sand is 3 to 9 percent. The *Qay* alluvium is thin bedded; the individual beds are irregular and discontinuous. Carbonate is 4 to 7 percent; organic carbon occurs in very small amounts in the young alluvium. Soil horizons are absent in *Qay*.

OSL age of *Qay*. Two OSL ages from the young alluvium are 330 ± 40 and 250 ± 50 years or AD 1680 and 1760 with a large 1σ error. These ages document the filling of a small gully on the Jornada and may be related to early historic, pre-American land use in the area.

Qe, Young Eolian Sand

The young eolian sand unit is documented at five stratigraphic sections (BHTs 14, 16, 17, 18, Test Pit 3). In each case, it overlies the *Qes* eolian sand sheet and the *Qah* A-horizon soil, unless the soil has been removed by erosion. *Qe* is thin, ranging from 10 to 30 cm in thickness.

The young eolian sand is brown fine- to medium-textured sand. Its silt content averages 19 to 23 percent, and clay is 3 to 5 percent. *Qe* exhibits an absence of soil horizons; carbonate content is 1 to 3 percent and organic carbon is less than 0.2 percent. The young eolian sand is massive to weakly laminar. *Qe* has a sand texture that is similar to that of the underlying *Qes*, although *Qe* has significantly lower percentages of silt and clay than *Qes*.

OSL age of *Qe*. Four OSL ages were obtained from the young eolian sand at three stratigraphic sections at BHT 14, BHT 18, and Test Pit 3. The four ages range from 150 ± 20 to 100 ± 10 years, or AD 1860 to 1911. The deposition of the wind-transported sand occurred largely during the late nineteenth century.

Qec, Coppice Dune Sand

Mesquite coppice dunes are common in areas with Holocene eolian sand deposits. Elsewhere on the piedmont slope where eolian sand is absent, coppice dunes are generally absent as well. The coppice dunes in the study area are small, generally less than 1 m in height and no more than 3 m across at the base. North and east of the study area, coppice dunes reach nearly 2m height and more than 6 m across. Seager (2005) mapped parabolic dunes in the sand sheet on the piedmont surface on the east side of the Jornada; parabolic dunes do not occur in our study area.

The sand that makes up the coppice dunes is brown fine- to very fine-textured quartz sand. Silt ranges from 7 to 38 percent, and clay ranges from 7 to 6 percent. Carbonate content ranges from 1 to 4 percent, and organic carbon ranges from 0.4 to 0.8 percent. The *Qec* sand is generally laminar, the beds parallel to the relief of the low dune. In many cases, however, bioturbation by rodent burrowing has destroyed the original bedding structures. Based on the similar texture of the coppice dune sand and the eolian sand sheet (*Qes*), the dune sand may be derived from deflation of the sand sheet.

OSL age of *Qec*. Two OSL ages were obtained from near the base of two coppice dunes in the project area. The ages are 150 ± 40 and 150 ± 50 years or about AD 1860 with a large 1σ error. All of the other OSL ages from coppice dunes in southern New Mexico are twentieth century. The two dated coppice dunes in the Jornada are the earliest thus far documented in the region. Although dunes in some areas are being eroded today, some dunes in the valley may be slowly growing.

Discussion of Stratigraphy

Piedmont-Slope Alluvium from the San Andres Mountains

The trenches from which we describe *Qps1* and *Qps2* alluvial units are located on the *Qpad* mapping unit. Seager (2005) states: "*Qpad* refers to fine-grained, distal piedmont-slope deposits derived from the San Andres Mountains and located along the eastern margins of Jornada Draw." Seager also notes that *Qpad* is "located on active depositional surfaces subject to sheetfloods and to anastomozing, closely spaced, channelized runoff." The results of our OSL dating indicate that the alluvium that Seager refers to as *Qpad* is late Pleistocene in age, extending from 40 ka to earlier than 65 ka. Even though our cover sediment *Qcs* mantles the piedmont alluvium to a thickness of 70 cm in places, neither it nor the piedmont alluvium seems to be accumulating deposits today. Local runoff and sheet flow are indeed active processes today across the piedmont slope during intense rainstorms. However, the OSL-dated sedimentary record preserved in the trench exposures indicates that deposition of the piedmont alluvium ended about 40 ka.

Our BHTs 1, 2, 3, and 17 localities document the presence of *Qps1* and *Qps2* on the west side of Jornada Draw, about one-half mile west of the modern channel in an area mapped as *Qpo* (Seager 2005). The stratigraphy, lithology, and soils of *Qps1* and *Qps2* are distinct from the *Qpc1* and *Qpc2*, which occur farther north and west closer to the Caballo Mountains. Evidently, the fine-grained piedmont-slope alluvium from the San Andres Mountains extends slightly farther west than shown on the geologic map.

Fluvial Deposition in Jornada Draw and on Piedmont Slope

The Jornada Draw alluvium (*Qaj*) we describe from BHT 15 was deposited during the late stage of piedmont-slope alluvial accumulation about 40 to 50 ka during the mid-Wisconsin glacial stage and marine isotope stage 3 (Richmond and Fullerton 1986). Fluvial deposition in Jornada Draw and on piedmont slopes evidently ended about 40 ka, although the axis of the draw was not investigated and may incorporate younger alluvium. Sediment data indicate that the alluvium from Jornada Draw and the piedmont slope are similarly textured silt and fine to very fine sand. The data in hand indicate that silt-dominated stream flow characterized the Jornada during the middle Wisconsinan, possibly indicating a wetter climate than today. Why stream flow ended about 40 ka is unclear.

Sedimentation Rate of *Qes* Eolian Sand Sheet

Three OSL-dated sequences of *Qes* eolian sand sheet were analyzed for sedimentation rates (Fig. 21.5, Table 21.7). Two of the sequences, BHT 13 and BHT 18, yielded similar accumulation rates, 0.15 and 0.17 mm/year, respectively. The sequence from BHT 17, however, accumulated much more rapidly, 0.46 mm/year. An explanation for the differences in these rates is not apparent. The sedimentation rates from the *Qes* sand sheet are greater than those rates for the Bolson sand sheet in the Tularosa Valley (Hall et al. 2010). However, the *Qes* accumulated more slowly than the upper eolian sand unit of the Mescalero sand sheet (Hall and Goble 2006). Overall in southern New Mexico, sand sheets generally accumulate much more slowly than the sand in dune fields, a relationship noted previously (Hall et al. 2010).

The age of the top of eolian sand deposits, whether buried or at the present-day surface, can be calculated using sedimentation rates. In this study, the top of the *Qes* sand sheet was determined to be 2690, 4040, and 1080 years at BHTs 13, 17, and 18, respectively (Table 21.7). These terminal ages relate to the duration of periods of sand-sheet stability, the formation of soils, and potential prehistoric cultural activity.

Gully Erosion Since AD 1680

The channel of a small ephemeral gully was exposed along with the adjacent Pleistocene piedmont alluvium during trenching at BHT 9. The fluvial sand and small gravel in the channel fill extends to a maximum depth of 85 cm below the 2010 dry surface of the wash. An OSL age from 7 cm above the base of the alluvial fill is 330 ± 40 years, and an OSL age from 19 cm depth below the top of the wash is 250 ± 50 years, or AD 1680 and 1760, respectively.

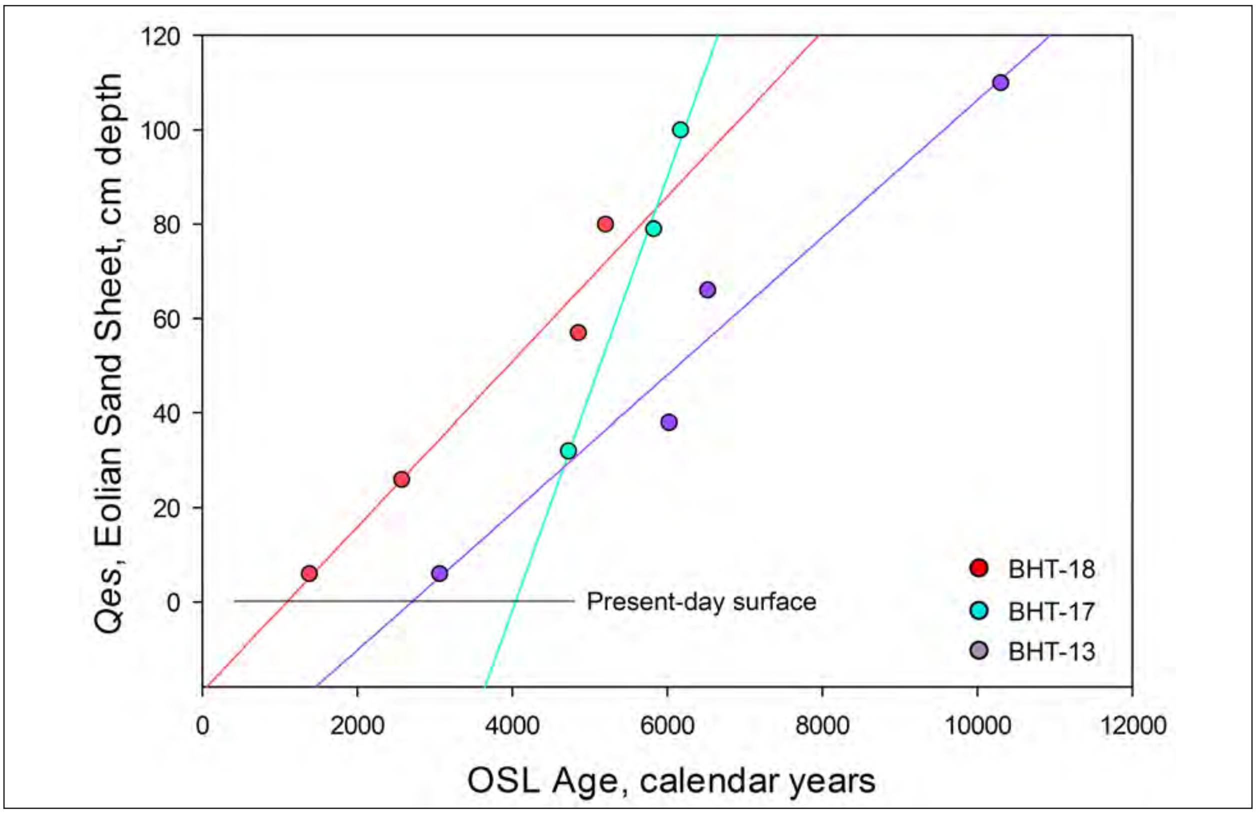

Figure 21.5. Plots of depth versus age for Qes, eolian sand sheet, at three trenches (data in Table 21.7).

Table 21.7. Sedimentation rates of Qes, eolian sand sheet.

BHT	Site	No. of OSL Ages	Linear Regression	r^2	Sedimentation Rate of *Qes* (mm/yr)	Age of Zero Depth of *Qes* (years)
13	LA 111429	4	Depth (cm) = -39.294 + (0.0146 x Age)	0.963	0.15	2,691 680 BC
17	LA 111422	3	Depth (cm) = -185.303 + (0.0459 x Age)	0.995	0.46	4,037 2026 BC
18	LA 111435	4	Depth (cm) = -18.928 + (0.0175 x Age)	0.955	0.17	1,082 AD 929

Note : statistical analysis by SigmaPlot® 12

Consequently, the initial erosion of the gully and the expansion of the small watershed by rill erosion occurred during the past 330 years, since about AD 1680. The erosion cut down through the cover sediment (*Qcs*), the upper piedmont alluvium (*Qpc2*), and into the lower piedmont alluvium (*Qpc1*). Local mesquite coppice dunes (*Qec*) were also removed by erosion, leaving behind the exposed tap root of dead mesquite shrubs (Figs. 21.6, 21.7). The maximum amount of vertical erosion is 2.2 m measured from the 2010 top of the channel fill over a cross-sectional lateral distance of 156 m to the edges of the uneroded surface (Fig. 21.8). The effect of the erosion on local features of archaeological site LA 155963 is pronounced and is discussed later.

Formation/Correlation of the *Qah* A-horizon Soil

A-horizon soils form in a specific set of conditions on semiarid landscapes. Their formation requires a stable surface on which a desert-grass vegetation is established, especially on a preexisting substrate of eolian sand. The grass vegetation must also have sufficient moisture to thrive and increase in abundance. As the grass cover increases in abundance and density, the stability of the surface is enhanced. In the classic text, *The Physics of Blown Sand and Desert Dunes*, the presence of grasses has been regarded as "a special kind of surface roughness" (Bagnold 1954:183). Blades of grass have the effect of raising the height of the level of zero wind velocity, resulting in the collection and storage of sand grains. Bagnold further observed that grass blades have an added effect of bending with wind and grain impact, and that sand grains do not bounce away but instead tend to be deposited. With time, the grass blades grow higher and more sand is captured (Bagnold 1954:184).

Grass vegetation also acts as a dust trap, capturing and retaining atmospheric silt and clay particles that are deposited on the surface. Increased amounts of silt have been observed in A-horizon soils in northern New Mexico (Hall and Periman 2007) and in the southern Rocky Mountains of Colorado (Muhs and Benedict 2006).

The formation of the A-horizon soil includes the incorporation of organic matter from the grasses and other plants in the vegetation as well as silt and sand grains that accumulate around the stems and blades of grasses and other plants. In this regard, the A-horizon is both a sedimentary unit and a soil unit. The sediments that make up the soil may differ significantly from the sediments that make up the substrate. Also, the age of the A-horizon may be hundreds or thousands of years younger than the age of the substrate.

A-horizon soils forming in the above situations are generally thin and short-lived. In the eolian sand sheet on the Jornada, the *Qah* is 10 to 20 cm thick and formed during the period about AD 1400 to 1500. The top of the soil is missing due to erosion, so the period of soil formation may have extended later than AD 1500.

Figure 21.6. LA 155963, remains of mesquite core of now-removed coppice dune; 80 cm of erosion has occurred at this locality, based on the amount of exposure of the tap root; scale is 1 m.

Figure 21.7. LA 155963, early stage of local erosion and exposure of mesquite shrub tap roots.

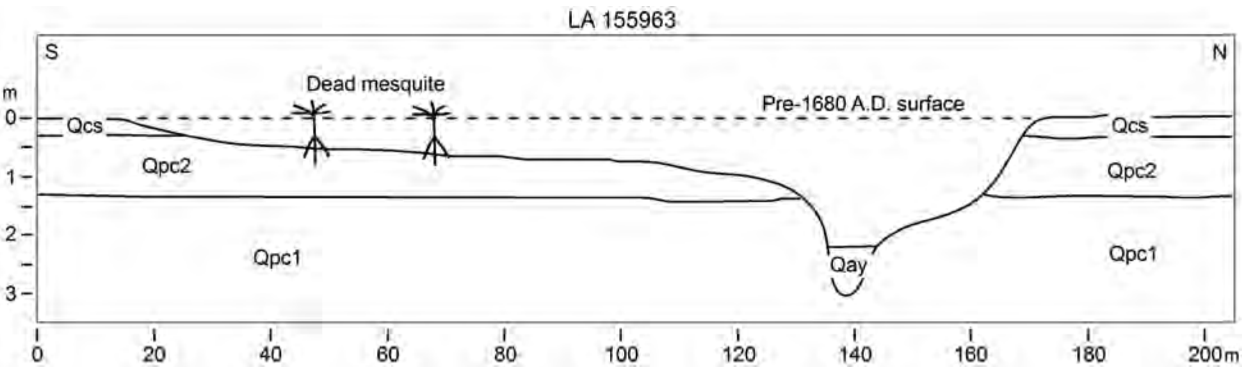

Figure 21.8. LA 155963, sketch of topographic cross-section at the location of BHT 9; based on the OSL age of the Qay alluvium in the channel of the wash, the erosion has occurred largely since AD 1680.

Qah occurs at the top of the *Qes* eolian sand sheet, the sand sheet forming the substrate for the soil. However, the A-horizon soil and the sand sheet are unrelated, except for the silt and sand particles that are wind-deposited on the soil and that may be derived from the sand sheet where it is not protected by vegetation. In our study area, the *Qes* sand sheet may have accumulated as late as 1100 years ago, or about AD 900. Based on the geochronology, the A-horizon soil did not begin to form until about 500 years after the deposition of the sand sheet ended.

Correlation of the *Qah* A-horizon soil. All of the eolian sand sheets in southern New Mexico incorporate an A-horizon soil, and the soils evidently correlate directly with each other, forming at the same time. The McGregor soil is an A-horizon soil on the Bolson sand sheet in the Tularosa Valley at Fort Bliss Military Reservation (Hall et al. 2010). It is radiocarbon-dated from 480 ± 40 to 160 ± 90 ^{14}C years BP. The McGregor occurs at the top of the Q3 eolian sand that has a terminal OSL age of about 5000 years. The Loco Hills soil is an A-horizon soil that occurs on the Mescalero sand sheet in southeastern New Mexico (Hall and Goble 2006). The Loco Hills soil is radiocarbon-dated 370 ± 40 to 150 ± 40 ^{14}C years BP. The Loco Hills soil occurs at the top of the upper eolian sand unit that ended deposition about 5000 years ago, a terminal chronology similar to the Q3 eolian sand on the Bolson sand sheet. In all of these cases, the A-horizon soil formed independent of the age of the substrate. In the Mescalero sand sheet, the Loco Hills soil developed on eolian sand, on colluvium, and on alluvium.

The presence of an A-horizon soil on all of the sand sheets across southern New Mexico—the soil forming during the period about AD 1400 to 1800—is not a coincidence. The soil is related to the establishment and growth of a desert grass vegetation in response to favorable amounts of rainfall. The clearest paleoclimatic event during this time period is the Little Ice Age. The Little Ice Age occurred worldwide and lasted from AD 1300 to 1850 (Grove 2004). These advances in glaciers were a result of lower temperatures and increased snowfall although not all glaciers across the globe expanded at exactly the same time within that period. Glacial moraines from the Little Ice Age have not been documented in the Sangre de Cristo Mountains of northern New Mexico. In the Rocky Mountains of central Colorado, the Arapaho Peak moraines were described and dated by lichenometry to about AD 1600 to 1850 and correlated with the Little Ice Age (Benedict 1973; Davis 1988; Grove 2004).

The actual amount of rainfall in southern New Mexico during the Little Ice Age is not known. However, growth records from columnar stalagmites in caves in the Carlsbad Caverns area indicate slightly greater than present-day precipitation during the period AD 1540 to 1830 (Polyak and Asmerom 2001). The speleothem record of higher rainfall during the Little Ice Age supports the presence and growth of a desert grass vegetation on the sand sheet. The grass vegetation and wetter ground in turn promote the stability of the sand sheet, leading to the formation of the A-horizon soil across the region during the Little Ice Age. Thus, the Loco Hills soil, the McGregor soil, and the *Qah* soil on the Jornada formed during the same slightly wetter period during the Little Ice Age. The OSL and radiocarbon ages from the soils indicate that soil formation occurred during the middle and late stage of the Little Ice Age, about AD 1400 to 1850.

Fossils in Stratigraphic Units

Very few fossil remains were observed during the stratigraphic studies on the Jornada. Fossil vertebrates were not observed in the 18 backhoe trenches. Remains of plants, such as wood or charred wood fragments, are not present. An occasional shell of the land snail *Succinea* sp. was observed in the *Qes* sand sheet.

Sedimentology

Textural and chemical analyses of 273 sediment samples provide a valuable characterization of the late Quaternary sedimentary record on the Jornada. The sedimentology of each stratigraphic section is shown in a series of diagrams throughout this chapter.

All of the sedimentary deposits we examined are fine-textured and dominated by fine sand and silt. In a plot of percentages of fine sand versus silt of the various deposits, several relationships are suggested and discussed below (Fig. 21.9).

(a) The piedmont alluvium (*Qps2*, *Qpc2*) is among the finest-textured of the twelve units in this study, marked by high percentages of silt. The alluvium was deposited during a period beginning before 65 ka and ending about 40 ka. The high percentages of silt may be related to the presence of comparatively large amounts of dust in the atmosphere during the Wisconsin Glaciation and the deposition of dust in the Jornada. On the Bolson sand sheet in the Tularosa Valley, larger amounts of

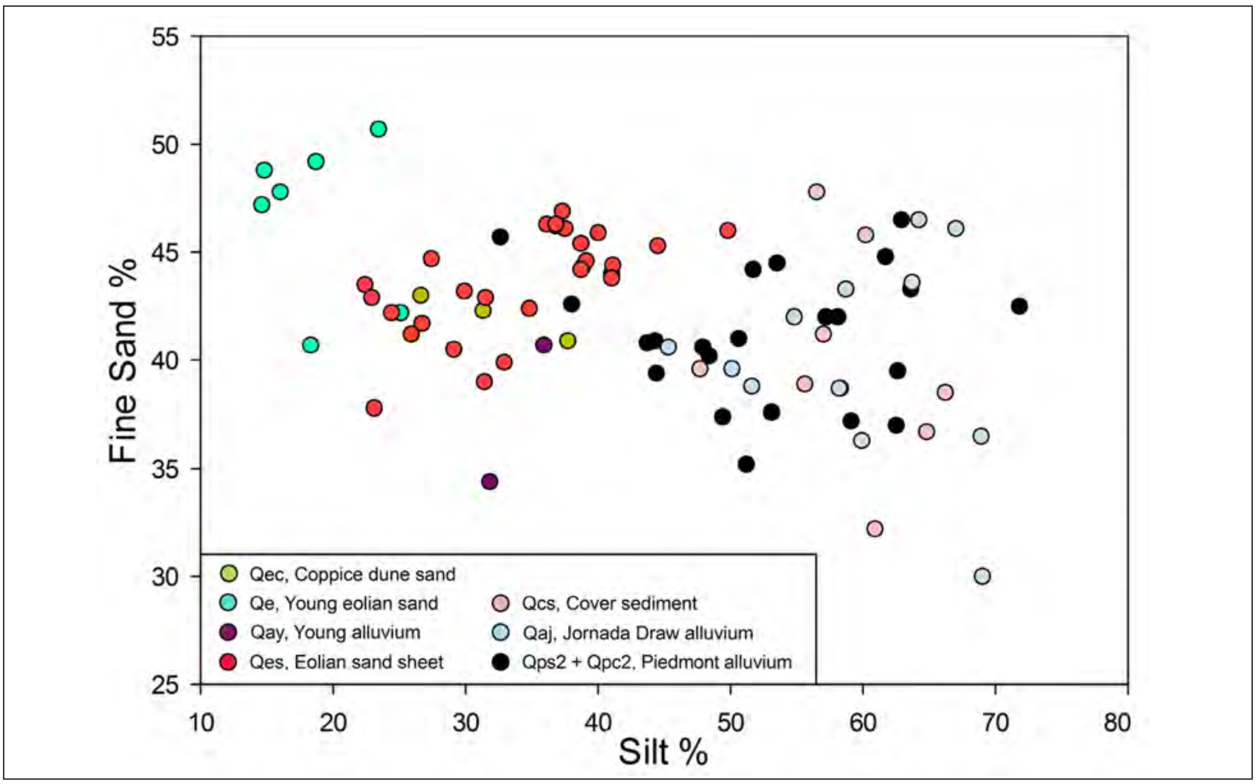

Figure 21.9. Plot of fine-sand percent versus silt percent from the various stratigraphic units. For consistency, all of the textural data shown are from laser diffraction analysis (Pedology Laboratory, University of Kansas).

silt occur in the Q2 eolian sand dated 44 ka and in the Q2 eolian sand during the period 24 to 14.5 ka (Hall et al. 2010). The piedmont alluvium is derived from Paleozoic carbonate rocks in the adjacent San Andres and Caballo mountains that may contain quartz silt in their insoluble residue, thereby contributing to silt in the alluvium.

(b) The late Pleistocene alluvium (*Qaj*) along Jornada Draw is dominated by silt with thin beds of small gravel composed of rounded clasts of caliche. The particle size of the alluvium is similar to that of the piedmont-slope alluvium (*Qps2*, *Qpc2*). The upper *Qaj* alluvium was deposited during the same period of time that the upper piedmont-slope alluvium was deposited about 40 to 50 ka. During this period, more water was evidently moving through the landscape, resulting in fine-textured sediment as well as small gravel deposition. By about 40 ka, sediment accumulation evidently ceased in Jornada Draw and on piedmont slopes.

(c) The cover sediment (*Qcs*) that mantles the piedmont alluvium has a fine texture in which the percentages of fine sand and silt are almost identical to those in the underlying piedmont alluvium. The cover sediment is largely derived from the piedmont alluvium and is a product of colluvial and turbation processes.

(d) The origin of the sand sheet on the east side of the Jornada is less clear, and a source of sand for the extensive sand sheet deposits in the valley is not apparent. The eolian sand sheet (*Qes*) has percentages of fine sand similar to that of piedmont alluvium. The amount of silt, however, is significantly less in the sand sheet compared with the piedmont alluvium.

(e) Young eolian sand (*Qe*) that mantles the sand sheet (*Qes*) does not significantly overlap the fine sand and silt percentages of the sand sheet on which it occurs, indicating that *Qe* may not be reworked from *Qes*. Instead, *Qe* may be fresh eolian sand derived from alluvial sand (*Qay*) in channels of small, local gullies. In areas adjacent to the sand sheet, however, the *Qe* may be derived from *Qes*.

(f) Mesquite coppice dunes (*Qec*) occur throughout the Jornada, and sediments from a few of the dunes were analyzed. Where the coppice dunes occur on the *Qes* sand sheet, the dune sand appears to be derived from the sand sheet. Where the sand sheet is absent, coppice dune sand may be derived from another source, probably alluvial sand (*Qay*) in channels of small, local gullies, similar to the origin of *Qe* discussed above.

Bioturbation of Surficial Deposits

The disturbance and mixing of the upper levels of surficial deposits and soils by organisms can have a significant effect on the sediments. With the passage of time, primary structures become lost and the sediment takes on new properties that differ from the parent sediment. The zone of disturbed, "new" sediment, when it dominates the sediment column, is sometimes referred to as a soil biomantle and has been documented in the Tularosa Valley at Fort Bliss (Johnson 1997; Abbott et al. 2009). Several cases of significant bioturbation were encountered during our investigation in the Jornada valley and are discussed below.

Ants

Ants do not mix sediment such as occurs with burrowing mammals. Instead, they produce small vertical tunnels 5 to 10 mm in diameter down into the sediment, to depths as great as 1 m or more. Small tunnels branch off laterally to small chambers for eggs and food storage. The main geologic work that ants do in southern New Mexico is to bring granules and small pebbles to the surface, forming low mounds of these materials. In a study of ant-transported materials in the Mescalero sand sheet, Whitford et al. (1986) found that ants transport and deposit 84 grams of granules and small pebbles per sq m per year. In the Mescalero sands, the granules and small pebbles were mostly 3 to 6 mm in diameter and nearly all were caliche. A similar observation was made on the Jornada. After deposition around the entrance to the main tunnel, the granules and small pebbles are dispersed by runoff and sheet flow and, with the passage of time, become part of the lag gravel and an early developmental stage of desert pavement.

During our investigation on the Jornada, an active ant colony was inadvertently disturbed at BHT 13. The active nest extended to 60 cm depth in soft *Qes* eolian sand. Egg-bearing chambers are flat and slightly elliptical about 40 mm wide and 5 mm high (Fig. 21.10). Other chambers of the same size appeared to be empty, and other chambers were completely filled with dark gray granular particles, not identified. In the same trench, previously abandoned elliptical chambers occur at 76 to 100 cm depth. Strati-

Figure 21.10. BHT 13, close-up of ant chambers at about 60 cm depth; large chambers about 40 mm wide and 5 mm high; white-colored eggs are present in the far right chamber; this view is about 33 cm wide.

graphic profiles with ant chambers are avoided when sampling for sediment analysis and OSL dating.

Cicadas

Cicada insects, also known as locusts, have about 2500 species and occur worldwide. Most species have life cycles of two to five years, although the life cycles of some species extend to 13 and 17 years. The adult phase generally lasts only four to six weeks. During that time, the adults mate and lay eggs. Upon hatching, the nymphs drop to the ground and enter the soil and the subsurface. The nymphs burrow underground for years. Most of the cicada life cycle occurs as nymphs underground between about 30 to 250 cm depth, feeding on juice from plant roots. They dig small burrows with their strong front legs, backfilling as they go, producing distinctive crescent-ridged burrow fills. They burrow through soft and hard sediment alike, including calcic horizons of stage III calcic paleosols.

Burrow fills have been observed in Pleistocene and Holocene eolian sands in the Mescalero and Bolson sand sheets (Hall and Goble 2006; Hall et al. 2010). In one case, 100 percent of the early Holocene eolian sand had been burrowed by cicada nymphs, with burrows cross-cutting other burrows (Hall and Goble2008). The burrow fills are often difficult to see in a fresh exposure because the sediment that is being burrowed is back-filled with the same sediment; the burrow fill is often the same texture and color as the background sediment. However, when an exposure is left in the open for several days and the exposure is etched by wind-driven sand, the faint outlines of the burrow fills become clear.

In the Jornada, we observed cicada-insect burrow fills in all stratigraphic units. The most pronounced case of cicada burrowing occurs in the upper part of the *Qps2* piedmont alluvium. The silty alluvium between about 30 and 100 cm depth appears to be 100 percent disturbed by burrows. The burrow fills are comparatively small, 6 to 10 mm and 8 to 12 mm in diameter. Some burrows are partly open, although most are filled. For a reason not entirely clear, carbonate is preferentially precipitated in burrow fills, resulting in rounded carbonate structures that mimic carbonate nodules of stage II paleosols. Cicadas also penetrate prehistoric hearth features at archaeological sites, producing a mottled appearance of the sediment.

In one case, we were fortunate to collect a desiccated carcass of an adult cicada, a rare occurrence. This is the first time that we have encountered an adult cicada specimen in the field in southern New Mexico during our many years of fieldwork, and live nymphs have not been observed in numerous trenches. The specimen is one of many adult individuals encountered at 20 cm depth in the blackened sediment of Feature 6 hearth fill at LA 111435. A number of desiccated cicada individuals occurred together in a small tunnel-like cavity in the soft sand fill of the prehistoric hearth. The origin of the assemblage of adult cicada is unknown. Charred yucca and saltbush from the cicada-bearing hearth is AMS-dated 1630 ± 30, 1620 ± 30, and 1600 ± 30 ^{14}C years BP. The specimen is very well preserved with color patterns still visible, although its legs are missing. It has been identified by Tim McNary, USDA, as *Beameria wheeleri* (Fig. 21.11). The presence of a clump of adult cicadas in the sediment fill of the prehistoric hearth is a puzzle. Adult cicadas do not burrow. We are uncertain how they became buried and concentrated together in the sediment. Nevertheless, because of the small size of *B. wheeleri* and the small diameter of the burrow fills in the stratigraphic units, it is reasonable to conclude that the burrowing activity in the Jornada can be attributed to this species. *B. wheeleri* occurs in southern New Mexico as far north as Socorro and west through the Chihuahuan Desert into Arizona (Sanborn et al. 2011) (Fig. 21.12). Another small cicada that occurs in the area and that could be responsible for small burrows is *B. venosa*.

Carnivores

Coyotes (*Canis latrans*) and badgers (*Taxidea taxus*) are the dominant large mammal predators on the Jornada. They feed primarily on burrowing rodents and other small mammals. Coyotes are known to dig into the entrance of rodent burrows in soft sand. Badgers, however, are the primary excavators of rodent dens. Coyotes have been observed waiting patiently to run down escaping rodents while badgers dig rapidly into the dens. Badgers generally require a diet of about 1.7 rodents a day (Findley 1987). Their home burrows may be as deep as 3 m with 10 m of tunnels. During the summer they may dig burrows daily. In the Tularosa Valley, badgers have churned up wide areas of alluvial fans, completely mixing the deposits and artifacts from local archaeological sites and forming a broad biomantle across the fans (Johnson 1997; Johnson and Johnson 2004; Johnson et al. 2005).

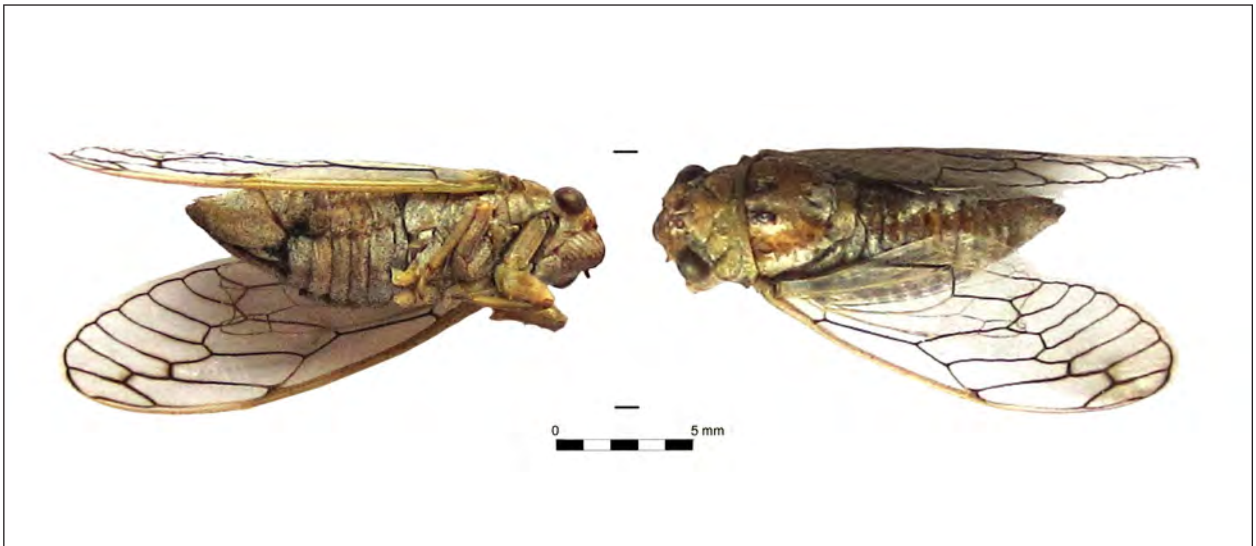

Figure 21.11. LA 111435, Feature 6, cicada adult Beameria wheeleri recovered from a cavity in sediment fill of a prehistoric hearth; the specimen is identified by Tim McNary, USDA, Fort Collins, Colorado, and is reposited in the C. P. Gillette Museum of Arthropod Diversity, Colorado State University, Fort Collins, Colorado. This is the first case where a known species of cicada has been circumstantially tied-in with the massive bioturbation of subsurface deposits in southern New Mexico.

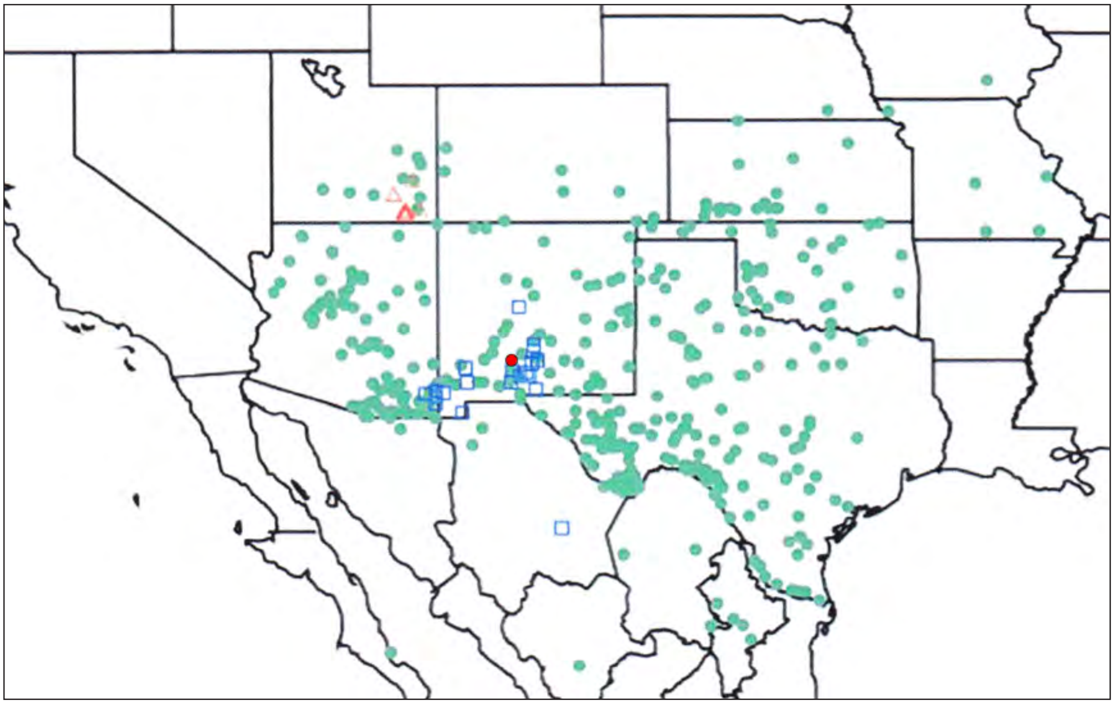

Figure 21.12. Distribution map of the cicada species Beameria wheeleri (blue squares), Beameria venosa (green circles), and Beameria ansercollis (red triangles); the location of the specimen of B. wheeleri from this study is shown by a red dot; map adapted from Sanborn et al. 2011.

Today, badgers occur throughout the state of New Mexico (Findley et al. 1975). They have been around for a long time with fossil records from many caves in southern New Mexico, including Pendejo Cave in the Tularosa Valley where *T. taxus* was recovered from mid-Wisconsin and late Wisconsin strata radiocarbon-dated greater than 37 ka to 19 ka (Harris 1993, 2003). *T. taxus* also occurs in vertebrate faunas from Texas and Kansas that extend to the late Pliocene (Kurtén and Anderson1980).

In the Jornada, badgers have excavated large burrows into the eolian sand sheet (*Qes*), piedmont-slope alluvium (*Qps2*, *Qpc2*), and into the calcrete (*Qcc*) of the Camp Rice Formation. Most of these burrows are old. Only a few modern burrows were observed in the study area. One recent burrow extended through cover sediment (*Qcs*) into the underlying calcrete. Chunks of caliche were brought to the surface, forming a low mound of caliche rubble (Fig. 21.13). Older burrows can be recognized by the eroded condition of mounds of caliche as the fragments become moved by surface processes, forming the appearance of a local quasi-lag gravel. The caliche pebbles in the cover sediment may be derived by this process. Likely badger burrows were encountered at BHTs 4, 6, 8, 10, 11, 12, and 16. In two cases (BHTs 11, 12), badger burrows have a similar geometry (Figs. 21.14, 21.15). A vertical burrow about 30 cm wide extends from near the surface to about 1 m depth, where it turns and runs laterally about 2m or more, where it either ends or turns in another direction. Badger turbation may overlap with the passage of time, such as in the Tularosa Valley, resulting in nearly continuous disturbance across wide areas (Johnson 1997).

Archaeological Geology

The geology of the archaeological sites is based on the study of the stratigraphy of the deposits that are associated with each site. A series of 18 backhoe trenches were excavated in the vicinity of most of the archaeological sites. One or more trenches were placed where cultural features were absent but close enough to the center of prehistoric cultural activity so that cultural deposits and surfaces could be traced to the geological deposits and stratigraphy exposed in each trench. In a few cases where

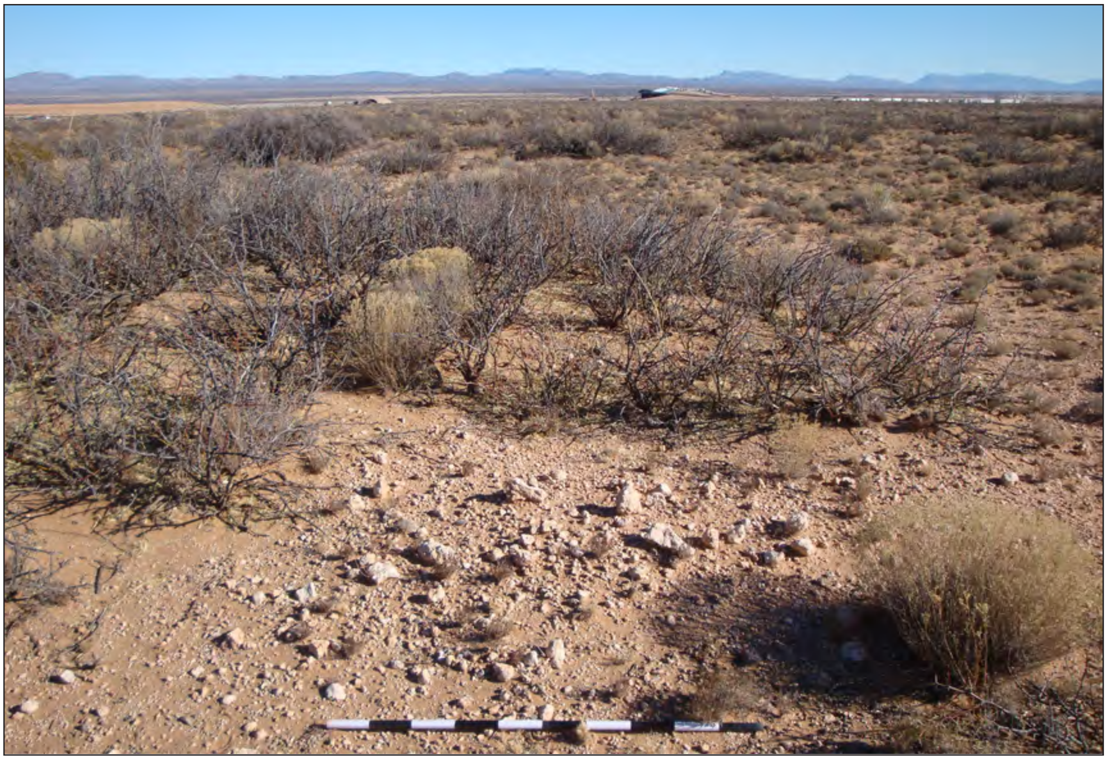

Figure 21.13. LA 155963, mound of caliche from recent burrowing activity by a badger; the caliche is from the underlying calcrete (Qcc) of the upper Camp Rice Formation; Spaceport America facilities in the background; San Andres Mountains in the distance; scale is 1 m.

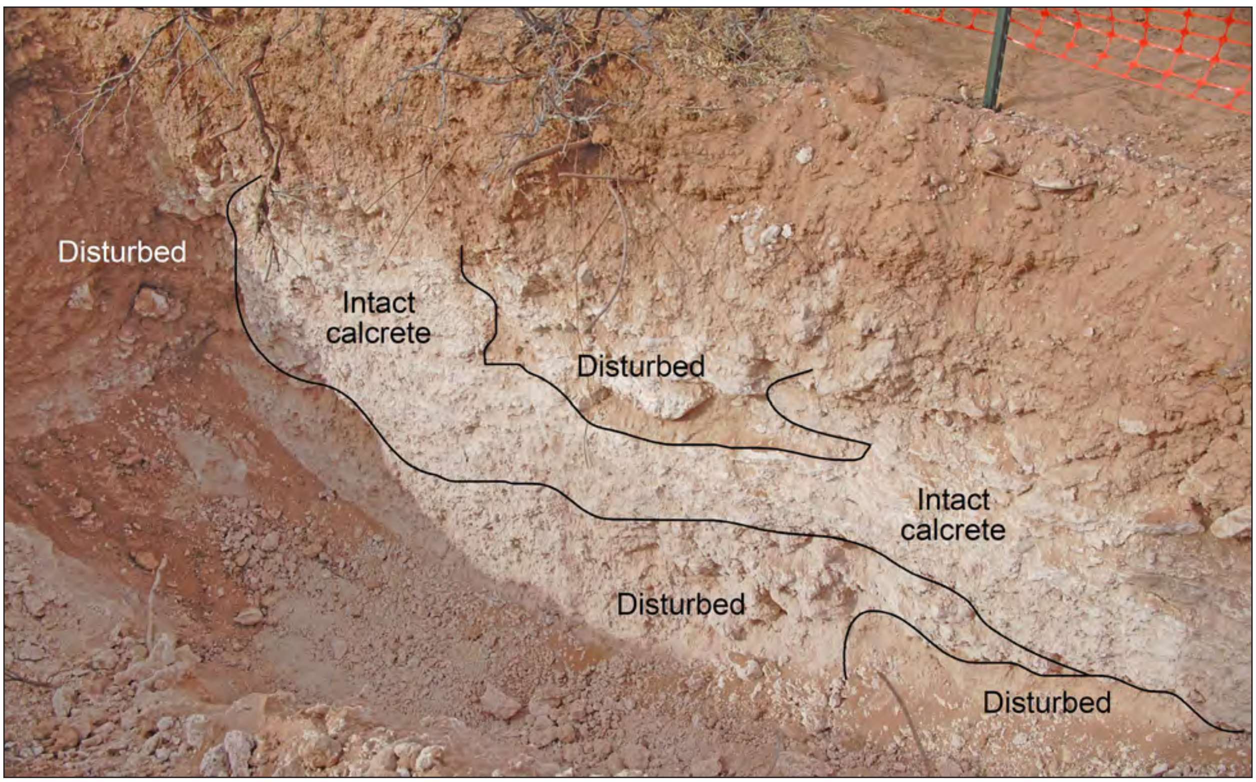

Figure 21.14. LA 155963, BHT 11, extensive burrowing by badgers in Qcc calcrete of the upper Camp Rice Formation.

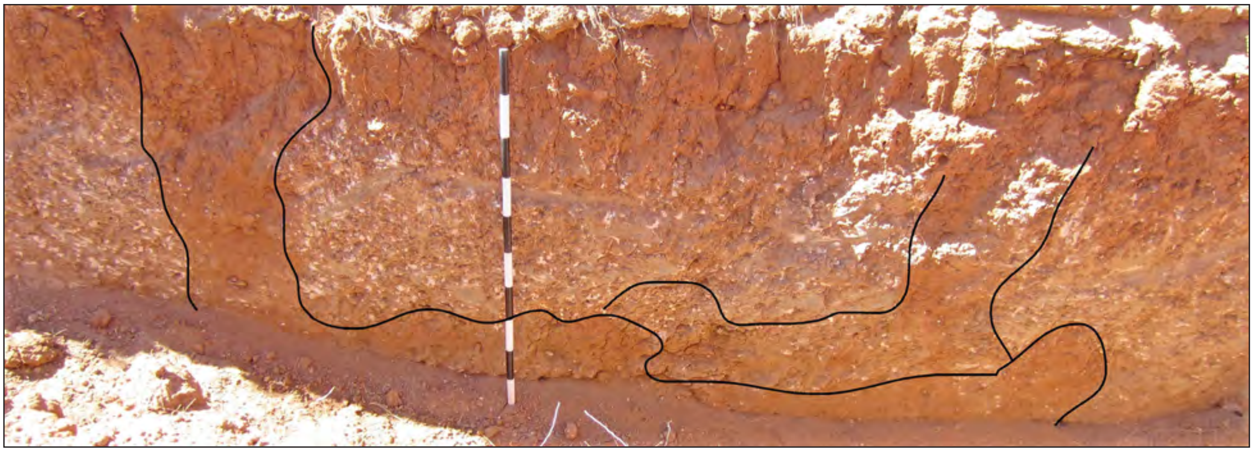

Figure 21.15. LA 155964, BHT 12, badger burrow in Qpc2 piedmont alluvium; geometry of burrow similar to that in BHT 11; scale is 1 m.

the geomorphology of a site was unique, a trench was placed within the boundary of a site. When this was the case, the trench location was selected to avoid archaeological features and artifacts and the excavation of the trench was monitored in the event that cultural evidence was encountered. In most cases, archaeological sites and their deposits are commonly avoided when selecting a location for a trench. Extended prehistoric cultural activity over time produces a site footprint in which soil horizons and stratigraphic layers are disturbed. Thus, if the goal is to determine the position of the archaeological site in the broader context of stratigraphy and geologic time, such as in the case of this project, site footprints are to be avoided.

The mapping units from this study and the geologic map by Seager (2005) are referred to throughout the descriptions of the archaeological geology of the following site. It should be noted again that the stratigraphic-unit symbols introduced by us in this report are specifically different from those used by Seager so as not to imply direct correlations of our units and Seager's units, even though in some cases a correlation is warranted. The archaeological sites are discussed below in numerical order by their Laboratory of Anthropology (LA) catalog number.

LA 111420

This site, as well as sites LA 111421 and LA 111432, occur in the same area on the west side of Jornada Draw. The geology of the area is mapped as older piedmont-slope alluvium (*Qpo*) by Seager (2005). BHT 3 at LA 111420 exposes 2 m of piedmont-slope alluvium overlain by about 25 cm of sandy silt cover sediment (*Qcs*) (Figs. 21.16, 21.17, 21.18; Table 21.8). The cover sediment (*Qcs*) is brown silt with fine quartz sand. The sediment is massive with many insect burrows, some open but most filled with sediment. *Qcs* does not contain visible carbonate or soil horizons. One OSL age from the middle of the thin unit at 12 cm depth is 11,300 ± 900 years. Underlying *Qcs* is *Qps2* and *Qps1* piedmont alluvium. The *Qps2* is light-brown silt with carbonate concentrated in numerous insect burrow fills. The lower part of *Qps2* is gravel with granule to small pebble clasts of subrounded igneous rock and gray-black limestone. OSL ages from the two piedmont alluvial units are >51.6 ka and >51.7 ka.

LA 111421

This site occurs immediately south of LA 111420, and BHT 2 at the site exposes piedmont alluvium (*Qps2*) at the present-day surface. The *Qps2* alluvium is massive light-brown silt (Figs. 21.19, 21.20, 21.21; Table 21.9). *Qps2* is strongly turbated by cicada insects. Soft concentrations of carbonate may indicate the presence of a Bk-horizon. A zone of laminar sand at the base of *Qps2* is OSL-dated >52.3 years. Underlying *Qps2* is *Qps1* alluvium; it is undated at this site.

LA 111422

This site occurs on a low bench of eolian sand on the west side of Jornada Draw. The eolian sand

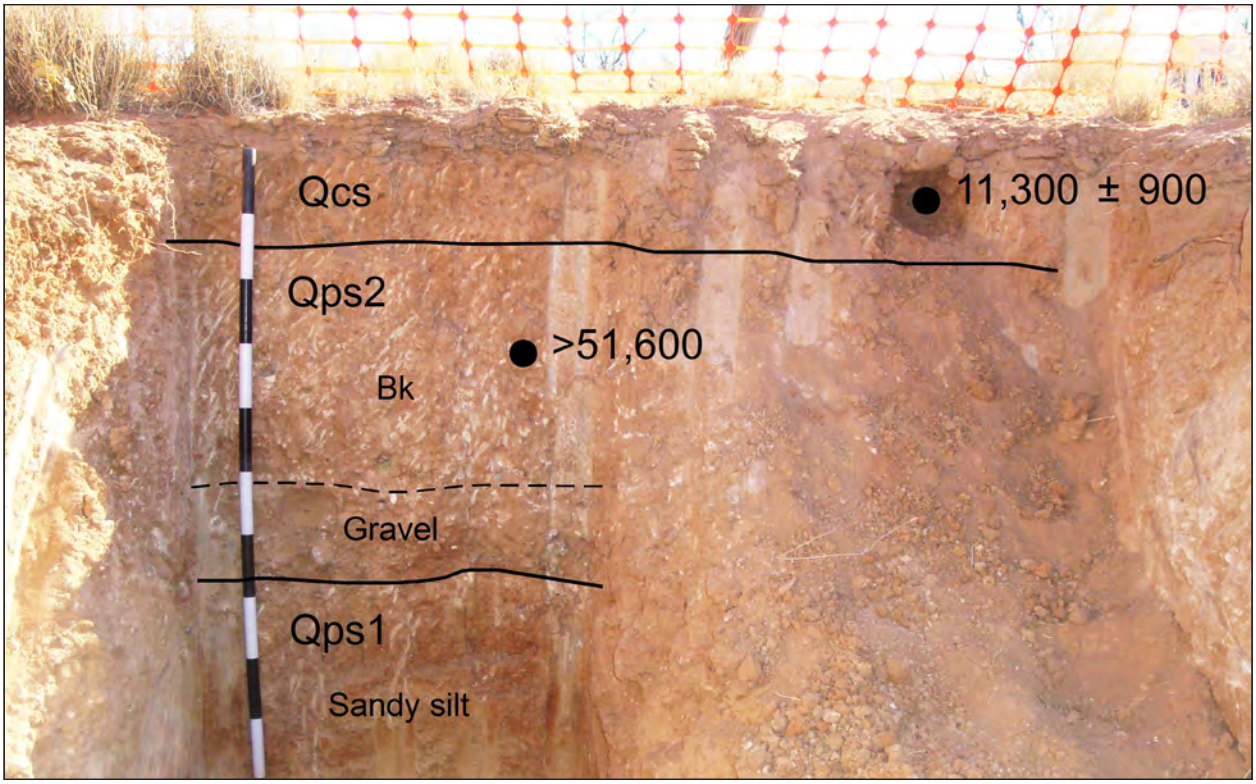

Figure 21.16. LA 111420, BHT 3, piedmont alluvium (Qps1, Qps2) and cover sediment (Qcs); scale is 1 m.

(*Qes*) is 114 cm thick and rests directly on piedmont alluvium (*Qps2*), exposed in BHT 17 (Figs. 21.22, 21.23, 21.24; Table 21.10). The unit is massive brown silty sand; silt ranges from 25 to 40 percent. The sand is soft and incorporates many cicada insect burrow fills. The sand contains 2 to 6 percent carbonate; soil horizons are absent. The sand sheet is OSL-dated 6170 ± 260 to 4720 ± 240 years. The sand sheet rests unconformably on the eroded surface of piedmont alluvium (*Qps2*). The piedmont alluvium is light-brown silt with 16 to 31 percent sand and 12 to 19 percent clay. Numerous insect burrow fills have a concentration of carbonate, forming a Bk-like soil horizon. At BHT 17, the sand sheet is overlain by 20 cm of non-dune eolian sand (*Qe*). The *Qe* sand is undated at this site; nearby at LA 111435, *Qe* is OSL-dated 120 and 100 years or AD 1891 and 1911.

LA 111429

This is a large multi-component site, covering a wide area on the east side of Jornada Draw where the narrow drainage merges with the distal piedmont slope from the San Andres Mountains. The piedmont area is partly mantled by the eolian sand sheet (*Qes*) although the sand sheet is not shown on the geologic map. The subsurface geology of the site is well documented with four trenches and two other localities where surface deposits were exposed during archaeological testing and an additional locality where an OSL age was obtained from a vertical sample from the cover sediment (*Qcs*).

BHT 14. The surficial geology of the eastern edge of the site is exposed in BHT 14 where 1.3 m of eolian sand occurs at the surface. The upper 30 cm is young eolian sand (*Qe*) that is OSL-dated 100 ± 10 or AD 1911. *Qe* is silty fine sand that is massive but weakly laminar in the upper 10 cm. It is a thin mantle of eolian sand locally covering the sand sheet. Beneath the young sand is the massive sand of the eolian sand sheet (*Qes*) that occurs throughout the area. The sand sheet at BHT 14 is brown to light-brown silty sand to sandy silt; the texture tends to coarsen upwards (Figs. 21.25, 21.26, 21.27; Table 21.11). Two OSL ages from *Qes* are 8890 ± 400 and 1710 ± 100 years. A 10 cm thick A-horizon soil (*Qah*) occurs on the top of the sand sheet; the top

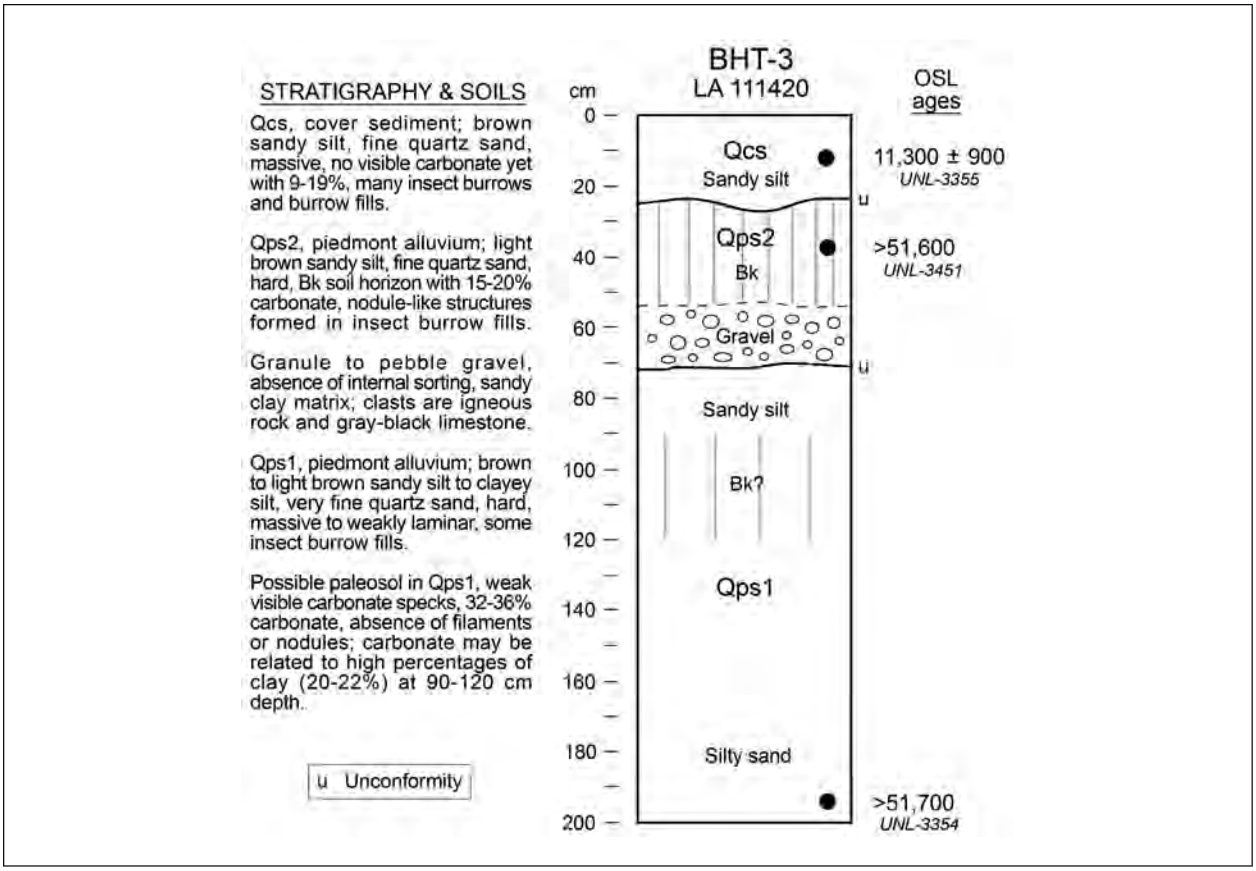

Figure 21.17. LA 111420, BHT 3, stratigraphic column of piedmont alluvium and cover sediment.

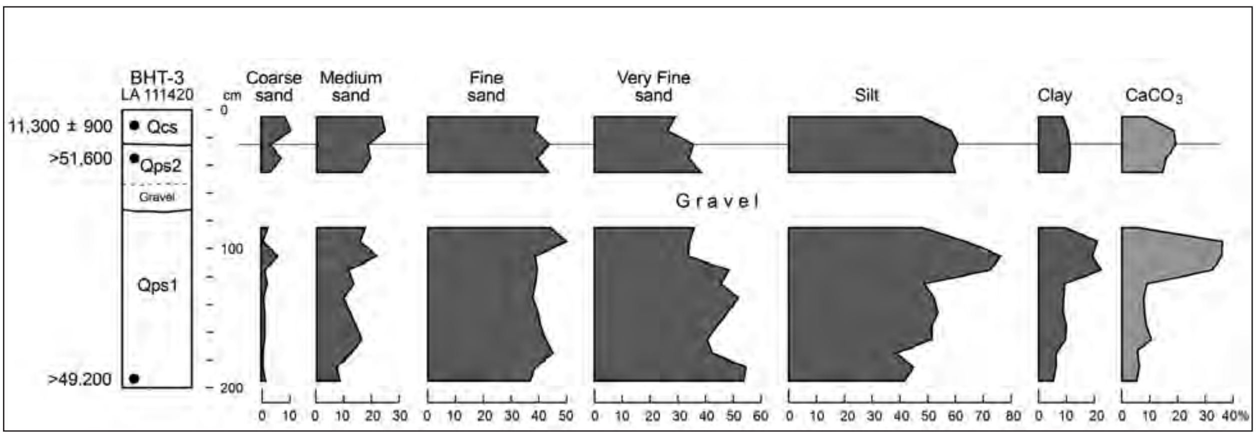

Figure 21.18. LA 111420, BHT 3, sediment diagram of piedmont alluvium and cover sediment (data in Table 21.8).

Table 21.8. LA 111420, BHT 3, sediment data.

Field/ Lab No.	Interval (cm)	Very Coarse Sand (%)	Coarse Sand (%)	Medium Sand (%)	Fine Sand (%)	Very Fine Sand (%)	Sand (%)	Silt (%)	Clay (%)	$CaCO_3$ (%)	Dry Munsell Color[a]
Qcs Cover Sediment											
67	0–10	0.2	8.2	23	39.6	28.9	43.6	47.7	8.8	8.6	7.5YR 5/3
68	20–?	0.2	10.1	24.8	38.7	26.2	31.6	58.3	10.1	18.6	7.5YR 5/4
Qps2 Piedmont Alluvium											
69	20–30	0	3.2	17.8	43.3	35.7	28.2	60.8	11.2	19.4	7.5YR 6/3
70	30–40	0	7	19.7	39.2	34.2	30.6	58.8	10.6	15.9	7.5YR 6/3
71	40–50	0.1	2.7	15.7	43	38.5	29.6	59.9	10.5	14.8	7.5YR 6/3
Qps1 Piedmont Alluvium											
72	80–90	0	2.3	17.4	44.6	35.7	41.9	48.3	9.8	6.9	7.5YR 5/3
73	90–100	0	0.2	15.3	50	34.5	14.3	63.8	21.8	36.2	7.5YR 6/3
74	100–110	0	5.8	21.6	38.6	34	3.4	76.8	19.7	36.1	7.5YR 6/3
75	110–120	0	0.9	11.5	39.7	47.9	5.4	72.3	22.3	32.2	7.5YR 6/3
76	120–130	0	2.1	13.3	38.8	45.7	41.9	48.5	9.6	8.2	7.5YR 5/4
77	130–140	0	0.5	9.5	38	52	38.2	52.4	9.5	7	7.5YR 5/3
78	140–150	0	0.7	11.9	39.5	47.9	37.4	53.5	9.1	7.9	7.5YR 5/4
79	150–160	0	1.5	14.2	40.3	44.1	38.2	51.7	10	8.8	7.5YR 5/4
80	160–170	0	1	16.1	42.6	40.3	38.4	51.7	9.9	10.4	7.5YR 6/4
81	170–180	0	0.2	12.5	45	42.3	55.4	38.2	6.3	5.5	10YR 5/3
82	180–190	0	0.2	7.3	37.8	54.7	48.5	45.5	6	6.5	10YR 5/3
83	190–200	0.2	1.8	7.7	37	53.3	53	41.6	5.4	5.3	10YR 5/3

Note: analyses by Pedology Laboratory, University of Kansas.

[a] Normalized to color categories in Munsell Color, 2009; spectrophotometer data in Table 21.2.

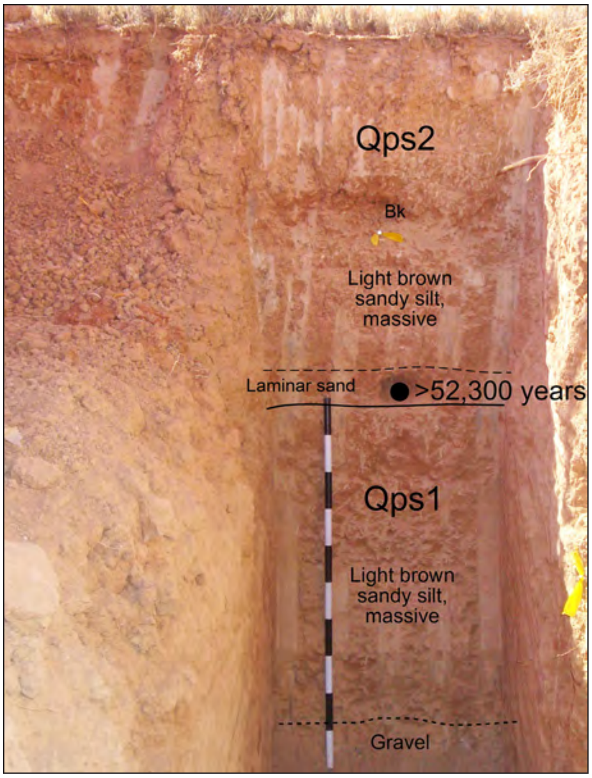

Figure 21.19. LA 111421, BHT 2, piedmont alluvium (Qps1, Qps2); scale is 1 m.

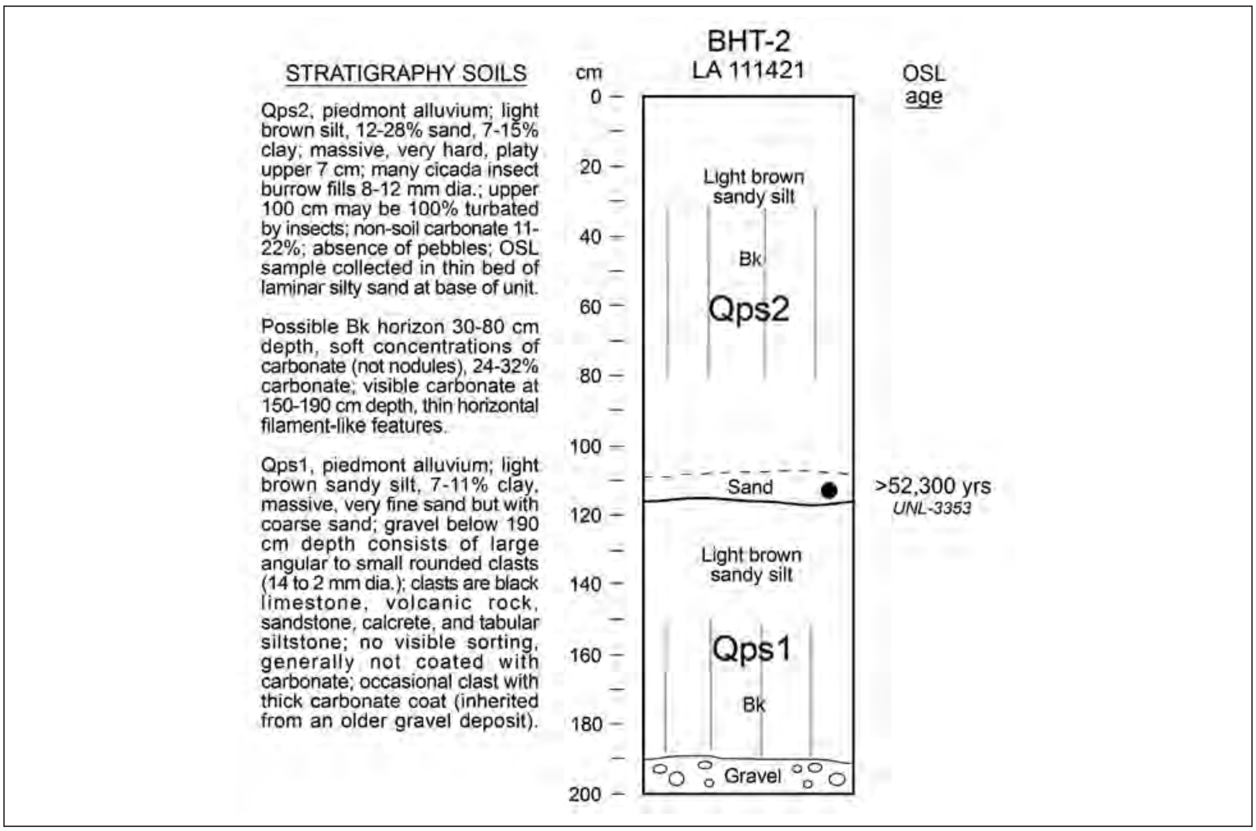

Figure 21.20. LA 111421, BHT 2, stratigraphic column of piedmont alluvium and paleosols.

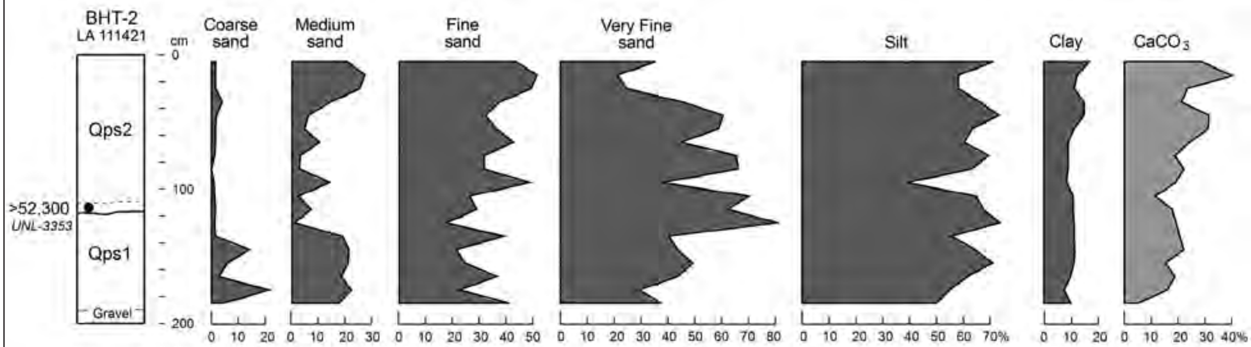

Figure 21.21. LA 111421, BHT 2, sediment diagram of piedmont alluvium (data in Table 21.9).

of the soil is eroded. The base of the sand sheet is not exposed in BHT 14 although nearby the sand sheet overlies piedmont alluvium (*Qps2*).

BHT 13. The subsurface geology of the southern edge of the site is revealed in BHT 13 where the local eolian sand (*Qes*) overlies piedmont alluvium (*Qps2*) (Figs. 21.28, 21.29, 21.30; Table 21.12). The piedmont alluvium underlies the sand sheet throughout the area, and, in a few cases where the sand sheet is missing, the piedmont alluvium occurs at the surface. The piedmont alluvium is light-brown silt, very hard, and contains numerous insect burrow fills that incorporate a high concentration of carbonate. The top of *Qps2* is an erosional surface. One OSL age from *Qps2* is 43,700 ± 2000 years.

Overlying the piedmont alluvium is the eolian sand sheet (*Qes*). *Qes* is light-brown to brown silty fine sand and about 130 cm thick. It is massive and incorporates a weak Bk soil horizon with 6 to 9 percent carbonate. Four OSL ages at BHT 13 range from 10,300 ± 400 to 3060 ± 170 years. The 10.3 ka age is the earliest age of the sand sheet. Elsewhere, the sand-sheet age extends to about 1.2 ka, indicating that at BHT 13 the upper part of the sand sheet, representing about 1800 years, is missing due to erosion or non-deposition. A partly eroded, weak A-horizon soil (*Qah*) occurs on the sand sheet and at the present-day surface.

BHT 16. The surficial geology at the north edge of LA 111429 is similar to that observed in the other areas of the site. The trench exposes 70 cm of eolian sand overlying piedmont alluvium (*Qps2*) (Figs. 21.31, 21.32, 21.33; Table 21.13). The piedmont alluvium is the same unit that is exposed at the present-day surface or mantled by Holocene eolian sand throughout the area. It is brown silty clay, very hard, and with densely packed insect burrow fills with high concentrations of carbonate. The piedmont alluvium is OSL-dated 39,500 ± 3500 years, the youngest age from *Qps2*. The top of the alluvium is eroded and buried by the eolian sand sheet (*Qes*). *Qes* is brown fine sand, massive, and devoid of soil horizons. One OSL age from *Qes* is 5400 ± 270 years. The A-horizon soil (*Qah*) occurs on the surface of the sand sheet, and quartz sand grains from the soil are OSL-dated 500 ± 30 years.

BHT 15. Jornada Draw and its fluvial deposits occur immediately west of LA 111429. BHT 15 was located so as to examine the alluvial deposits at the eastern edge of the draw as well as the subsurface stratigraphy of the Paleoindian area 1. The alluvial sediment (*Qaj*) is massive brown silt with thin beds of small gravel (Figs. 21.34, 21.35; Table 21.14). The gravel is dominated by granule (2 to 4 mm diameter) and small pebbles (4 to 16 mm diameter) with rare cobble clasts (Table 21.15). The gravel clasts are 95 percent caliche and 2 percent gray limestone (Fig. 21.36). The upper 130 cm of the alluvium is

Table 21.9. LA 111421, BHT 2, sediment data.

Field/ Lab No.	Interval (cm)	Very Coarse Sand (%)	Coarse Sand (%)	Medium Sand (%)	Fine Sand (%)	Very Fine Sand (%)	Sand (%)	Silt (%)	Clay (%)	$CaCO_3$ (%)	Dry Munsell Color[a]
Qps2 Piedmont Alluvium											
222	20–?	0	0.2	20.7	43.2	35.8	11.9	71.1	17	28.9	7.5YR 6/3
223	20–30	0	0.3	27.2	51.4	21.1	30.1	57.8	12.2	40.3	7.5YR 6/3
224	30–40	0	0.5	25.5	49	24.9	31.1	57.6	11.3	23.6	7.5YR 6/3
225	40–50	0	3.6	13.4	37.4	45.6	18.9	66.1	15	21.4	7.5YR 6/3
226	50–60	0	1	6.4	31.9	60.7	11.9	73	15	31.5	7.5YR 6/3
227	60–70	0	0.5	4.7	36.1	58.8	25.7	63.5	10.8	31.3	7.5YR 6/3
228	70–80	0.5	1.5	10.4	42.6	45	30.4	60.5	9	24.5	7.5YR 6/3
229	80–90	0	0.5	2.7	31.1	65.7	21.8	69.1	9.1	18.6	7.5YR 6/3
230	90–100	0	0	2.3	31.7	66	27.8	62.9	9.3	22.3	7.5YR 6/3
231	100–108	0	0.3	13.3	48.7	37.6	53.1	38.8	8	18.3	7.5YR 6/3
232	108–113	0	0.4	2.6	26.7	70.3	24.8	64.7	10.5	11.3	7.5YR 5/3
233	113–120	0	1.7	7	28.7	62.6	22.1	67.2	10.7	17.8	7.5YR 5/3
Qps1 Piedmont Alluvium											
234	120–130	0	0.9	0.9	17	81.2	15.9	73.3	10.8	19	7.5YR 5/3
235	130–140	0	1.5	18.8	39.5	40.3	34.2	55.4	10.3	20.8	7.5YR 6/3
236	140–150	0.4	14.6	21.2	20.7	43.2	24.8	64.2	10.9	22.2	7.5YR 5/3
237	150–160	0	5.5	21	24.3	49.2	18.6	70.8	10.5	15.2	7.5YR 6/3
238	160–170	0	2.2	17.9	36.1	43.8	28.5	61.7	9.8	18	7.5YR 6/3
239	170–180	5.1	21.2	22.1	22.6	29	38	54.6	7.4	16.5	7.5YR 6/3
240	180–190	0	4.2	17.5	41.1	37.2	40.3	49.6	10.1	4.8	7.5YR 5/4

Note : analyses by Pedology Laboratory, University of Kansas.

[a] Normalized to color categories in Munsell Color, 2009; spectrophotometer data in Table 21.1.

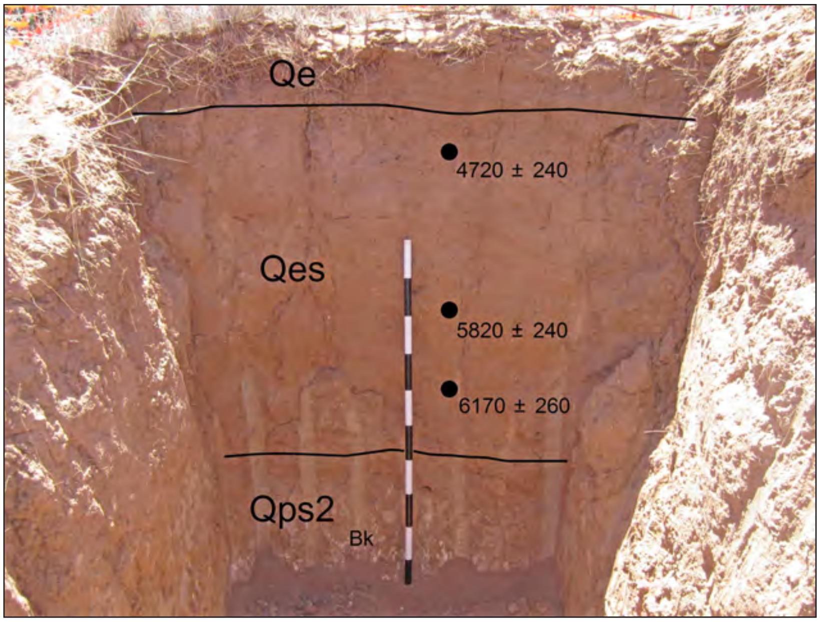

Figure 21.22. LA 111422, BHT 17, eolian sand (Qes, Qe) overlying piedmont alluvium (Qps2); scale is 1 m.

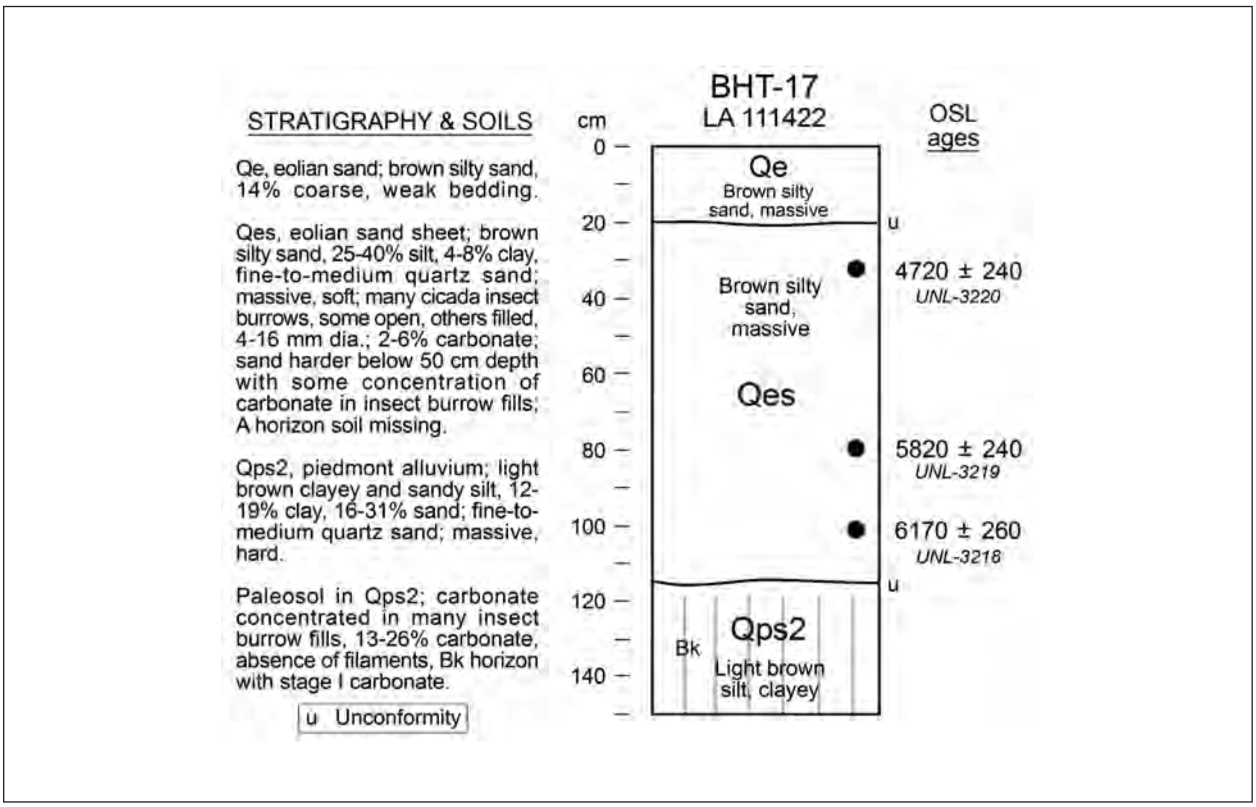

Figure 21.23. LA 111422, BHT 17, stratigraphic column of eolian sand overlying piedmont alluvium.

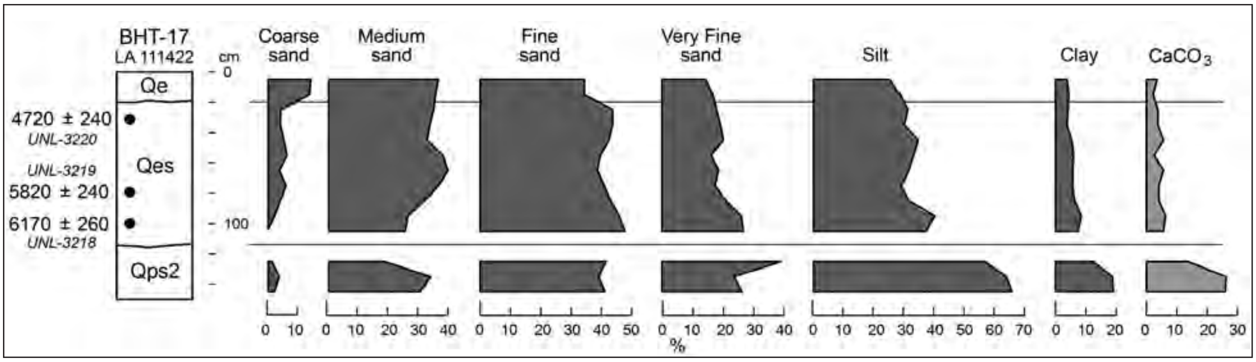

Figure 21.24. LA 111422, BHT 17, sediment diagram of eolian sand overlying piedmont alluvium (data in Table 21.10).

Table 21.10. LA 111422, BHT 17, sediment data.

Field/ Lab No.	Interval (cm)	Very Coarse Sand (%)	Coarse Sand (%)	Medium Sand (%)	Fine Sand (%)	Very Fine Sand (%)	Sand (%)	Silt (%)	Clay (%)	$CaCO_3$ (%)	Dry Munsell Color[a]
Qe Young Eolian Sand											
185	0–10	1.1	13.6	35.9	34.6	14.7	71	25	3.9	2.8	7.5YR 5/3
186	20–?	0.3	13.2	35.2	34.3	17	66.6	29	4.5	2.3	7.5YR 5/3
Qes Eolian Sand Sheet											
187	20–30	0	4	34.6	43.5	17.9	65.5	31	3.6	4	7.5YR 5/3
188	30–40	0	4.3	33.1	43.2	19.5	66.6	30	3.5	3.8	7.5YR 5/3
189	40–50	0	5.1	32.3	42.4	20.2	60.1	35	5.1	5.5	7.5YR 5/3
190	50–60	0	6.4	37.8	39.9	16	61.6	33	5.5	2.2	7.5YR 5/3
191	60–70	0	3.1	39.6	39	18.3	63.2	31	5.4	5.5	7.5YR 5/3
192	70–80	0	5.4	36.6	40.5	17.5	65.6	29	5.3	4.2	7.5YR 5/3
193	80–90	0	4.2	31.2	42.9	21.8	62.5	32	6	4.2	7.5YR 5/4
194	90–100	0	2	26.1	45.9	26	51.8	40	8.1	6.4	7.5YR 5/4
195	100–110	0	0.8	25.1	47.6	26.5	55.3	37	7.4	5.3	7.5YR 5/4
Qps2 Piedmont Alluvium											
196	120–130	0	1	18.5	41.2	39.2	31.4	57	12	13.2	7.5YR 5/4
197	130–140	0	3.8	33	39.4	23.7	17.9	64	18.4	25.9	7.5YR 6/3
198	140–150	0	2.3	30	41	26.7	15.6	66	18.8	25.7	7.5YR 6/3

Note : analyses by Pedology Laboratory, University of Kansas.

[a] Normalized to color categories in Munsell Color, 2009; spectrophotometer data in Table 21.2.

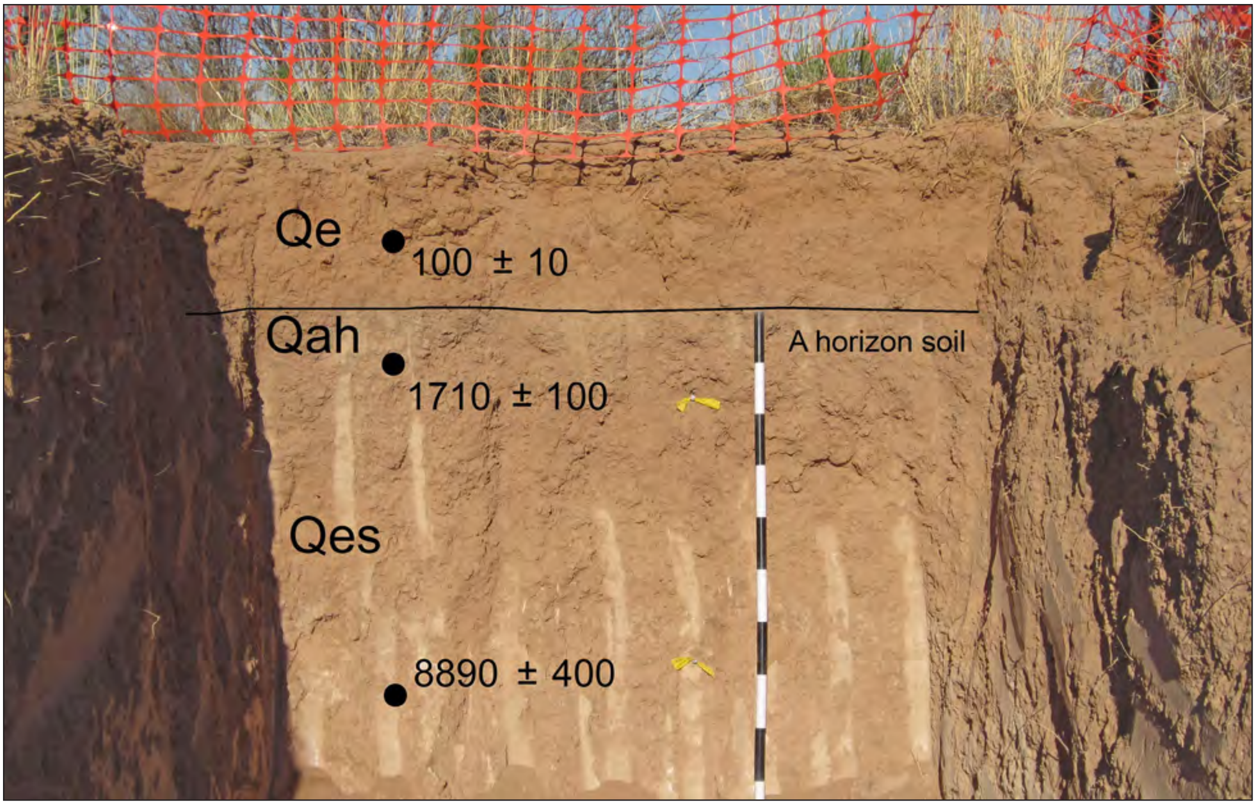

Figure 21.25. LA 111429, BHT 14, eolian sand and A horizon soil; scale is 1 m.

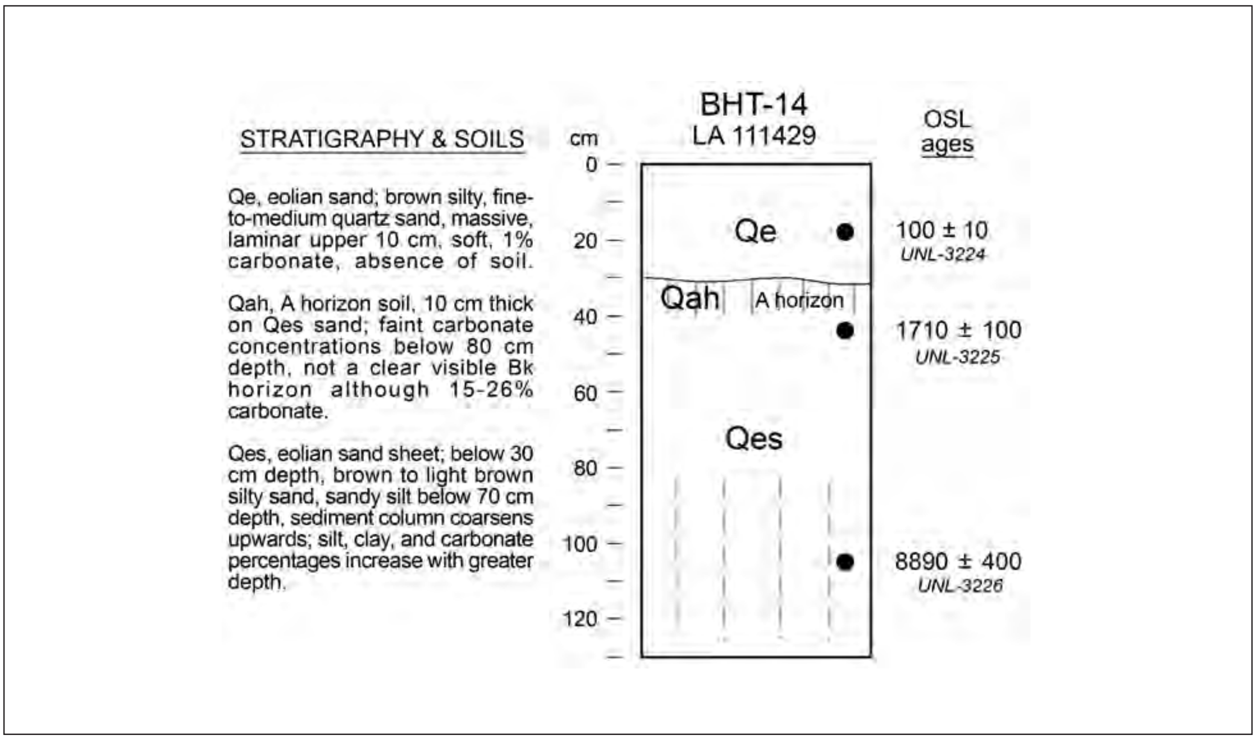

Figure 21.26. LA 111429, BHT 14, stratigraphic column of eolian sand and A-horizon soil.

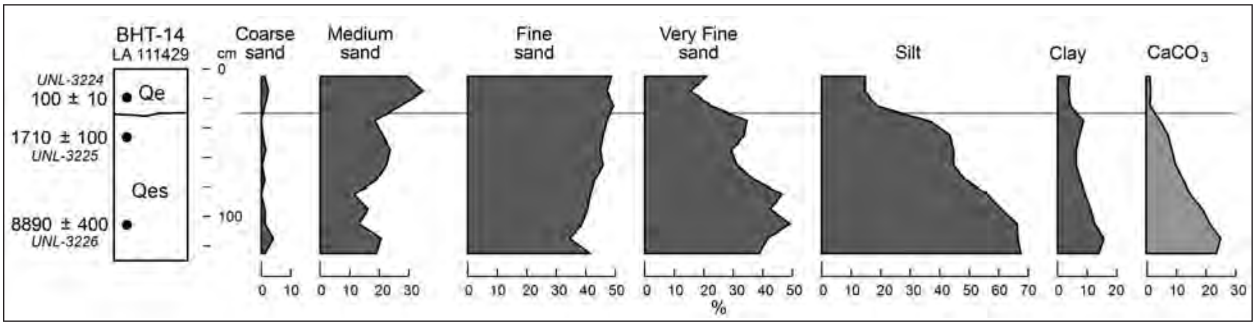

Figure 21.27. LA 111429, BHT 14, sediment diagram of eolian sand (data in Table 21.11).

Table 21.11. LA 111429, BHT 14, sediment data.

Field/ Lab No.	Interval (cm)	Very Coarse Sand (%)	Coarse Sand (%)	Medium Sand (%)	Fine Sand (%)	Very Fine Sand (%)	Sand (%)	Silt (%)	Clay (%)	$CaCO_3$ (%)	Dry Munsell Color
Qe Young Eolian Sand											
102	0–10	0	1.3	29.3	48.8	20.5	82.2	14.8	3	1	7.5YR 5/3
103	20–?	0	2.3	35.1	47.2	15.5	82.7	14.6	2.8	1.4	7.5YR 5/4
104	20–30	0	1.2	27	49.2	22.6	77.9	18.7	3.4	1.6	7.5YR 5/3
Qah A Horizon Soil											
105	30–40	0	0.2	18	47.1	34.7	54.6	37	8.4	4.5	7.5YR 5/3
Qes Eolian Sand Sheet											
106	40–50	0	0.5	20.4	45.7	33.4	49.2	43.5	7.4	7.4	7.5YR 5/3
107	50–60	0	1.7	23.9	44.9	29.5	48.5	44.7	6.9	8.4	7.5YR 5/3
108	60–70	0	0.6	22.3	45.8	31.2	49.2	44.2	6.6	10	7.5YR 5/3
109	70–80	0	1.1	18.7	42.9	37.3	43.7	48.5	7.7	12.4	7.5YR 6/3
110	80–90	0	0.1	11.8	41.8	46.3	34.1	56.5	9.5	15.1	7.5YR 6/3
111	90–100	0	0.9	16.1	40.6	42.5	27.4	60.8	11.8	18.7	7.5YR 6/3
112	100–110	0	0.3	12.2	38.5	49	21.8	66	12.2	21.4	7.5YR 6/3
113	110–120	0	3.9	20.2	34.6	41.3	18	66.4	15.6	25.6	7.5YR 6/3
114	120–130	0	0.8	19.2	41.4	38.6	19.3	67.3	13.4	23.8	7.5YR 6/3

Note : analyses by Pedology Laboratory, University of Kansas

[a] Normalized to color categories in Munsell Color, 2009; spectrophotometer data in Table 21.2.

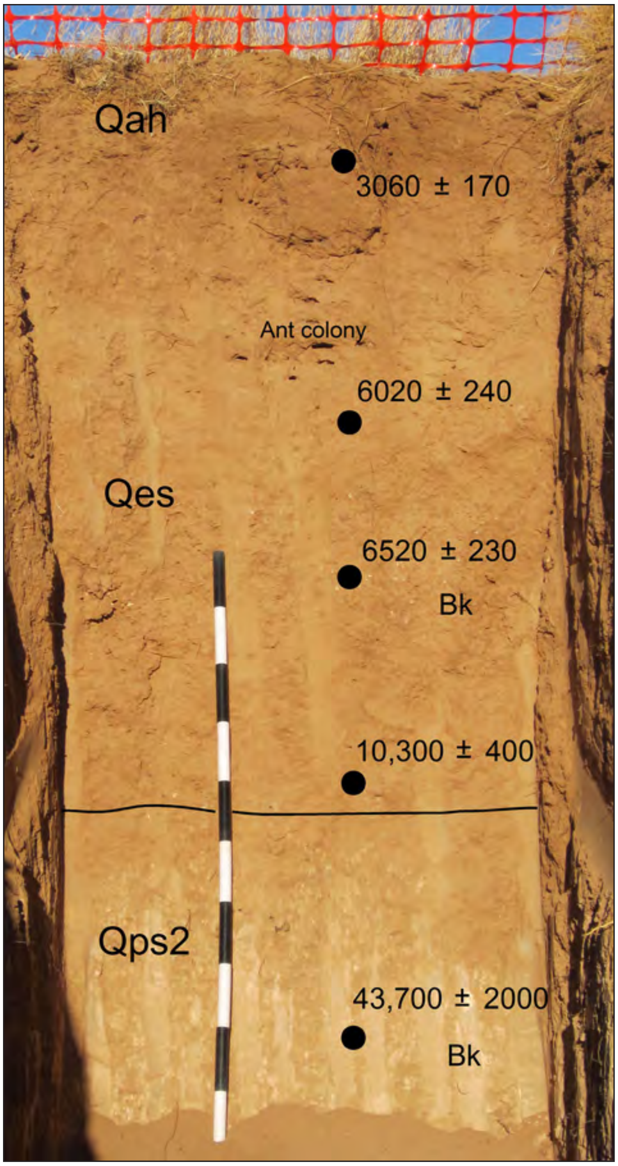

Figure 21.28. LA 111429, BHT 13, eolian sand overlying piedmont alluvium; scale is 1 m.

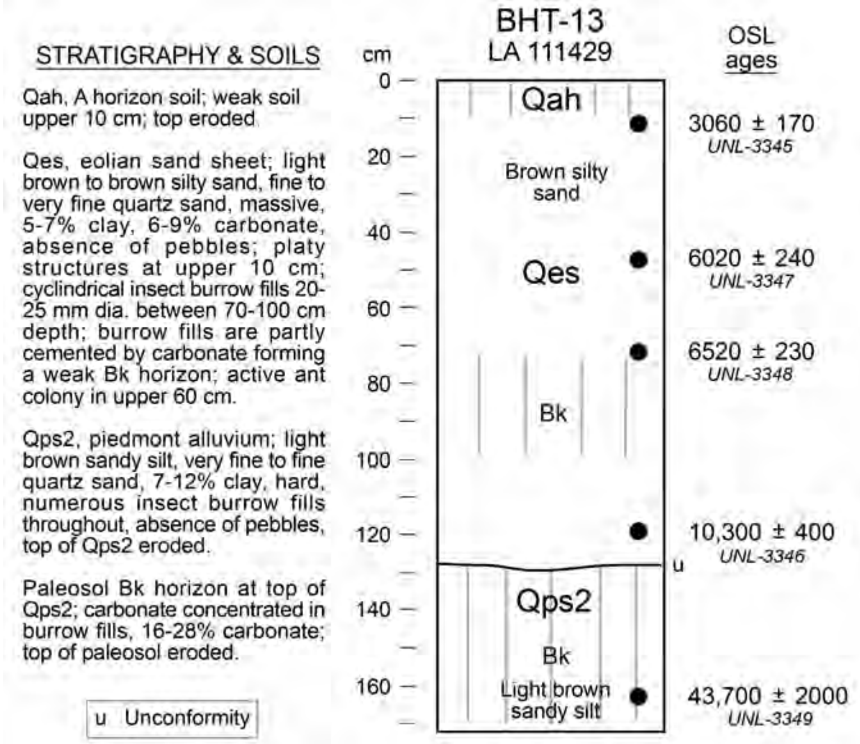

Figure 21.29. LA 111429, BHT 13, stratigraphic column of eolian sand overlying piedmont alluvium.

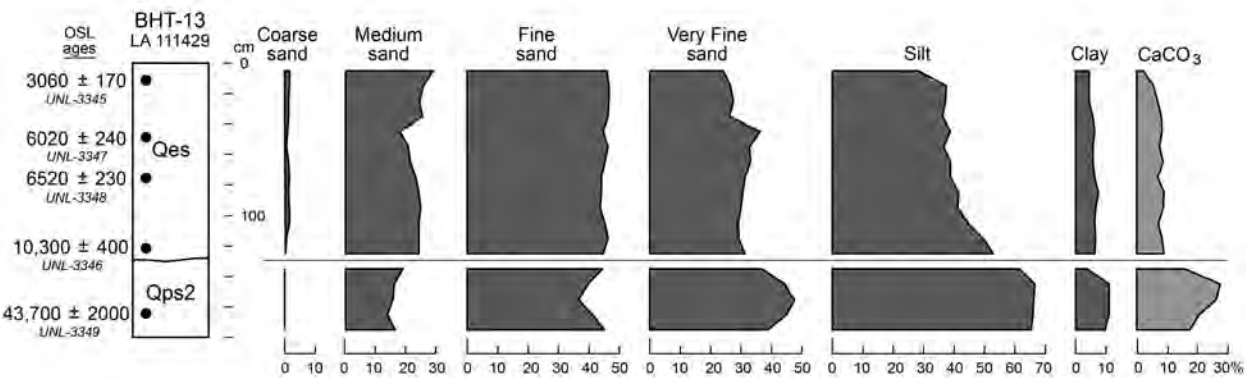

Figure 21.30. LA 111429, BHT 13, sediment diagram of eolian sand and piedmont alluvium (data in Table 21.12).

Table 21.12. LA 111429, BHT 13, sediment data.

Field/ Lab No.	Interval (cm)	Very Coarse Sand (%)	Coarse Sand (%)	Medium Sand (%)	Fine Sand (%)	Very Fine Sand (%)	Sand (%)	Silt (%)	Clay (%)	$CaCO_3$ (%)	Organic Carbon (%)	Dry Munsell Color
Qah A Horizon Soil												
138	0–10	0	1.7	28.8	45.8	23.7	67.6	28	4.6	2.3	0.22	7.5YR 5/3
Qes Sand Sheet												
139	20–?	0	1.6	25.6	46.1	26.8	57.9	38	4.6	5.7	0.21	7.5YR 5/3
140	20–30	0	1.2	24.4	46.9	27.5	58	37	4.7	6.9	0.28	7.5YR 5/3
141	30–40	0	1.4	25.3	46.3	26.9	58.7	36	5.2	7.9	0.12	7.5YR 5/3
142	40–50	0	0.8	17.7	44.6	36.9	54.8	39	6	7.9	0.32	7.5YR 6/3
143	50–60	0	0.5	20.4	46.3	32.8	57.5	37	5.7	7.5	0.25	7.5YR 6/3
144	60–70	0	0.9	21	45.4	32.8	55.6	39	5.7	8.2	0.15	7.5YR 5/3
145	70–80	0	1.5	22.9	44.2	31.5	55	39	6.3	6.9	0.28	7.5YR 6/3
146	80–90	0	1.3	23.9	44.4	30.4	51.6	41	7.3	9.3	0	7.5YR 6/3
147	90–100	0	1.7	24.6	43.8	29.9	52.4	41	6.6	8.4	0.1	7.5YR 6/3
148	100–110	0	1.3	24	45.3	29.4	49.1	45	6.3	7.1	0.22	7.5YR 5/4
149	110–120	0	0.5	23.8	46	29.7	43.6	50	6.6	8.1	0.18	7.5YR 5/3
150	120–128	0	0.7	23.6	44.8	30.9	40.7	53	6.7	8.9	0.06	7.5YR 6/4
Qps2 Piedmont Alluvium												
151	130–140	0	0.3	18.2	44.4	37.1	32	62	6.5	15.7	0.29	7.5YR 6/3
152	140–150	0	0.2	15.8	39.7	44.3	21.4	67	11.7	27.3	0.28	7.5YR 6/3
153	150–160	0	0.6	15.6	36.5	47.3	22.3	67	11.1	26.3	<dl*	7.5YR 6/3
154	160–170	0	0.3	13.7	41.1	44.9	28.9	60	10.9	20.4	0.14	7.5YR 6/3
155	170–180	0	0.3	16.2	45	38.5	34.6	56	9.4	17.8	<dl*	7.5YR 6/3

Note: analyses by Pedology Laboratory, University of Kansas.
* <dl, below detection limit.
[a] Normalized to color categories in Munsell Color, 2009; spectrophotometer data in Table 21.2.

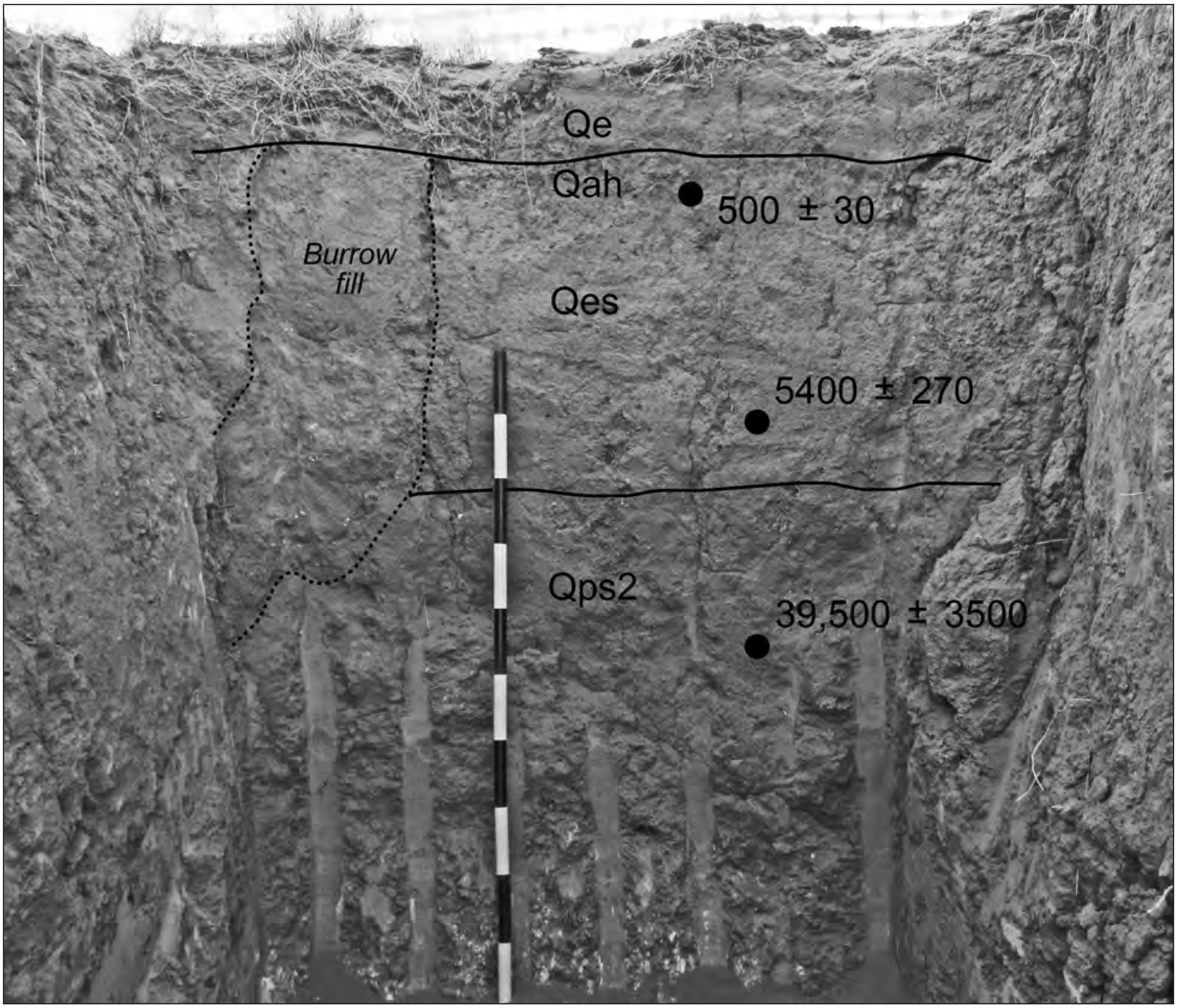

Figure 21.31. LA 111429, BHT 16, eolian sand (Qes, Qe) and A-horizon soil overlying piedmont alluvium (Qps2). At this locality, the badger burrowing occurred on the sand sheet between about 500 and 100 years ago; scale is 1 m.

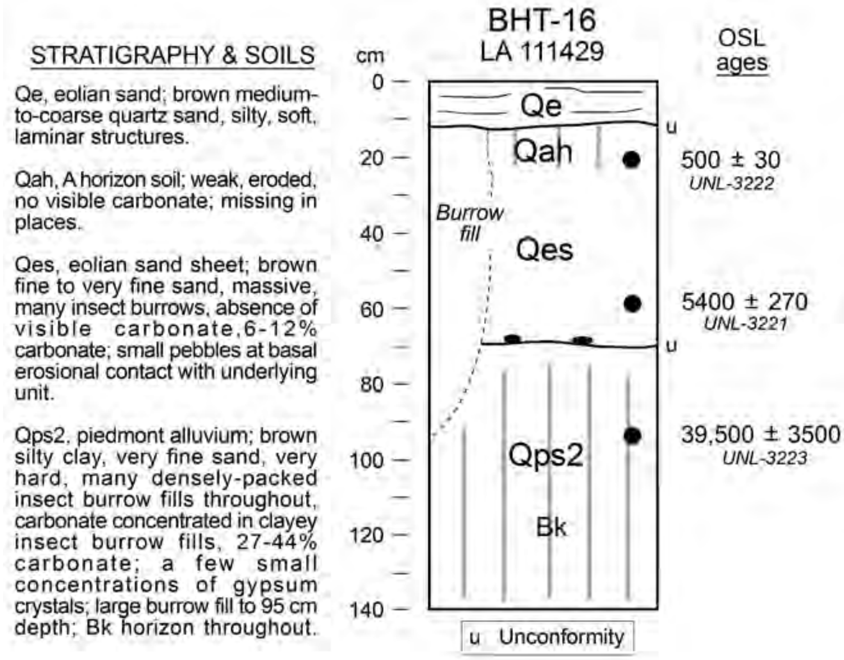

Figure 21.32. LA 111429, BHT 16, stratigraphic column of eolian sand overlying piedmont alluvium.

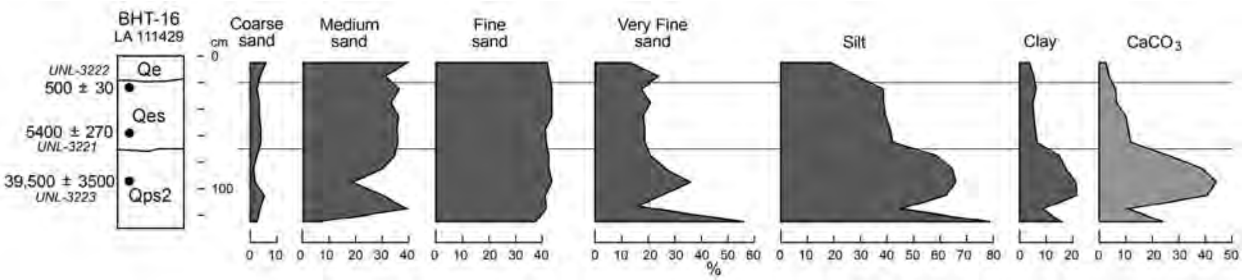

Figure 21.33. LA 111429, BHT 16, sediment diagram of eolian sand and piedmont alluvium (data in Table 21.13).

Table 21.13. LA 111429, BHT 16, sediment data.

Field/ Lab No.	Interval (cm)	Very Coarse Sand (%)	Coarse Sand (%)	Medium Sand (%)	Fine Sand (%)	Very Fine Sand (%)	Sand (%)	Silt (%)	Clay (%)	$CaCO_3$ (%)	Dry Munsell Color
Qe Young Eolian Sand											
199	0–10	0	5.8	38.9	42	13.3	77.1	19	3.8	2.3	7.5YR 5/3
Qah A Horizon Soil											
200	20–?	0	3.3	30.5	42.6	23.6	66	29	5.1	3.5	7.5YR 5/3
Qes Eolian Sand Sheet											
201	20–30	0	2.8	36.3	43.3	17.6	55.6	38	6	6.1	7.5YR 5/3
202	30–40	0	3.1	32.9	43.1	20.9	56.6	39	4.8	6.1	7.5YR 5/3
203	40–50	0	3.1	35.8	43.3	17.8	55	40	5.2	10	7.5YR 6/3
204	50–60	0	4.1	35.2	41.6	19.1	52.8	41	5.9	10.6	7.5YR 6/3
205	60–70	0	4.2	35.7	41.8	18.3	51.2	42	6.6	12.1	7.5YR 5/3
Qps2 Piedmont Alluvium											
206	70–80	0	2.7	34.4	42.2	20.7	26.8	58	15	26.6	7.5YR 6/3
207	80–90	0	1.4	29.9	42.4	26.4	17.5	65	17.7	38.3	7.5YR 6/3
208	90–100	0	2.1	18.9	43.3	35.7	12.8	66	21.4	43.8	7.5YR 6/3
209	100–110	0	5	29.7	40.9	24.4	16.6	62	21.5	40.2	7.5YR 6/3
210	110–120	0	3.8	39.1	41.3	15.9	45.8	45	9.1	10.3	7.5YR 6/3
211	120–130	0	2.2	4.7	37.2	56	5.8	79	15.4	24.4	7.5YR 6/3

Note : analyses by Pedology Laboratory, University of Kansas.

[a] Normalized to color categories in Munsell Color, 2009; spectrophotometer data in Table 21.2.

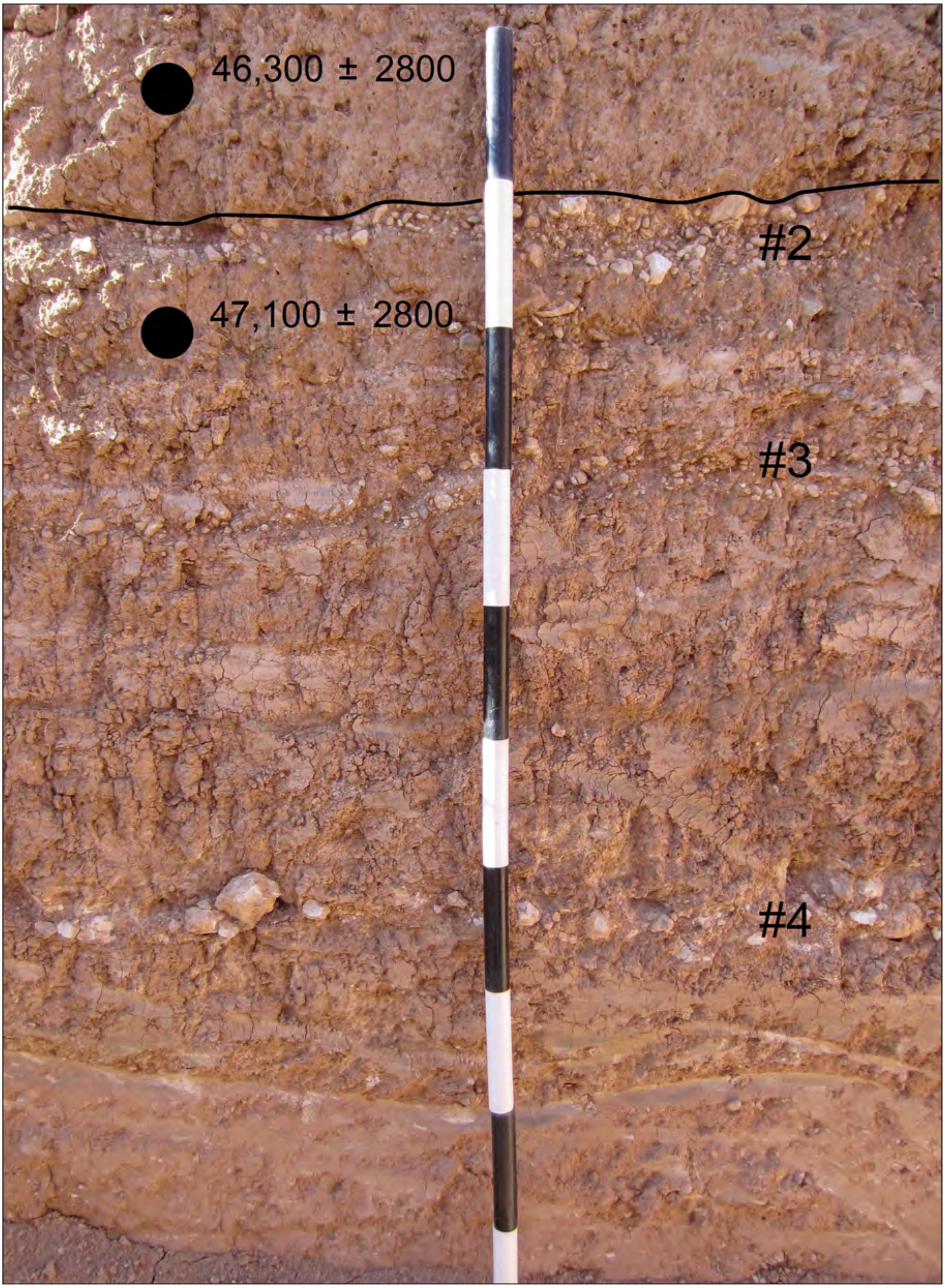

Figure 21.34. LA 111429, BHT 15, the late Pleistocene Jornada alluvium (Qaj) with thin, gravel zones #2, #3, and #4; selected gravels are shown in Fig. 21.36 (data in Table 21.15); scale is 1 m.

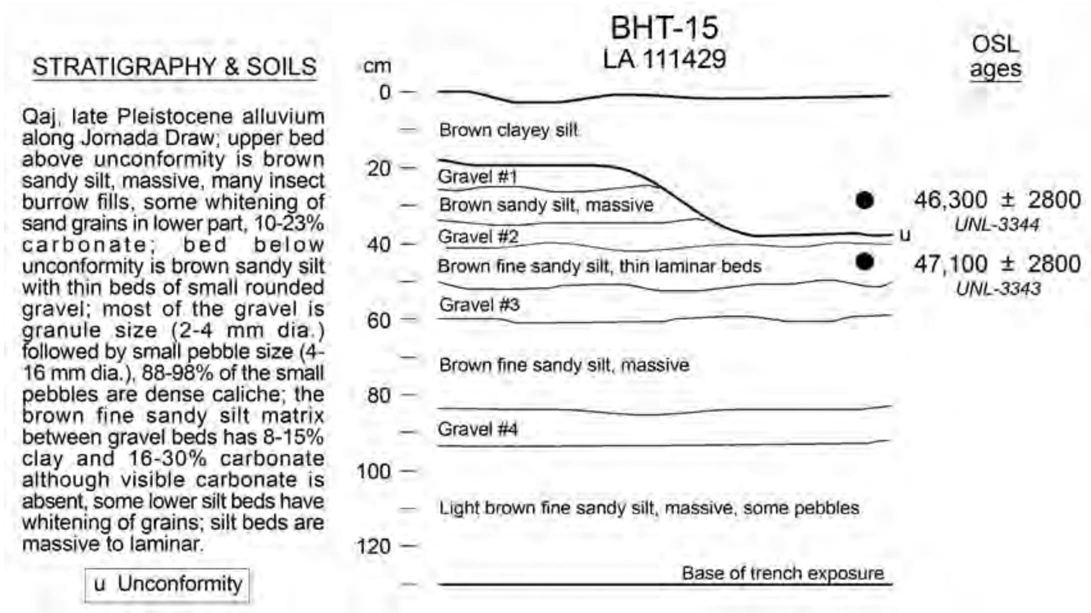

Figure 21.35. LA 111429, BHT 15, stratigraphic column of Jornada alluvium (Qaj) (data in Table 21.14).

Table 21.14. LA 111429, BHT 15, sediment data.

Field/ Lab No.	Interval (cm)	Very Coarse Sand (%)	Coarse Sand (%)	Medium Sand (%)	Fine Sand (%)	Very Fine Sand (%)	Sand (%)	Silt (%)	Clay (%)	$CaCO_3$ (%)	Dry Munsell Color
Qaj Jornada Draw Alluvium											
Upper bed above unconformity, thick section											
126	0–10	0	3.6	30.7	40.6	25.1	49.9	45.3	4.8	9.46	7.5YR 5/3
127	20–?	0	4.7	28.7	38.8	27.8	42.6	51.6	5.8	12.7	7.5YR 5/3
128	20–30	0	2.7	27.3	38.7	31.3	34.1	58.2	7.7	17.25	7.5YR 6/3
129	30–37	0	5.1	23.8	36.3	34.9	32	59.9	8.2	22.94	7.5YR 6/3
Lower bed below unconformity, offset from series of samples from upper bed											
130	25–34	0	1.3	24.7	43.6	30.4	28.6	63.7	7.7	17.42	7.5YR 5/3
131	42–51	4.8	13.2	15	30	37	15.9	69	15	28.4	7.5YR 6/3
132	60–70	0	0	14.7	46.1	39.2	18.2	67	15	30.1	7.5YR 6/3
133	70–80	0	0.6	26	46.5	26.9	20.4	64.2	15	23.6	7.5YR 6/3
134	94–100	0	0.9	13.4	36.5	49.2	16.8	68.9	14	26.29	7.5YR 6/3
135	100–110	0	2	26	42	30	37.1	54.8	8	16.24	7.5YR 6/3
136	110–120	0	4.9	27.9	39.6	27.6	41.9	50.1	8	18.79	7.5YR 6/3
137	120–130	0	2.9	26.6	43.3	27.2	32.7	58.7	8.5	24.28	7.5YR 6/3

Note : analyses by Pedology Laboratory, University of Kansas.

* Gravel beds not included in these analyses; not analyzed for gravel (see Table 21.15).

[a] Normalized to color categories in Munsell Color, 2009; spectrophotometer data in Table 21.2.

Table 21.15. LA 111429, BHT 15, texture of alluvial gravel zones.

	Granules 2–4 mm	Pebbles, Small 4–16 mm	Pebbles, Medium 16–32 mm	Pebbles, Large 32–64 mm
Gravel zone #1, 15 to 23 cm depth				
No. of clasts	583	406	49	12
Percent. clasts	55.50%	38.7	4.7	1.1
Clast wt. (g)	18.8	196.1	254.5	251
Percent. wt.	2.60%	27.2	35.3	34.8
Gravel zone #2, 28 to 39 cm depth				
No. of clasts	1370	528	16	0
Percent. clasts	71.60%	27.6	0.8	0
Clast wt. (g)	46.6	160.2	68.9	0
Percent. wt.	16.90%	58.1	25	0
Gravel zone #3, 47 to 60 cm depth				
No. of clasts	1038	365	19	2
Percent. clasts	72.90%	25.6	1.3	0.1
Clast wt. (g)	32.1	112.4	75.8	60.9
Percent. wt.	11.40%	40	27	21.7
Gravel zone #4, 84 to 90 cm depth				
No. of clasts	315	90	23	11
Percent. clasts	71.80%	20.5	5.2	2.5
Clast wt. (g)	8.8	35.2	117.4	349.7
Percent. wt.	1.70%	6.9	23	68.4

Note: Cobbles (64–256 mm) not included in analysis; sample from zone #2 contained 1 cobble, and zone #4 sample contained 2 cobbles; samples from zones #1 and #3 did not contain cobbles. Each sample consisted of about 1500 cc of sediment. The matrix of each sample is sandy silt.

Figure 21.36. Small pebbles selected from the four gravel zones in the Jornada alluvium; all of these pebbles are dense caliche except the far right-hand pebble from zone #3, which is gray limestone (data in Table 21.15)

exposed in the trench; the base of the *Qaj* alluvium is not exposed. Two OSL ages from the alluvium are 47,100 ± 2800 and 46,300 ± 2800 years. The Jornada Draw alluvium is too ancient to incorporate archaeology although the surface of the unit has the potential to have Paleoindian through Historic remains. The central axis of Jornada Draw is probably composed of younger alluvium, although no information on the stratigraphy or geochronology is available.

Test Pit 3. Ninety centimeters of eolian sand were exposed in the central area of LA 111429 at Test Pit 3. The upper 30 cm of the eolian sand is the young eolian sand unit (*Qe*) that locally covers some small areas on the sand sheet. The sediment is massive brown fine to medium sand with weak laminar structure in the lower 5 cm (Figs. 21.37, 21.38; Table 21.16). The OSL age of *Qe* is 150 ± 20 years or 1860 A.D. The unit unconformably overlies the sand sheet (*Qes*) and A-horizon soil (*Qah*). The eolian sand sheet is massive brown fine to medium sand with a slight coarsening-upwards of texture. A weak Bk-horizon with 7 percent carbonate occurs in the sand at the base of the exposure. One OSL age from *Qes* is 5120 ± 220 years. The A-horizon soil (*Qah*) occurs on the top of the sand sheet. An OSL age of quartz sand grains from the soil is 540 ± 20 years or AD 1470. An AMS radiocarbon age of organic carbon from the soil is 460 ± 30 ^{14}C years BP or about AD 1438 (Table 21.5). The two ages overlap at 2σ, indicating the ages are statistically the same.

Surface Strip 6. In the central area of LA 111429, a shallow test excavation was conducted near an occurrence of Paleoindian artifacts. The sediment exposed in the test block is soft, massive light-brown sandy silt (Figs. 21.39, 21.40; Table 21.17). The geomorphology and stratigraphy of the sediment indicate that it is the discontinuous cover sediment (Qcs) that commonly mantles piedmont alluvium in the study area. The sediment is 27 cm thick and rests on the *Qps2* piedmont alluvium. Three OSL ages were obtained from the thin cover sediment; the ages range from 8830 ± 440 years at the base, a good age for Paleoindian deposits, to 5000 ± 250 years near the top of the section at 9 cm depth, the youngest age from *Qcs* in the study area. The cover

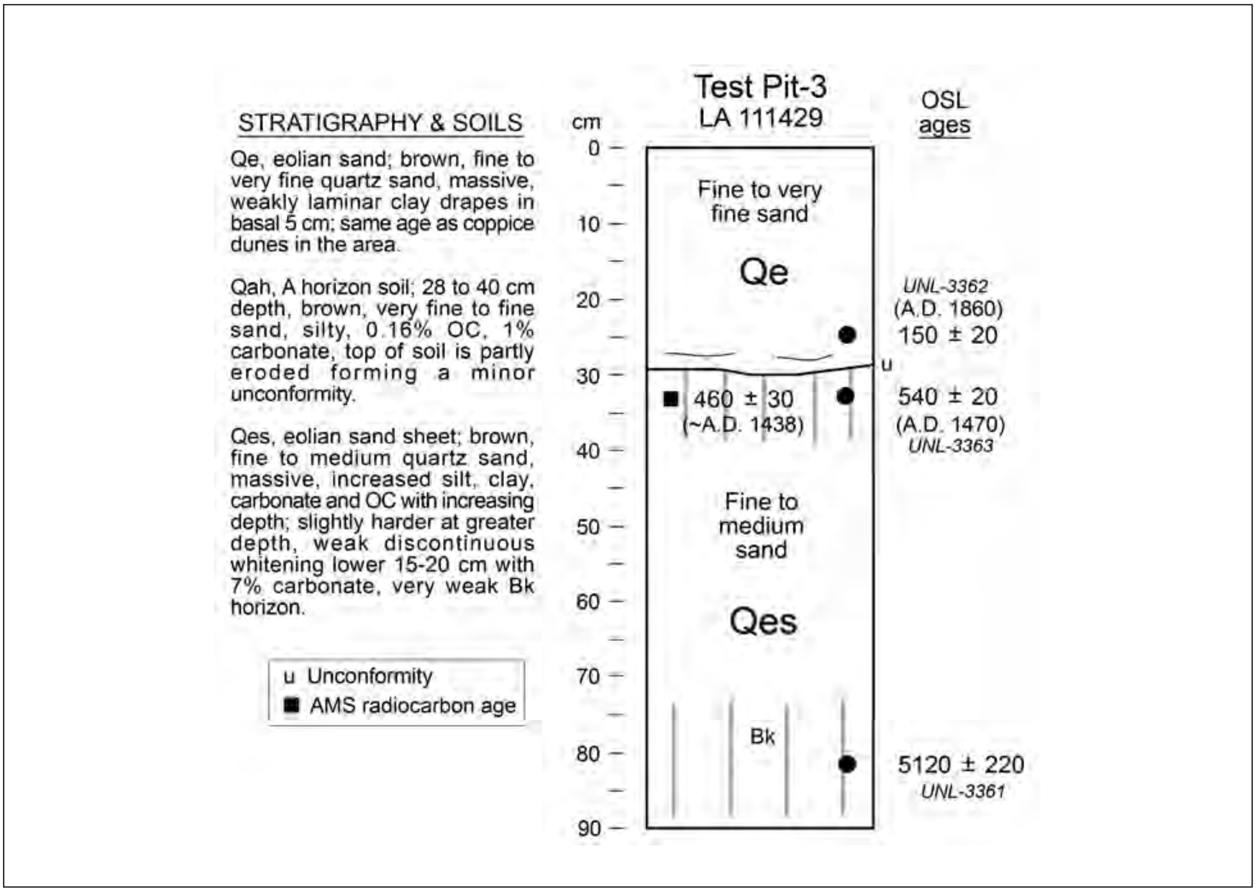

Figure 21.37. LA 111429, Test Pit 3, stratigraphic column of eolian sand (Qes, Qe).

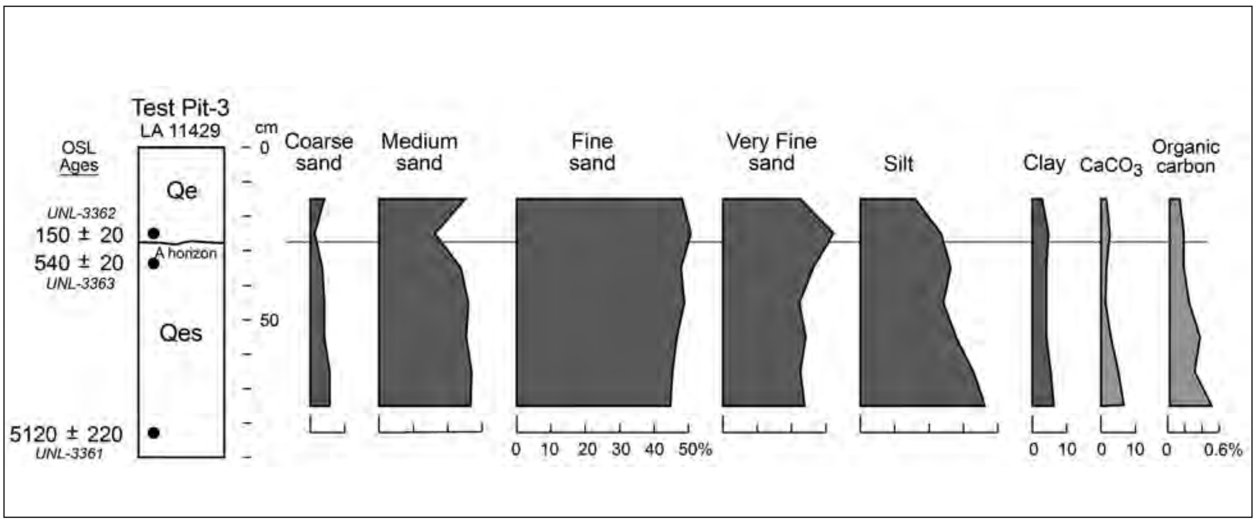

Figure 21.38. LA 111429, Test Pit 3, sediment diagram of eolian sand (data in Table 21.16).

Table 21.16. LA 111429, Test Pit 3, sediment data.

Field/ Lab No.	Interval (cm)	Very Coarse Sand (%)	Coarse Sand (%)	Medium Sand (%)	Fine Sand (%)	Very Fine Sand (%)	Sand (%)	Silt (%)	Clay (%)	$CaCO_3$ (%)	Organic Carbon (%)	Dry Munsell Color
Qe Young Eolian Sand												
60	20–?	0	4	25.5	47.8	22.7	81.2	16	2.7	0.8	0.11	7.5YR 5/4
61	20–26	0	0.7	16.5	50.7	32.2	71.7	23	4.9	2.4	0.17	7.5YR 5/4
Qah A Horizon Soil												
62	30–40	0	3.1	23.1	47.7	26	69.7	27	3.8	1.4	0.16	7.5YR 4/3
Qes Eolian Sand Sheet												
63	40–50	0	4	25.9	48.1	22.1	73	24	3.6	1.4	0.21	7.5YR 5/3
64	50–60	0	3.9	25.4	46.8	23.9	68.6	28	3.8	2.6	0.35	7.5YR 5/3
65	60–70	0	5.3	26.6	45.4	22.7	62.8	33	4.4	4.8	0.29	7.5YR 5/3
66	70–80	0	5.1	26.8	44.9	23.2	57.9	36	6.2	6.8	0.49	7.5YR 5/3

Note : analysis by Pedology Laboratory, University of Kansas.

[a] Normalized to color categories in Munsell Color, 2009; spectrophotometer data in Table 21.2.

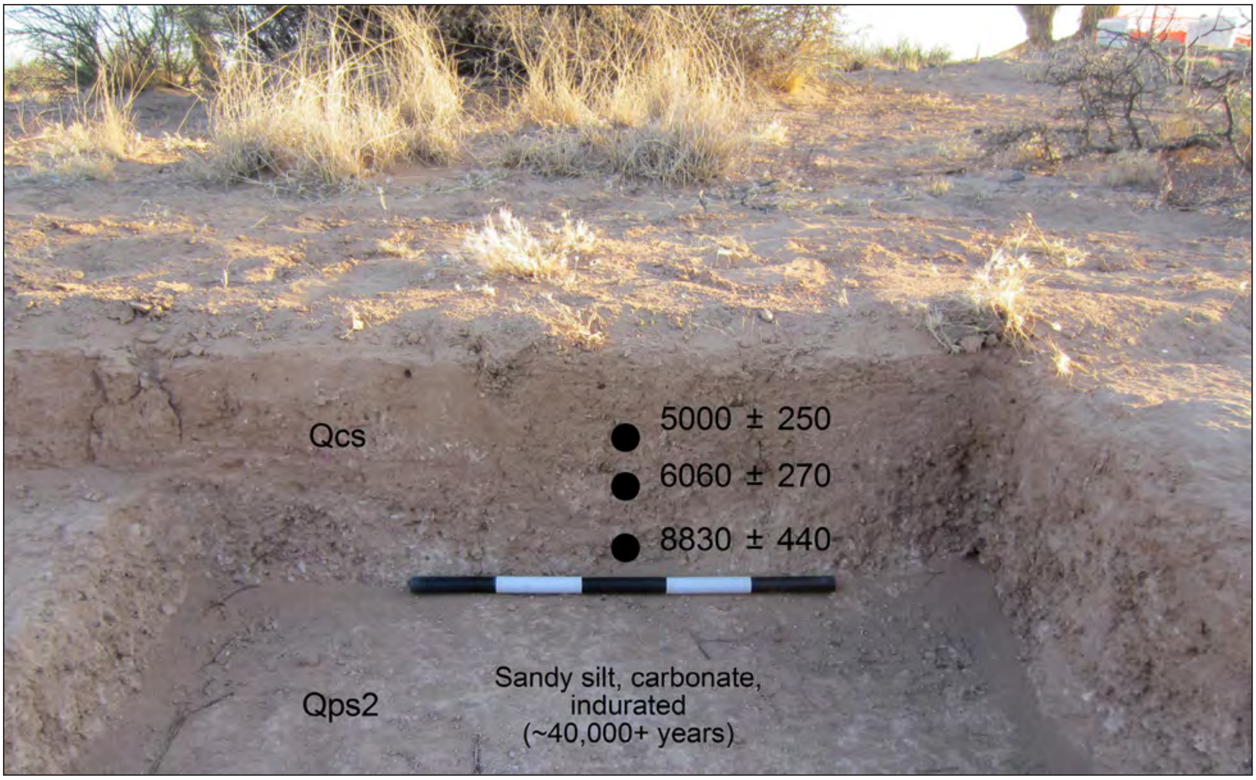

Figure 21.39. LA 111429, Surface Strip 6, showing cover sediment (Qcs) overlying piedmont alluvium (Qps2); scale is 50 cm.

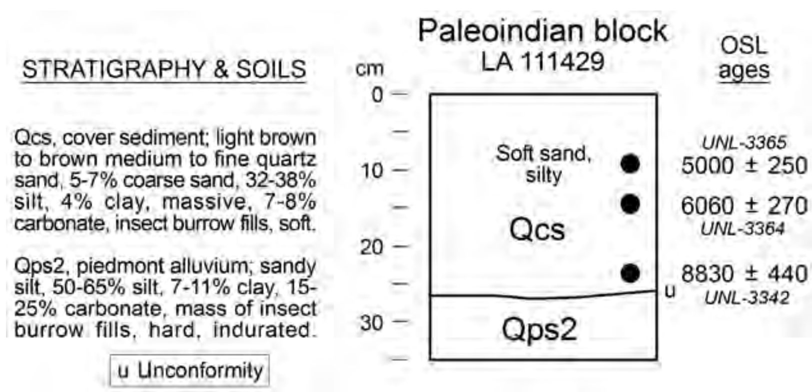

Figure 21.40. LA 111429, Surface Strip 6, stratigraphic column with cover sediment overlying piedmont alluvium (data in Table 21.17).

Table 21.17. LA 111429, Surface Strip 6 and vertical OSL sample, sediment data.

Field/ Lab No.	Interval (cm)	Very Coarse Sand (%)	Coarse Sand (%)	Medium Sand (%)	Fine Sand (%)	Very Fine Sand (%)	San d (%)	Silt (%)	Clay (%)	$CaCO_3$ (%)	Organic Carbon (%)	Dry Munsell Color
Surface Strip 6												
Qcs, Cover Sediment												
156	0–5	0	4.9	36.8	40.2	18.1	63.9	32	4.1	7.9	0.13	7.5YR 5/3
157	10–?	0	4.8	37	39.5	18.7	59.1	36.8	4.1	7.6	0.3	7.5YR 6/3
158	15–?	0	6.6	40	38.2	15.2	60.3	35.7	4	8.7	0.21	7.5YR 6/3
159	15–20	0	7.4	42.2	36.2	14.2	60.2	35.4	4.5	8.6	0.16	7.5YR 6/3
160	20–25	0	6.1	37.4	37.5	19	58	37.5	4.5	7.2	0.37	7.5YR 5/3
Qps2, Piedmont Alluvium												
161	25–30	0	8.4	37.7	34.8	19.1	43.1	49.5	7.4	15	0.13	7.5YR 6/3
162	30–35	0	2.7	34.4	40.2	22.5	24.4	65.3	10.6	25.4	0.46	7.5YR 6/3
Vertical OSL Sample												
Qcs, Cover Sediment												
184	~10–15	0	4.7	28.9	40.4	26	49.9	43.5	6.6	10.6	0.31	7.5YR 5/3

Note : analyses by Pedology Laboratory, University of Kansas.

[a] Normalized to color categories in Munsell Color, 2009; spectrophotometer data in Table 21

sediment incorporates cicada burrow fills and other possible indications of disturbance and bioturbation (Fig. 21.41), although the stratigraphic agreement of the three OSL ages with the earliest age at the base and the youngest age at the top suggests that the degree of disturbance of the sediments is minor.

Vertical Sample. In the vicinity of the Surface Strip 6 near the center of LA 111429, a vertical sample for OSL dating was obtained from the cover sediment (*Qcs*). The vertical sample was collected from about 5 to 23 cm depth below the present-day surface (Figs. 21.42, 21.43; Table 21.17). The sediment is brown fine- to medium-textured sand with 44 percent silt and 7 percent clay. The OSL age is 7370 ± 440 years, similar to the early Holocene ages from the Surface Strip 6 (Fig. 21.39).

LA 1 11432

This small site occurs on the present-day weathered surface of the *Qps2* piedmont alluvium. The alluvium exposed in BHT 1 is a light-brown silt; it is massive and very hard (Figs. 21.44, 21.45, 21.46; Table 21.18). Small carbonate nodules and carbonate-cemented cicada insect burrow fills occur throughout the unit, indicating the presence of a Bk soil horizon. The *Qps2* unit is not dated, although the underlying *Qps1* unit is OSL-dated >48.5 ka.

LA 111435

This is an extensive multiple component site with many features. It is located on a low bench of eolian sand on the west side of Jornada Draw, similar in occurrence to LA 111422. The upper-most 28 cm of young eolian sand exposed in BHT 18 is brown fine- to medium-textured quartz sand (*Qe*). The upper part is laminar, the lower is massive. Two OSL ages from the thin eolian sand at this site are 120 ± 10 and 100 ± 10 years or 1891 and 1911 A.D.; the closeness of the two ages with 2σ error indicate they are the same.

The young eolian sand unit directly overlies a A/Bw soil horizon (*Qah*). The soil does not appear to be related to the prehistoric site and is not an anthrosol. It is about 20 cm thick with 0.15 percent

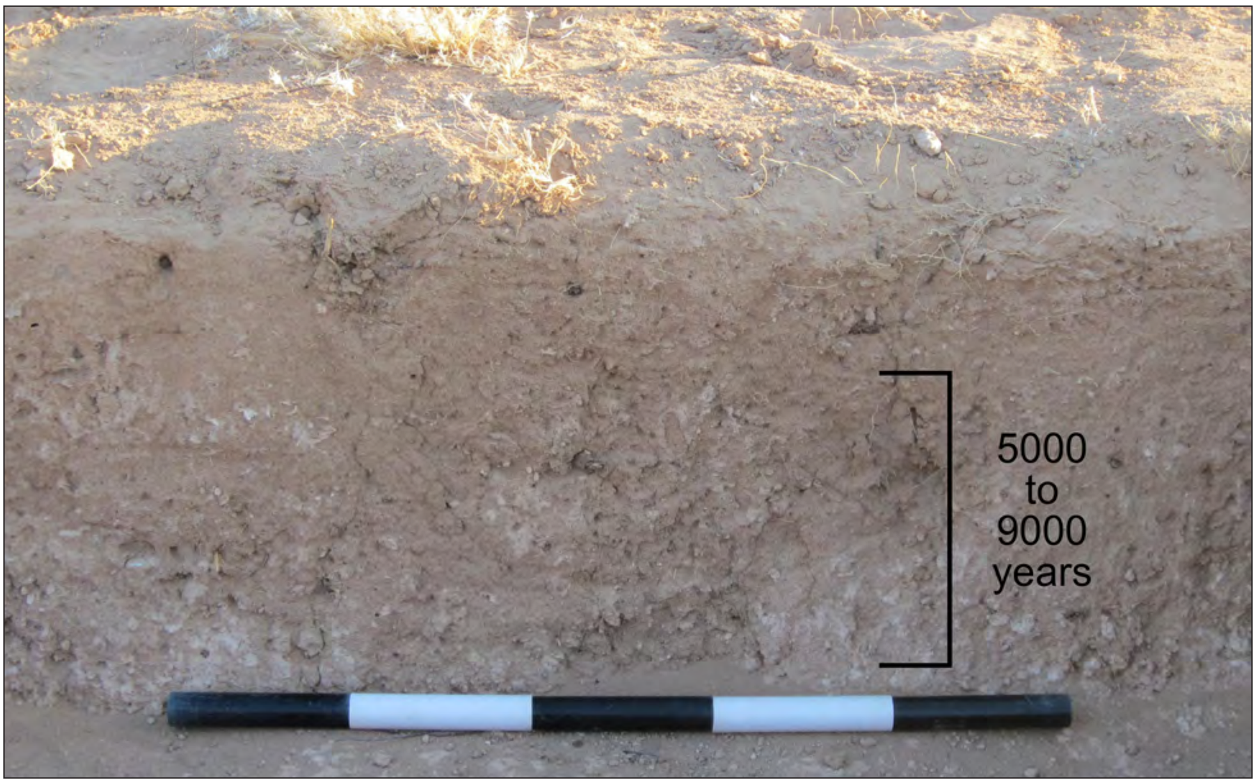

Figure 21.41. LA 111429, Surface Strip 6, close-up of Paleoindian horizon, showing cicada insect burrows and other small disturbance; scale is 50 cm.

Figure 21.42. LA 111429, location of the vertical OSL sample in cover sediment (Qcs) marked by orange/red flags (photographed Dec. 3, 2010).

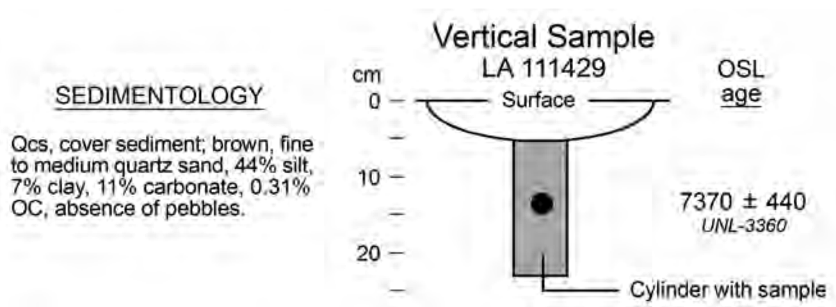

Figure 21.43. LA 111429, sedimentology of cover sediment (Qcs) at the vertical sample locality (data in Table 21.17).

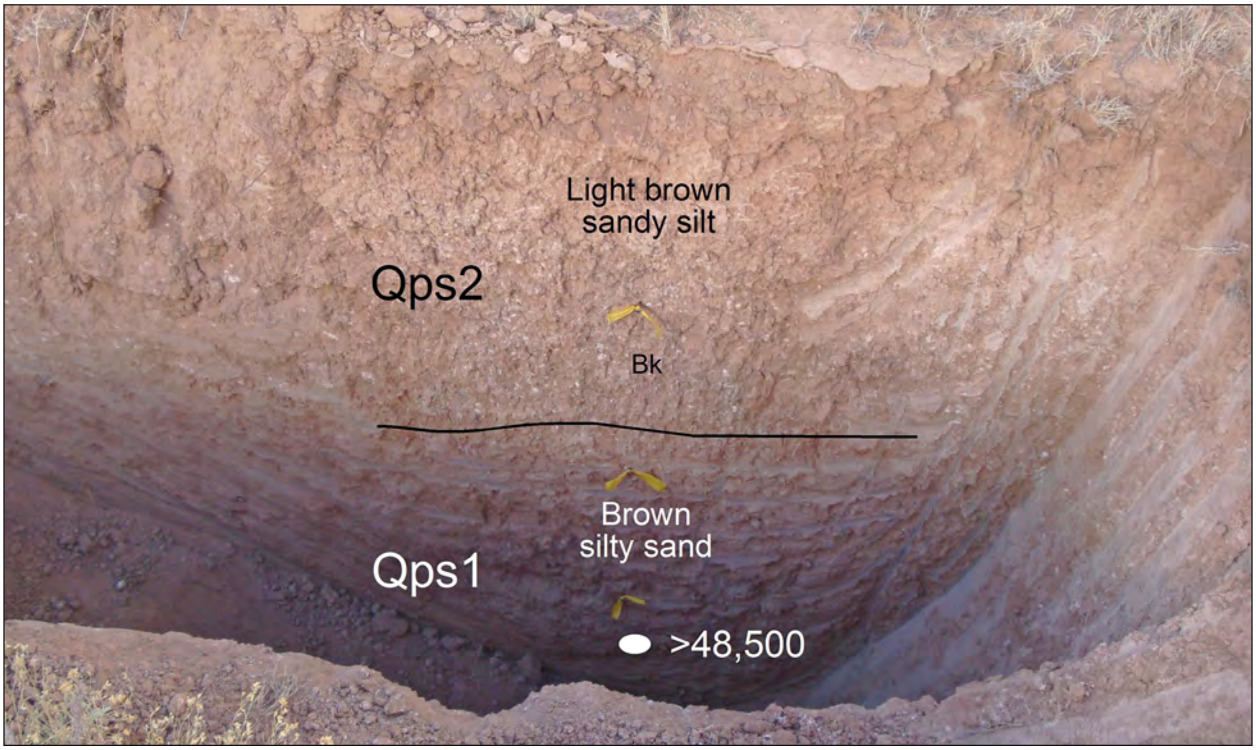

Figure 21.44. LA 111432, BHT 1, piedmont alluvium (Qps1, Qps2); yellow tags are at 50 cm intervals.

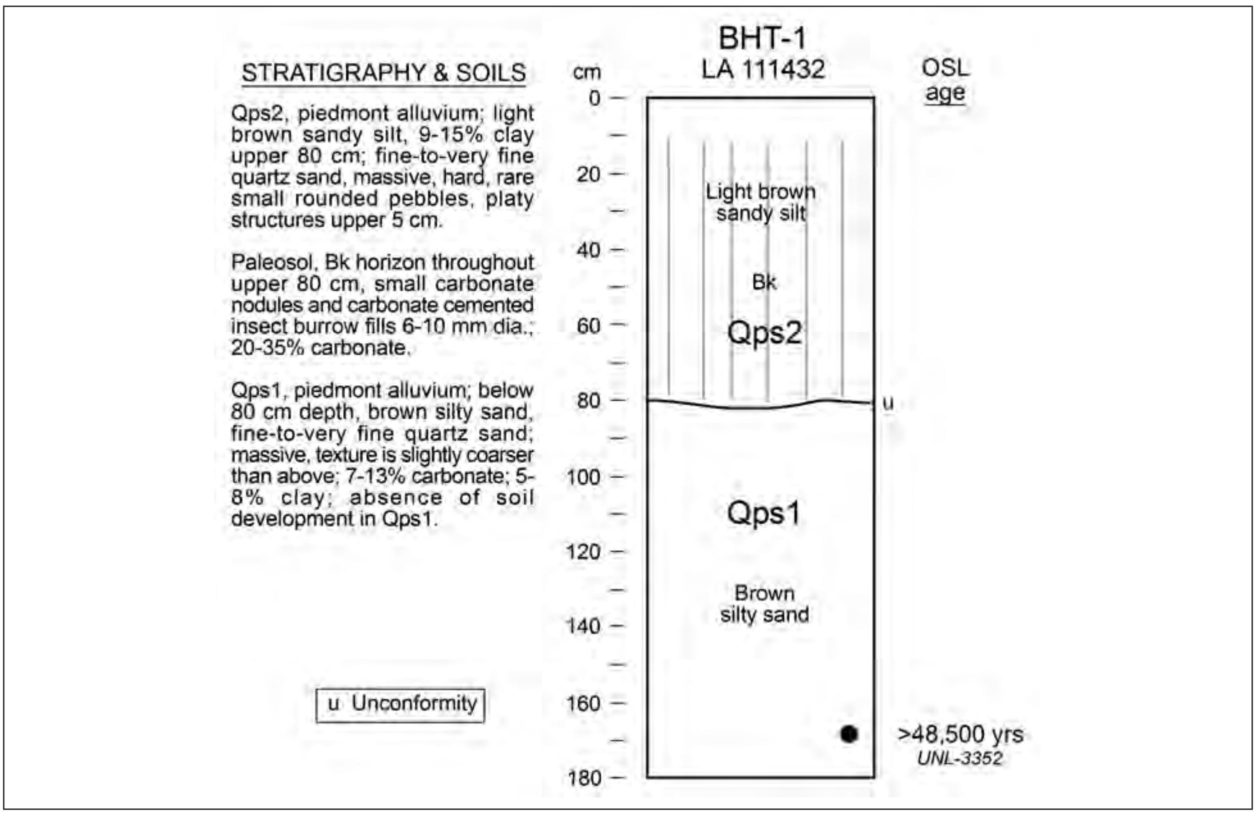

Figure 21.45. LA 111432, BHT 1, stratigraphic column of piedmont alluvium.

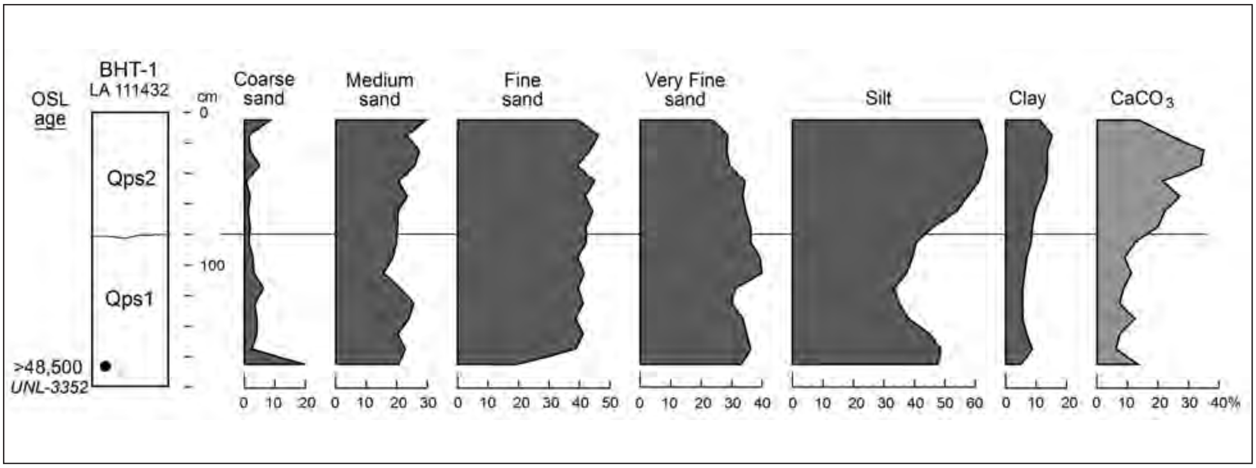

Figure 21.46. LA 111432, BHT 1, sediment diagram of piedmont alluvium (data in Table 21.18).

organic carbon and 1 to 2 percent carbonate. Organic matter from the soil is AMS radiocarbon-dated 490 ± 30 ^{14}C years BP or about AD 1427 (Table 21.5).

The A-horizon soil (*Qah*), with a possible very weak Bw component, rests directly on the eolian sand sheet (*Qes*). The sand sheet is brown fine- to medium-textured quartz sand with 22 to 30 percent silt (Figs. 21.47, 21.48, 21.49; Table 21.19). The sand has many insect-burrow fills up to 16 mm diameter and a few rodent-burrow fills 60 mm in diameter. A weak Bk soil horizon with faint carbonate filaments occurs between about 60 to 100 cm depth; carbonate content is 2 to 4 percent. Below 130 cm depth is a zone of eolian sand that is finer textured and contains more silt and clay. Small carbonate filaments with 7 to 8 percent carbonate indicate the presence of a Bk soil horizon. The sand may represent the early stage of wind-deposition of the sand sheet and a brief period of early soil development not observed in other trenches. Five OSL ages from the *Qes* sand at BHT 18 range from 6090 ± 230 to 1380 ± 80 years, or 4079 BC to AD 631, including the zone at the base of the sand.

LA 112370

The site occurs on the distal surface of the piedmont slope that originates in the San Andres Mountains to the east, similar to the occurrence of LA 112371 and LA 112374. The geology is mapped as fine-grained piedmont-slope deposits (*Qpad*) by Seager (2005). BHT 5 at the site exposes light-brown sandy silt at the immediate subsurface that is identified as piedmont alluvium (*Qps2*) (Figs. 21.50, 21.51, 21.52; Table 21.20). Although not directly dated at LA 112370, the piedmont alluvium unit is correlated to other trench exposures in the area where it is OSL-dated 40 ka to greater than 65 ka. Cover sediment is not present at LA 112370. Underlying *Qps2* is *Qps1*, an earlier piedmont alluvial deposit that is OSL-dated greater than 66.2 ka at this site. The late Pleistocene age of the subsurface sediments at LA 112370 indicates that buried cultural horizons are not present.

LA 112371

The site is located on the distal surface of the piedmont slope of the San Andres Mountains, and the geology is mapped as fine-grained piedmont-slope deposits (*Qpad*). Piedmont alluvium (*Qps2*) outcrops at the surface in BHT 6 at the site (Figs. 21.53, 21.54; Table 21.21). The piedmont alluvium is a light-brown silt, very hard, and incorporating numerous insect burrow fills that are a focus of carbonate concentration, mimicking soil carbonate nodules. Qps2 is 105 cm thick at the site and overlies the earlier piedmont alluvium Qps1. Neither piedmont alluvial units are dated at LA 112371 although elsewhere they are OSL-dated late Pleistocene and are earlier than the local archaeological record. Site features may intrude into the piedmont alluvium, but buried in situ cultural features will be absent.

Table 21.18. LA 111432, BHT 1, sediment data.

Field/ Lab No.	Interval (cm)	Very Coarse Sand (%)	Coarse Sand (%)	Medium Sand (%)	Fine Sand (%)	Very Fine Sand (%)	Sand (%)	Silt (%)	Clay (%)	$CaCO_3$ (%)	Dry Munsell Color
Qps2, Piedmont Alluvium											
256	0–10	0	8	29.2	39.3	23.5	27.5	61.2	11.3	13.6	7.5YR 6/4
257	20–?	0	1.5	23.4	46.5	28.6	21.9	62.9	15.2	23.1	7.5YR 6/4
258	20–30	0	1.5	27.2	43.3	28	22.2	63.6	14.2	35	7.5YR 6/3
259	30–40	0	4.8	26	39.5	29.8	23.3	62.6	14.1	34.2	7.5YR 6/3
260	40–50	0	0.4	20.5	44.8	34.4	25.4	61.7	12.9	21.8	7.5YR 6/3
261	50–60	0	1.8	22.9	42	33.2	31.7	57.2	11.1	27.1	7.5YR 6/3
262	60–70	0	0.7	20.1	44.5	34.7	36.9	53.5	9.6	22.3	7.5YR 6/3
263	70–80	0	2.1	19.5	42	36.5	44.6	46.3	9.1	20	7.5YR 6/3
Qps1, Piedmont Alluvium											
264	80–90	0	1.6	20	42.2	36.2	51.6	40.4	8	12.3	7.5YR 6/3
265	90–100	0	2.6	18.6	39.7	39.1	53.5	39.5	7	9.1	7.5YR 5/3
266	100–110	0.6	2.9	15.4	41.3	39.7	55.7	37.4	6.9	11	7.5YR 5/3
267	110–120	1.2	6.6	21.6	39.7	30.9	60.7	32.9	6.5	9.1	7.5YR 5/3
268	120–130	0	2.8	25.4	41.8	30	58.7	35	6.3	7.4	7.5YR 5/3
269	130–140	0	3.8	23.6	38.9	33.7	55.7	38.1	6.1	12.4	7.5YR 6/3
270	140–150	0.5	3.6	20.2	40.9	34.8	47.8	45	7.2	7.3	7.5YR 5/3
271	150–160	0	2.5	22.6	38.7	36.2	43.6	48.5	8	6.6	7.5YR 5/4
272	160–170	6.2	20.5	20.6	19.8	33	47.5	47.6	4.9	13.1	7.5YR 5/3

Note : analyses by Pedology Laboratory, University of Kansas.

[a] Normalized to color categories in Munsell Color, 2009; spectrophotometer data in Table 21.2.

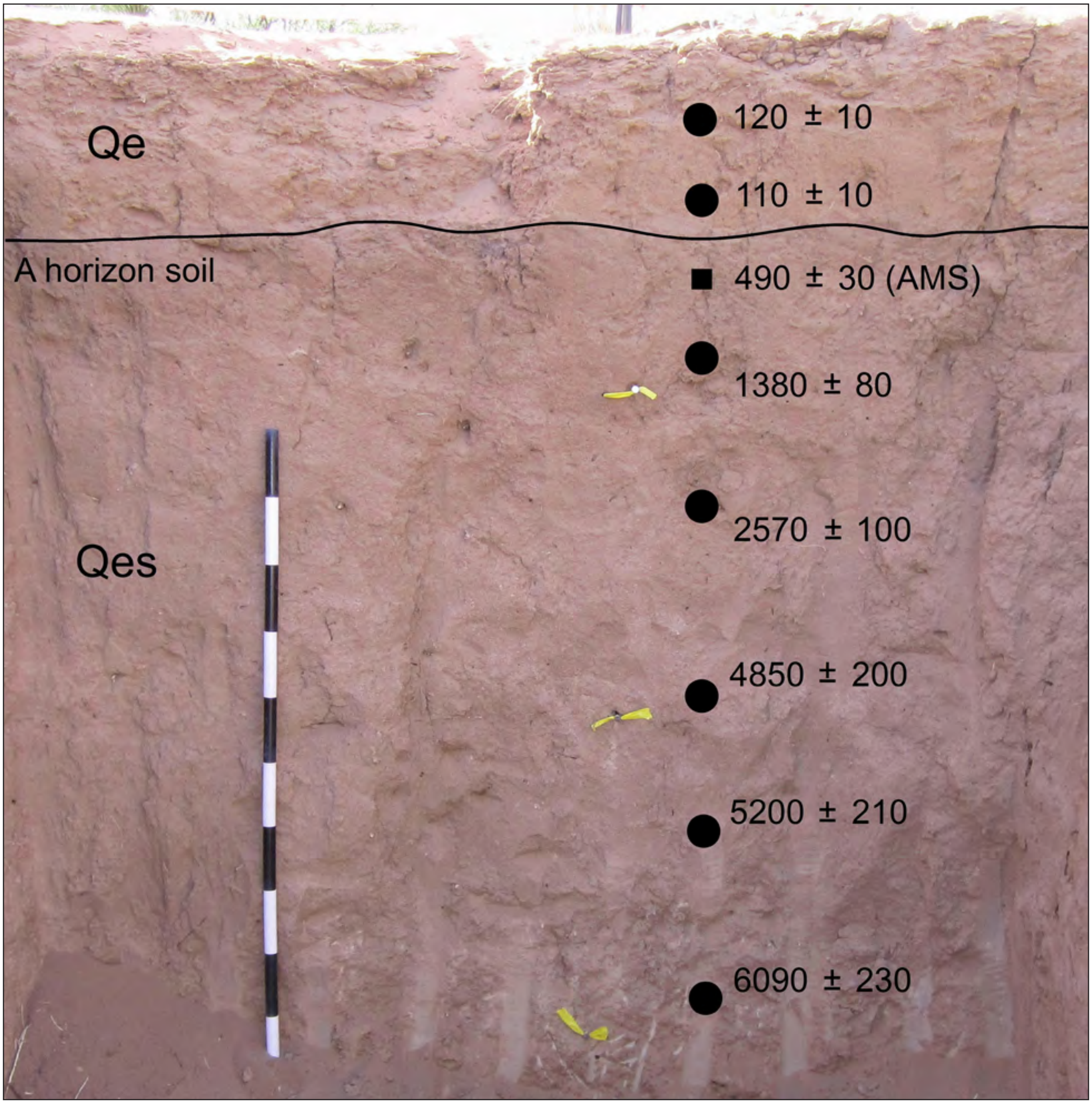

Figure 21.47. LA 111435, BHT 18, eolian sand (Qes, Qe) and A horizon soil; yellow tags at 50 cm intervals; scale is 1 m.

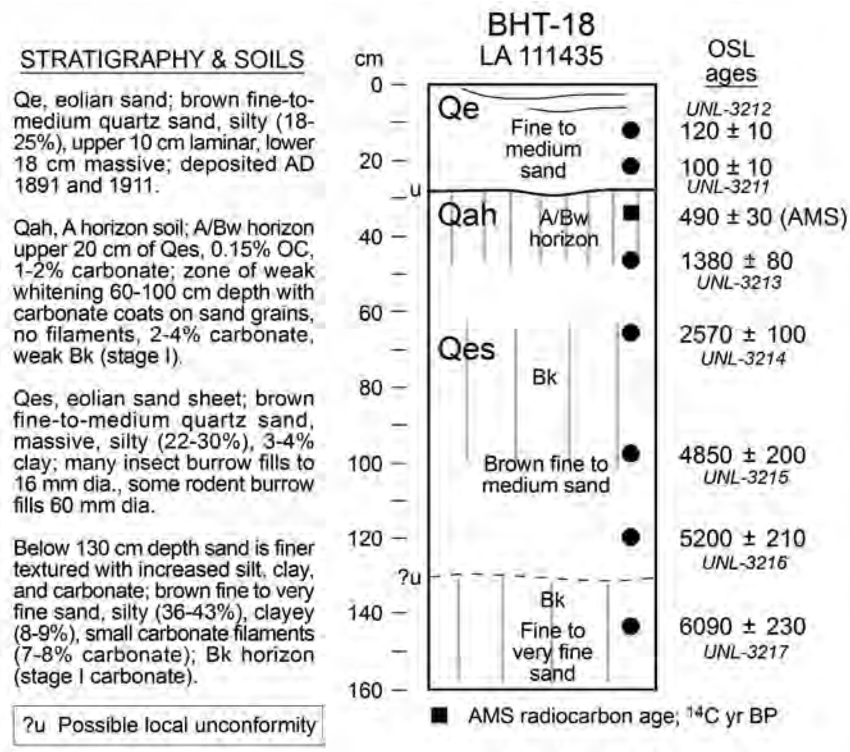

Figure 21.48. LA 111435, BHT 18, stratigraphic column of eolian sand.

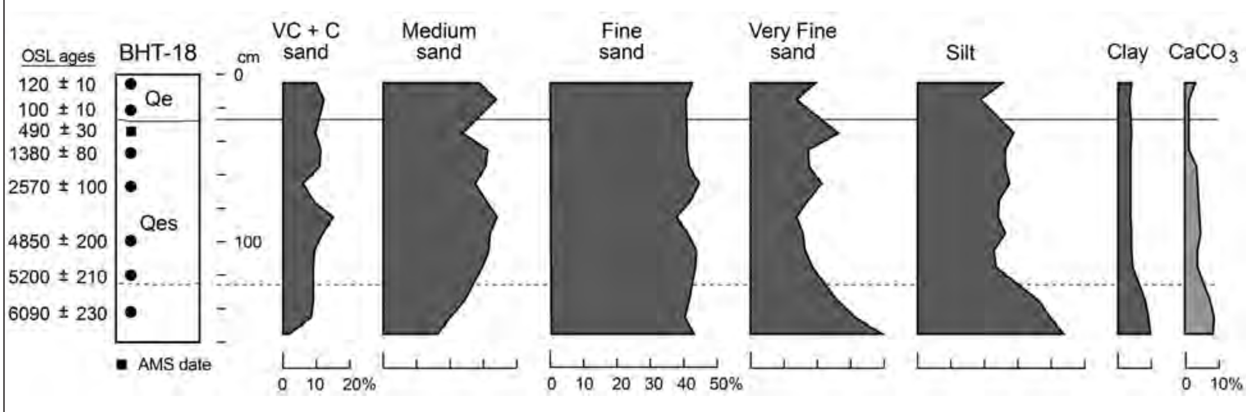

Figure 21.49. LA 111435, BHT 18, sediment diagram of eolian sand (data in Table 21.19).

Table 21.19. LA 111435, BHT 18, sediment data.

Field/ Lab No.	Interval (cm)	Very Coarse Sand (%)	Coarse Sand (%)	Medium Sand (%)	Fine Sand (%)	Very Fine Sand (%)	Sand (%)	Silt (%)	Clay (%)	$CaCO_3$ (%)	Organic Carbon (%)	Dry Munsell Color
Qe, Young Eolian Sand												
88	0–10	0.2	10	28.6	42.2	19	71.1	25.1	3.8	2.8	0.1	7.5YR 5/4
89	20–?	0.07	12.2	33.9	40.7	13.1	78.9	18.3	2.8	1.2	0.07	7.5YR 5/4
Qah, A Horizon Soil												
90	30–40	1	8.9	23.5	40.6	26	66.8	29.6	3.7	0.9	0.15	7.5YR 5/3
91	40–50	0.09	11.2	31	40.7	17	69.9	26.8	3.3	2.2	0.15	7.5YR 5/3
Qes, Eolian Sand Sheet												
92	50–60	0.03	10.5	30.3	41.7	17.5	70.2	26.7	3.1	2.6	0.05	7.5YR 5/3
93	60–70	0	6	27.6	44.7	21.7	69.5	27.4	3.1	2.5	<dl*	7.5YR 5/3
94	70–80	0	9.8	30.9	42.2	17.2	72.3	24.4	3.3	3	0.1	7.5YR 5/3
95	80–90	0.06	15	34.1	37.8	13.1	73.5	23.1	3.4	4.4	0.06	7.5YR 5/3
96	90–100	0	10.9	32	41.2	15.8	70.1	25.9	3.9	4.3	0.18	7.5YR 5/3
97	100–110	0	9	31	43.5	16.5	74.2	22.4	3.4	3.3	0.08	7.5YR 5/4
98	110–120	0	9.2	29.7	42.9	18.2	73.4	22.9	3.7	3.2	0.06	7.5YR 5/3
99	130–140	0.2	8.7	24.2	41.7	25.2	55.9	36.2	7.9	7.4	0.16	7.5YR 5/3
100	140–150	0.3	7.9	20	40.2	31.6	52.1	39.7	8.2	8	0.05	7.5YR 5/4
101	150–160	0	1.9	16.1	42.9	39.2	47.6	43.3	9	7.9	0.09	7.5YR 5/4

Note: analyses by Pedology Laboratory, University of Kansas.

* <dl, below detection limit.

[a] Normalized to color categories in Munsell Color, 2009; spectrophotometer data in Table 21.2.

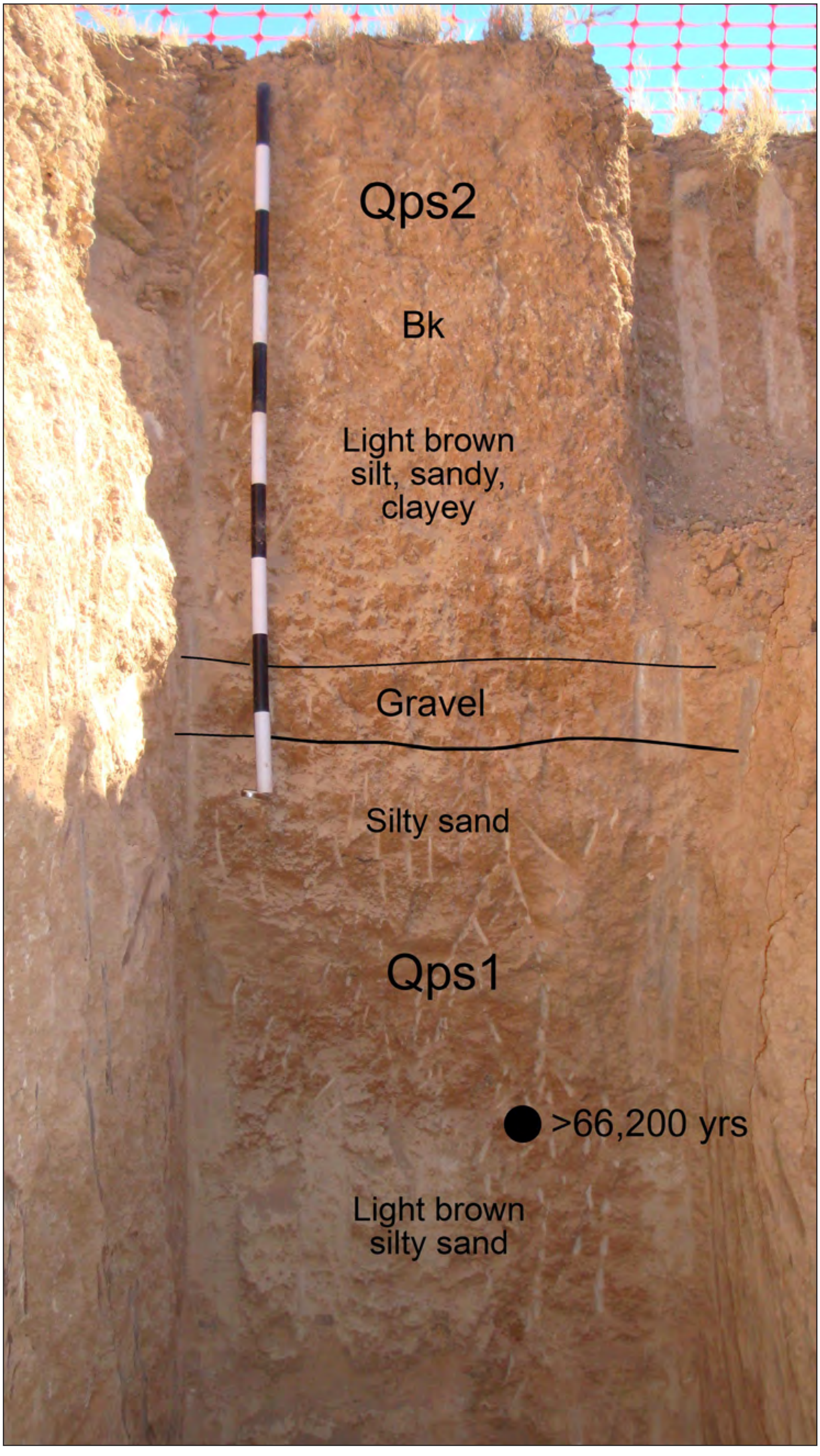

Figure 21.50. LA 112370, BHT 5, piedmont alluvium (Qps1, Qps2); scale is 1 m.

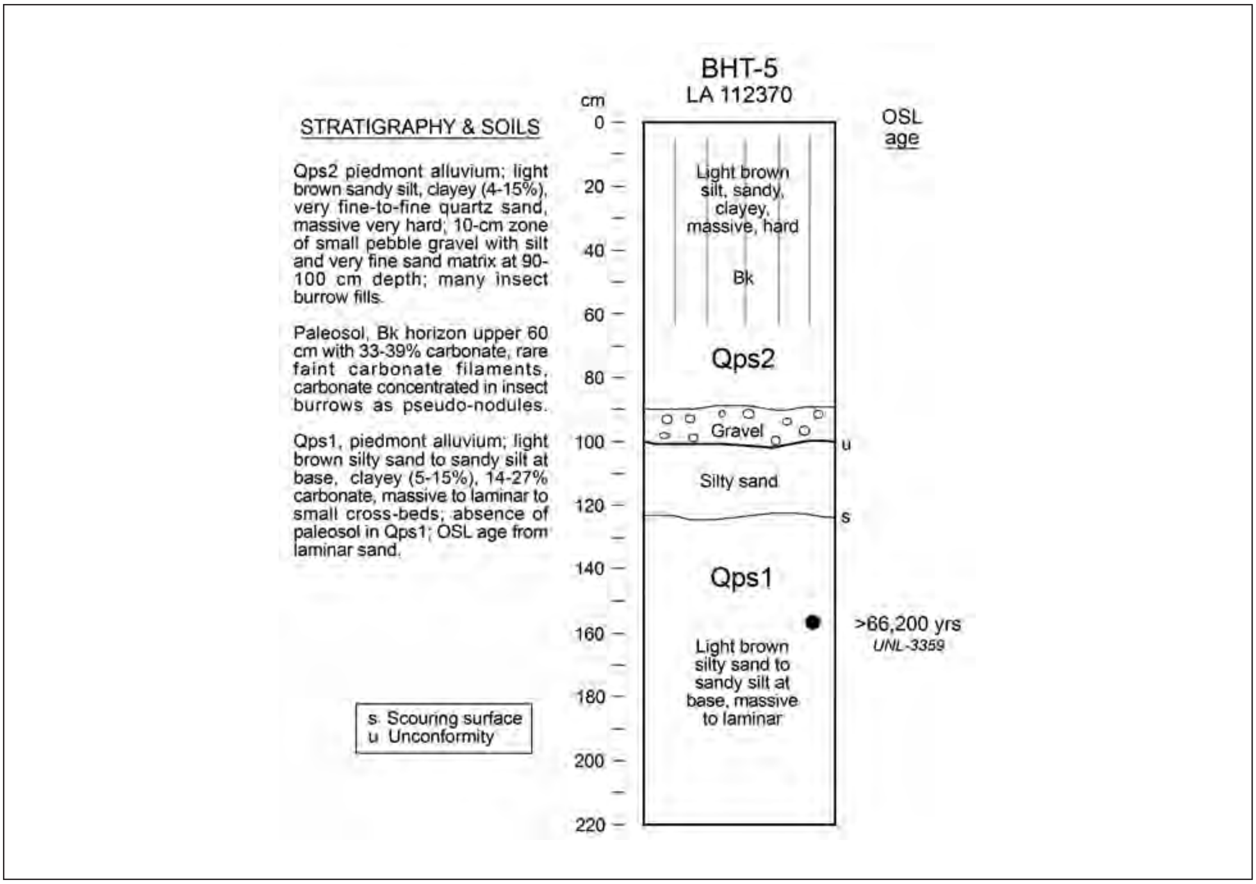

Figure 21.51. LA 112370, BHT 5, stratigraphic column of piedmont alluvium.

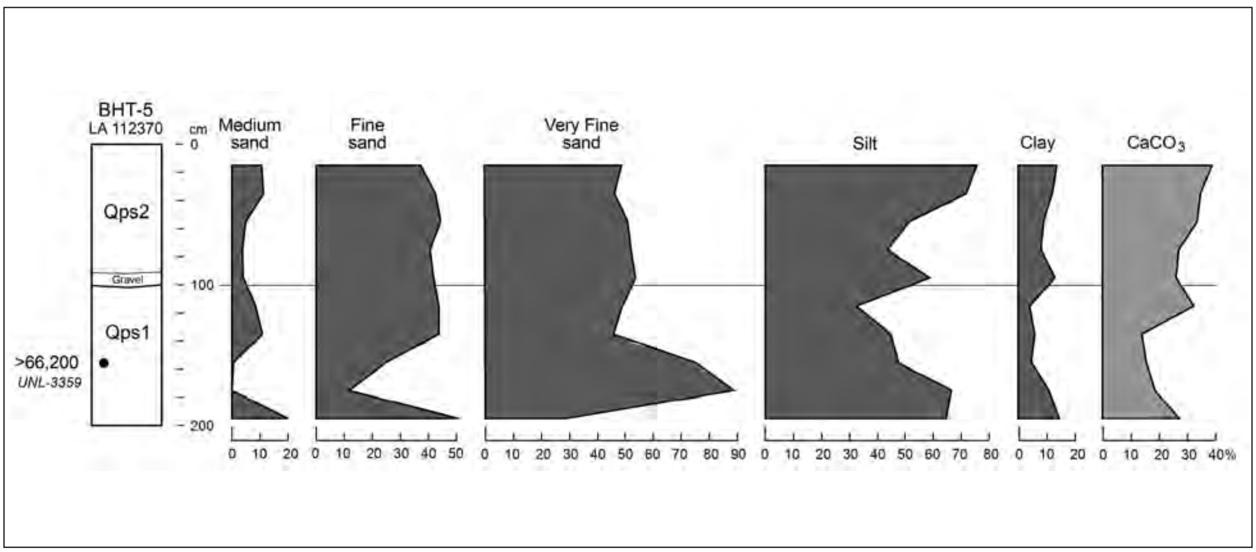

Figure 21.52. LA 112370, BHT 5, sediment diagram of piedmont alluvium (data in Table 21.20).

Table 21.20. LA 112370, BHT 5, sediment data.

Field/ Lab No.	Interval (cm)	Very Coarse Sand (%)	Coarse Sand (%)	Medium Sand (%)	Fine Sand (%)	Very Fine Sand (%)	Sand (%)	Silt (%)	Clay (%)	$CaCO_3$ (%)	Dry Munsell Color
Qps2, Piedmont Alluvium											
212	20–?	0	0	10.7	37.2	48.2	11.5	76	13	38.5	7.5YR 6/3
213	30–40	0	0.1	11	42.5	46.4	16	72	12.2	34.9	7.5YR 6/3
214	50–60	0	0	4.8	44.2	51	39.1	52	9.2	33.3	7.5YR 6/3
215	70–80	1.2	2.5	3.5	40.8	52.1	48.2	44	8.1	27	7.5YR 6/3
216	90–100	0	0	4.1	42	53.9	29	58	12.9	26.3	5YR 6/4
Qps1, Piedmont Alluvium											
217	110–120	0	0	7.9	43.8	48.3	63.7	32	3.9	32.2	7.5YR 6/3
218	130–140	0	0.1	10.9	43.1	45.9	49.7	45	5.6	13.8	7.5YR 6/4
219	150–160	0	0	0.02	24.6	75.3	47.9	48	4.6	15.9	5YR 6/4
220	170–180	0	0	0	11.4	88.6	22.8	66	10.7	18.8	7.5YR 6/4
221	190–200	0	0	20.3	51.7	28.1	21.3	64	14.5	27.1	7.5YR 6/3

Note: analyses by Pedology Laboratory, University of Kansas.

[a] Normalized to color categories in Munsell Color, 2009; spectrophotometer data in Table 21.2.

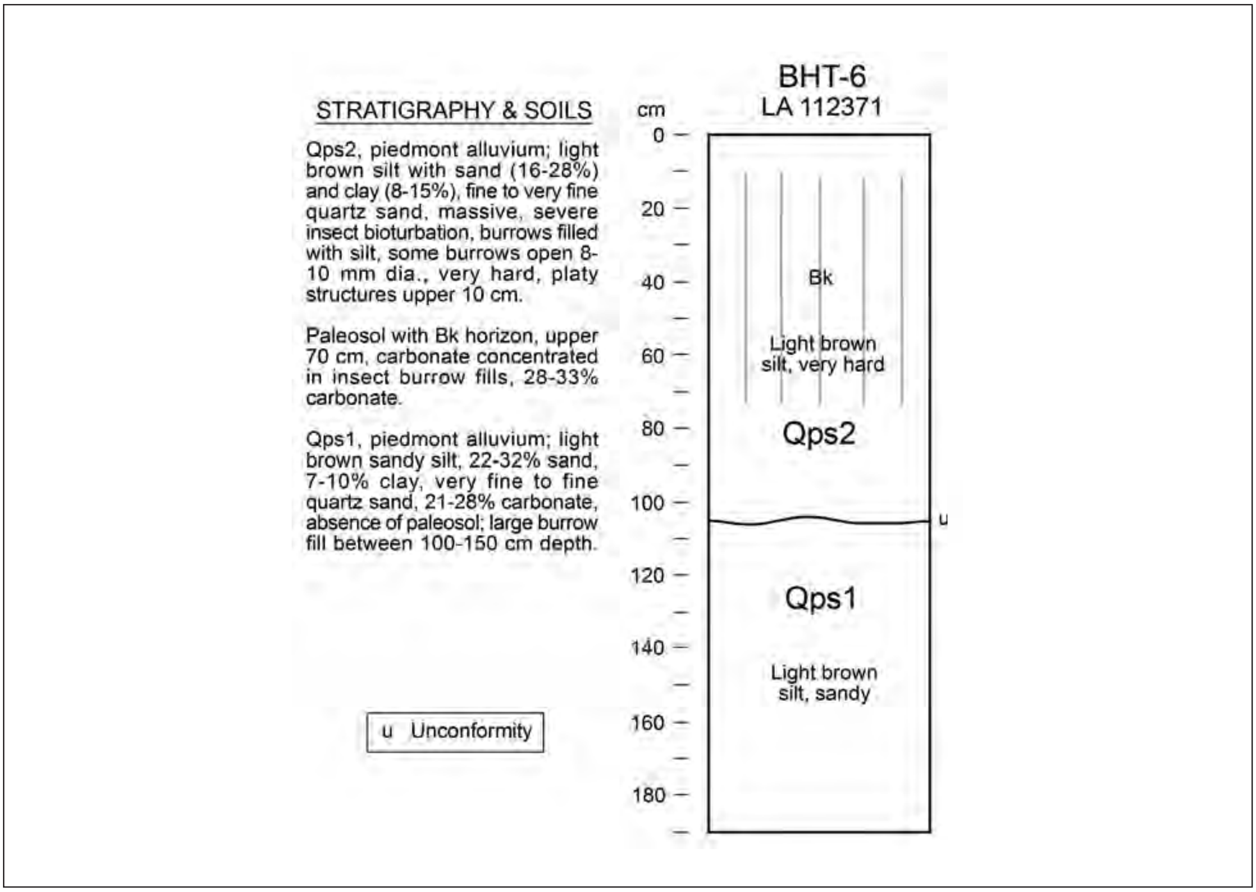

Figure 21.53. LA 112371, BHT 6, stratigraphic column of piedmont alluvium.

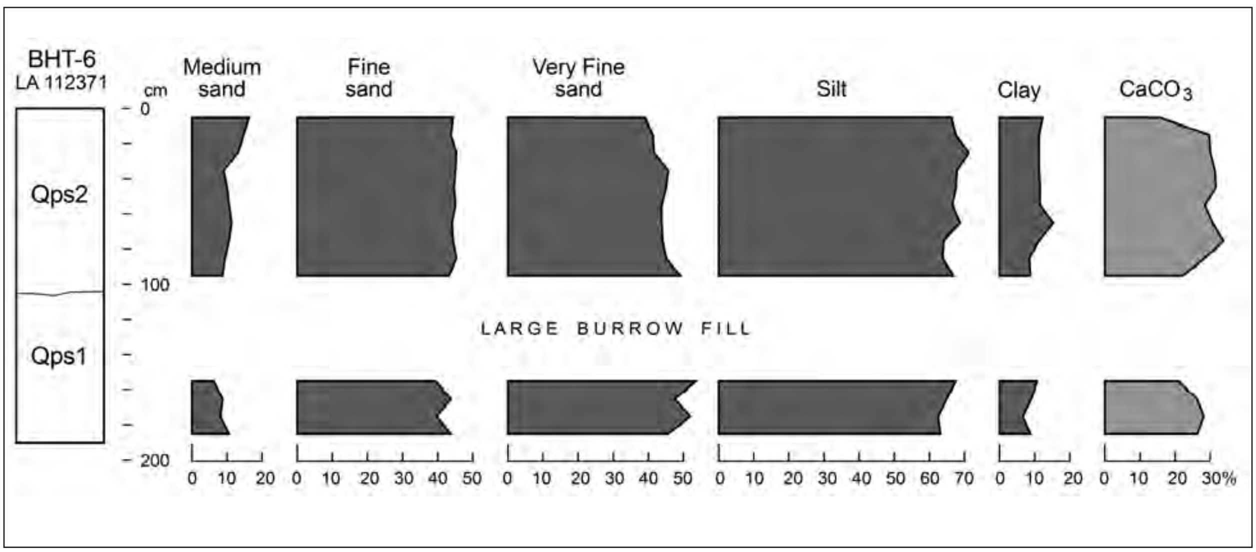

Figure 21.54. LA 112371, BHT 6, sediment diagram of piedmont alluvium (data in Table 21.21).

Table 21.21. LA 112371, BHT 6, sediment data.

Field/ Lab No.	Interval (cm)	Very Coarse Sand (%)	Coarse Sand (%)	Medium Sand (%)	Fine Sand (%)	Very Fine Sand (%)	Sand (%)	Silt (%)	Clay (%)	$CaCO_3$ (%)	Dry Munsell Color
Qps2, Piedmont Alluvum											
241	0–10	0	0.6	16.1	44.3	39	21.8	66	12	15.3	7.5YR 6/3
242	20–?	0	1.5	14.6	43	41	20.6	68	12	29.8	7.5YR 6/3
243	20–30	0	0.2	12.9	45.5	41.3	17.2	72	11	29.9	7.5YR 6/3
244	30–40	0	0.4	8.9	44.9	45.8	21.1	68	11	31.2	7.5YR 6/3
245	40–50	0	0.5	10	44.6	45	21.1	67	12	31.4	7.5YR 6/3
246	50–60	0	0.6	10.5	45.2	43.7	22	66	12	27.8	7.5YR 6/3
247	60–70	0	0.3	12.1	44	43.6	16.4	68	15	30.2	7.5YR 6/3
248	70–80	0	0.5	10.8	44.7	44	25.7	64	11	33	7.5YR 6/3
249	80–90	0	0.3	9.4	45.3	45	28.5	64	8	27.8	7.5YR 6/3
250	90–100	0	0.3	8.1	42.7	49	24.5	67	8.6	21.8	7.5YR 6/4
(100–150 cm interval skipped due to presence of large burrow fill)											
Qps1, Piedmont Alluvium											
251	150–160	0	0	6.1	39.6	54.3	22.4	67	10	20.9	5YR 5/4
252	113–120	0	0.5	8.2	43.4	47.8	27.6	63	9.3	26.7	7.5YR 6/4
253	120–130	0	0.4	7.8	39.8	52	32.3	61	6.8	27.9	7.5YR 6/4
254	130–140	0	0.6	10.3	43.8	45.3	28.7	63	8.5	26.2	7.5YR 6/4
Sediment from Large Burrow Fill at ~120 cm Depth											
255	~120	0	5.6	29.1	37.9	27.4	35.1	57	8.2	18.3	7.5YR 5/4

Note: analyses by Pedology Laboratory, University of Kansas.

[a] Normalized to color categories in Munsell Color, 2009; spectrophotometer data in Table 21.2

LA 112374

The site is located on the distal surface of the piedmont slope of the San Andres Mountains at the southeastern corner of the study area. The geology at the site is mapped as fine-grained piedmont-slope deposits (*Qpad*) by Seager (2005). The subsurface stratigraphy of the site is revealed in BHT 4 and is characterized by 70 cm of brown sandy silt representing the cover sediment unit (*Qcs*) (Figs. 21.55, 21.56, 21.57; Table 21.22). The cover sediment is OSL-dated 14,900 ± 1000 at LA 112374. Below 70 cm depth is brown sandy silt representing piedmont alluvium (*Qps2*). Four OSL ages from the piedmont alluvium are greater than 49.2 ka to greater than 65.6 ka. The occurrence of artifacts at the surface at LA 112374 is consistent with the antiquity of the subsurface deposits that pre-date the archaeology. Although pit-like features have the potential to intrude into cover sediment (*Qcs*), buried cultural horizons will not be present.

LA 155963

This is a large site covering a wide area in the northwestern corner of the study area. The site occurs on a comparatively flat, gently sloping surface of piedmont alluvium (*Qpo*) that surrounds a low-relief hill formed by resistant-to-erosion calcrete of the Camp Rice Formation (*Qcp*), as mapped by Seager (2005). Five backhoe trenches are located near LA 155963 to expose the variety of surface geology in the vicinity of the site.

BHT 7. This trench is located at the south edge of the site and exposes piedmont alluvium (*Qpc2*) overlain by 30 cm of cover sediment (*Qcs*). The cover sediment is massive light-brown to brown silt with fine- to very fine-textured sand. The sediment incorporates some insect burrow fills; pebbles are absent. The base of *Qcs* forms a sharp boundary with the underlying piedmont alluvium. One OSL age from near the base of *Qcs* is 9650 ± 750 years, compatible with the Paleoindian period.

The piedmont alluvium (*Qpc2*) is yellowish brown sandy silt to silty sand (Figs. 21.58, 21.59, 21.60; Table 21.23). It extends to the base of BHT 7 at 200 cm depth. The alluvium is massive and very hard; pebbles are absent. A nearly solid, dense mass of cicada insect burrow fills occurs between 60 and 120 cm depth. A Bk soil horizon occurs in the upper 60 cm of *Qpc2*. The paleosol has carbonate nodules 10 to 25 mm diameter. The outer layer of the nodules is soft carbonate and the inner core is hard. Overall bulk-sediment carbonate content is 10 to 16 percent. The top of the paleosol and the *Qpc2* unit are missing due to erosion.

Low relief, widely spaced mesquite coppice dunes (*Qec*) occur across the site. The base of a dune at BHT 7 is OSL-dated 150 ± 40 or AD 1860. The dune sediment is brown fine- to very fine-textured quartz sand (Table 21.24). The sand is weakly laminar, although the primary structures are disturbed due to rodent burrowing.

BHT 8. This trench and trenches 10 and 11 at LA 155963 expose the calcrete at the top of the Camp Rice Formation, all mantled by cover sediment (*Qcs*). The cover sediment is brown silty fine sand 38 cm thick. It is massive and contains many pebbles of caliche and limestone, derived from the underlying calcrete. A weak Bw soil horizon lies at the top of the unit, at the present-day surface.

The calcrete (*Qcc*) of the Camp Rice Formation extends from 38 to 260 cm depth; the base of the calcrete is not exposed. The calcrete is pinkish-white carbonate with an absence of laminar structure. The carbonate is hard but not dense; the amount of carbonate is 80 percent (Fig. 21.61; Table 21.25). The matrix of the calcrete, or the upper Camp Rice Formation, is very coarse- to coarse-textured quartz sand. It contains many limestone pebbles with 2 m thick carbonate coats. In some cases the upper surface of the limestone clasts has been removed by solution, probably representing different stages of calcrete formation (Fig. 21.62). A few isolated blocks of calcrete are present that may represent coarse-scale disturbance. Large burrow fills 20 cm across are present and extend to 140 cm depth. The burrow-fill material is powdery caliche. Quartz sand grains from a block of calcrete were processed for OSL dating resulting in an age of greater than 63 ka, consistent with the terminal age for the deposition of the Camp Rice Formation at about 780 ka (Seager and Mack 2003; Mack 1997).

BHT 9. This trench is located in the middle of the south area of LA 155963. The sediment exposed in the trench is piedmont alluvium, both the lower (*Qpc1*) and upper (*Qpc2*) units, to a depth of 270 cm. This is the only exposure of our lower piedmont alluvial unit (*Qpc1*) in the study area. It is light-brown to brown fine- to very fine-textured quartz sand with 19 to 28 percent silt and 21 to 35

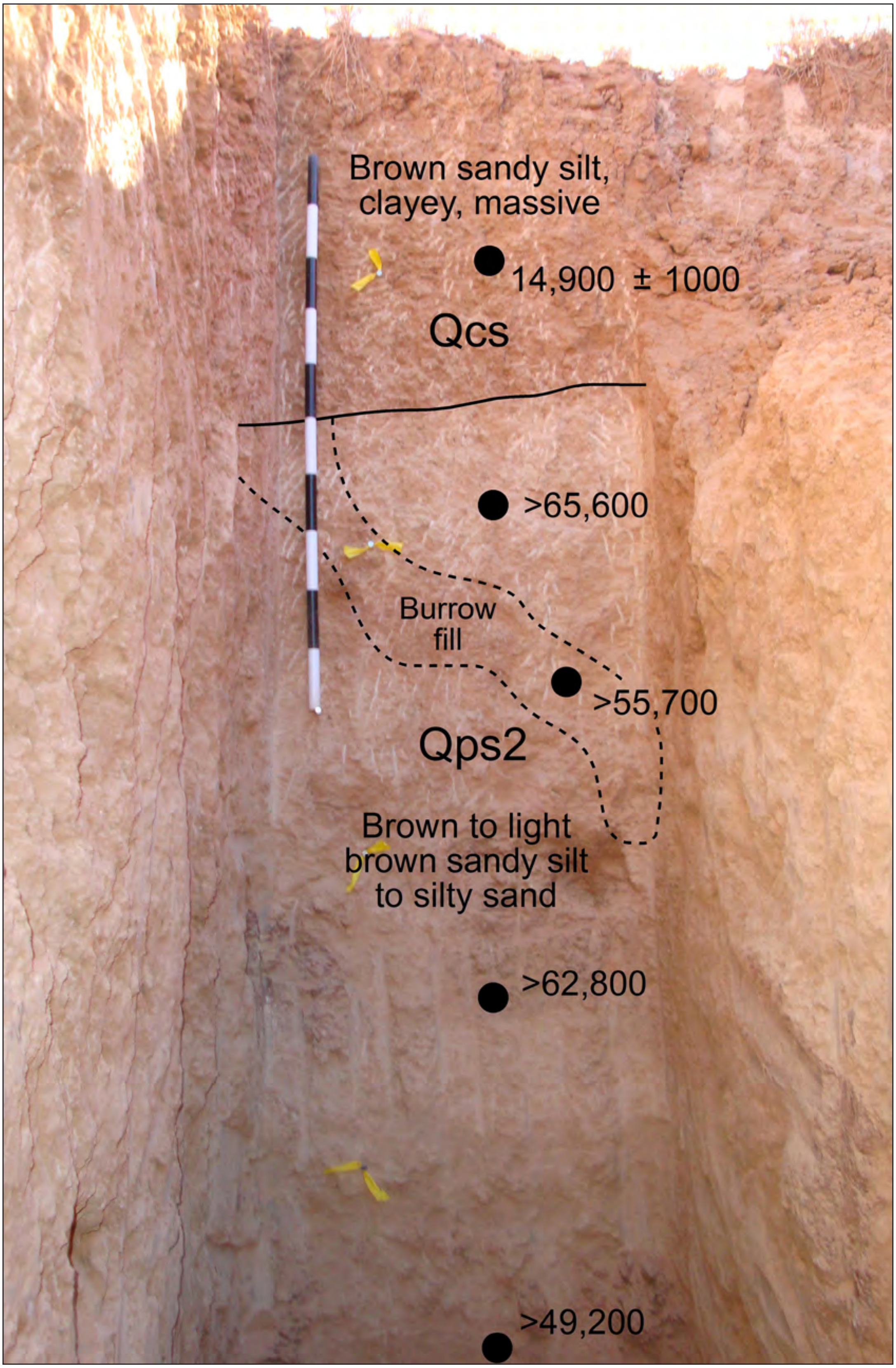

Figure 21.55. LA 112374, BHT 4, cover sediment (Qcs) overlying piedmont alluvium (Qps2) with large burrow fill; burrowing activity pre-dates Qcs, prior to 14.9 ka; yellow tags at 50 cm interval; scale is 1 m.

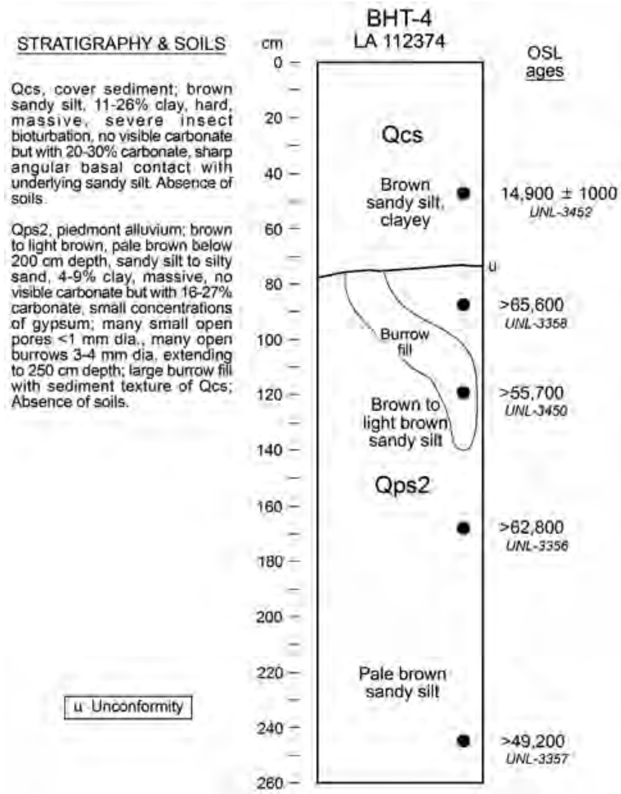

Figure 21.56. LA 112374, BHT 4, stratigraphic column of cover sediment and piedmont alluvium.

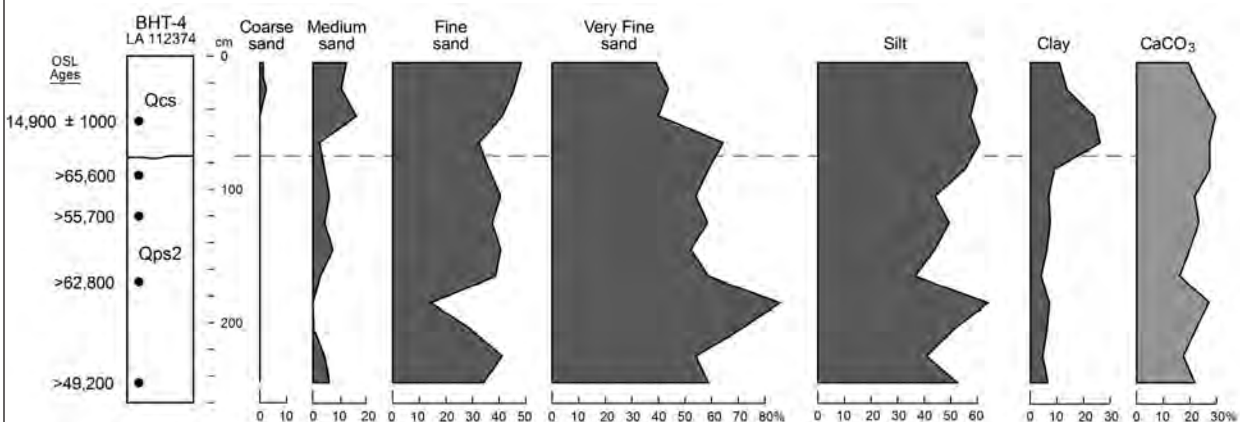

Figure 21.57. LA 112374, BHT 4, sediment diagram of cover sediment and piedmont alluvium (data in Table 21.22).

Table 21.22. LA 112374, BHT 4, sediment data.

Field/ Lab No.	Interval (cm)	Very Coarse Sand (%)	Coarse Sand (%)	Medium Sand (%)	Fine Sand (%)	Very Fine Sand (%)	Sand (%)	Silt (%)	Clay (%)	$CaCO_3$ (%)	Organic Carbon (%)	Dry Munsell Color
Qcs, Cover Sediment												
46	0–10	0	0.6	12.5	47.8	39.2	32.8	56.5	10.7	19.6	0.33	7.5YR 5/3
47	20–30	0	0.4	10.4	45.8	43.4	25.6	60.2	14.2	24.2	0.31	7.5YR 4/4
48	40–50	0	2.4	16.5	41.2	39.9	19.3	57	23.7	29.9	0.14	7.5YR 4/4
49	60–70	0	1.3	2.4	32.2	64.1	12.6	60.9	26.5	27.4	0.08	7.5YR 5/4
Qps2, Piedmont Alluvium												
50	80–90	0	0	4.5	36.7	58.8	35.6	55.2	9.2	27.5	<dl*	7.5YR 5/4
51	100–110	0	0.03	6.1	40.5	53.4	49.4	43.6	7	21.6	<dl	7.5YR 5/4
52	120–130	0	0	4.4	37.6	58	43.3	49.1	7.6	23.7	<dl	7.5YR 5/4
53	140–150	0	0.2	7.5	40.3	52	50.1	44.1	5.8	19.1	<dl	7.5YR 6/4
54	160–170	0	0	2.7	38.2	59.1	59	36.6	4.4	16.3	0.06	7.5YR 6/4
55	180–190	0	0	0	14.1	85.9	29.1	63.6	7.4	27.3	0.03	7.5YR 6/3
56	200–210	0	0	0.03	29.2	70.8	41.7	51.4	6.9	21.9	<dl	10YR 6/3
57	220–230	0	0	4.4	41	54.6	54.5	40.6	4.9	17.7	0.23	10YR 6/3
58	240–250	0	0.8	6.5	34.1	58.6	40.4	52.6	7.1	22	0.1	10YR 6/3
Zone of Irregular Red Clay with Gypsum												
59	150–180	0.2	2.1	8.3	38.5	50.9	29.9	45.3	24.8	12.6	–	5YR 5/3

Note: analyses by Pedology Laboratory, University of Kansas.

* <dl, below detection limit.

[a] Normalized to color categories in Munsell Color, 2009; spectrophotometer data in Table 21.2.

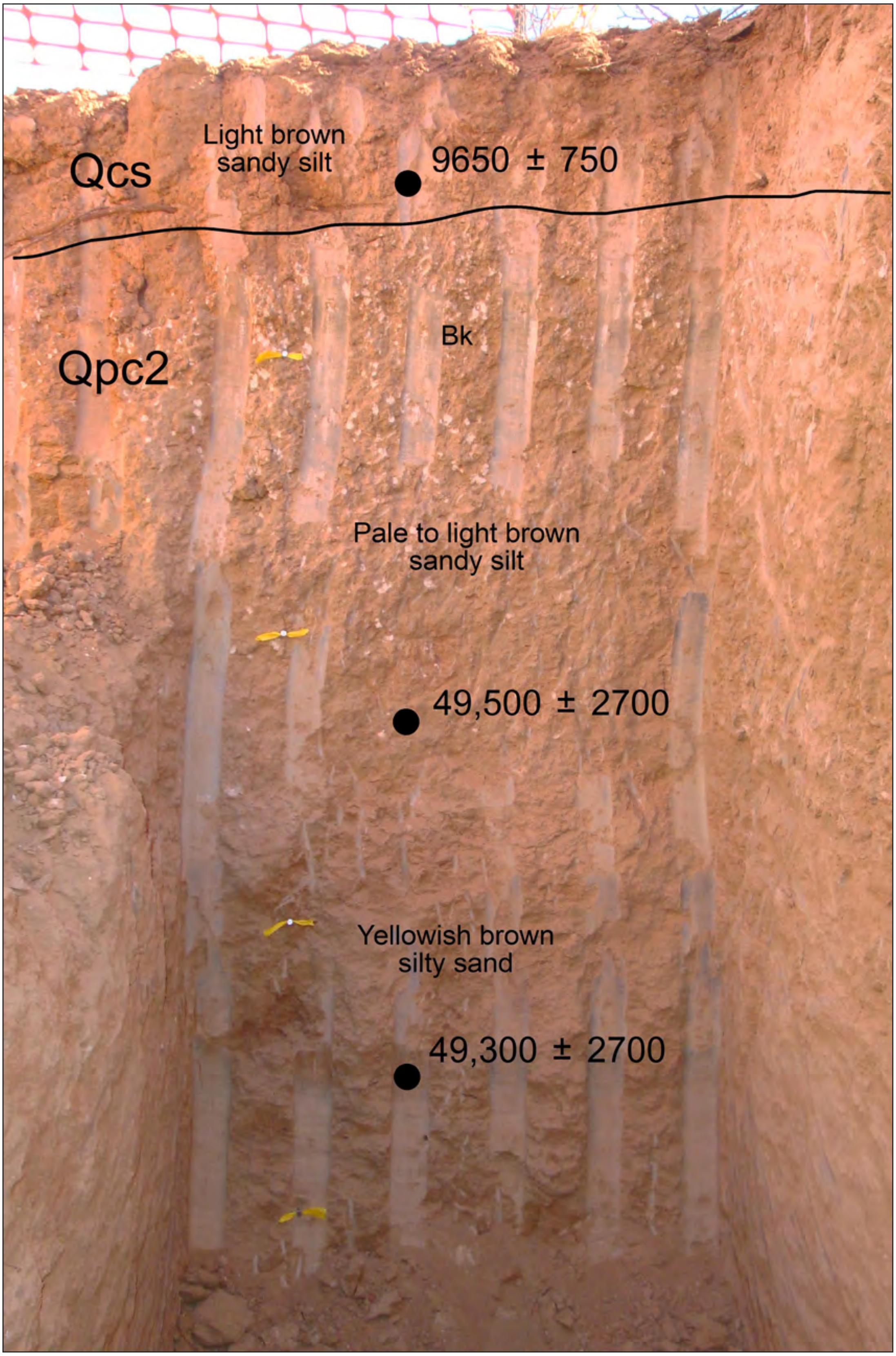

Figure 21.58. LA 155963, BHT 7, cover sediment (Qcs) overlying piedmont alluvium (Qpc2); yellow tags at 50 cm interval.

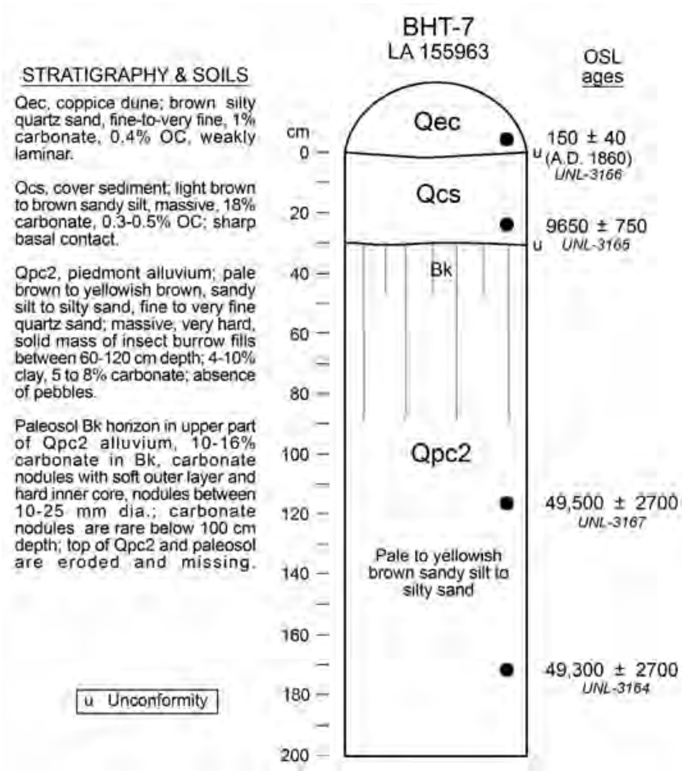

Figure 21.59. LA 155963, BHT 7, stratigraphic column of cover sediment and piedmont alluvium with overlying coppice dune.

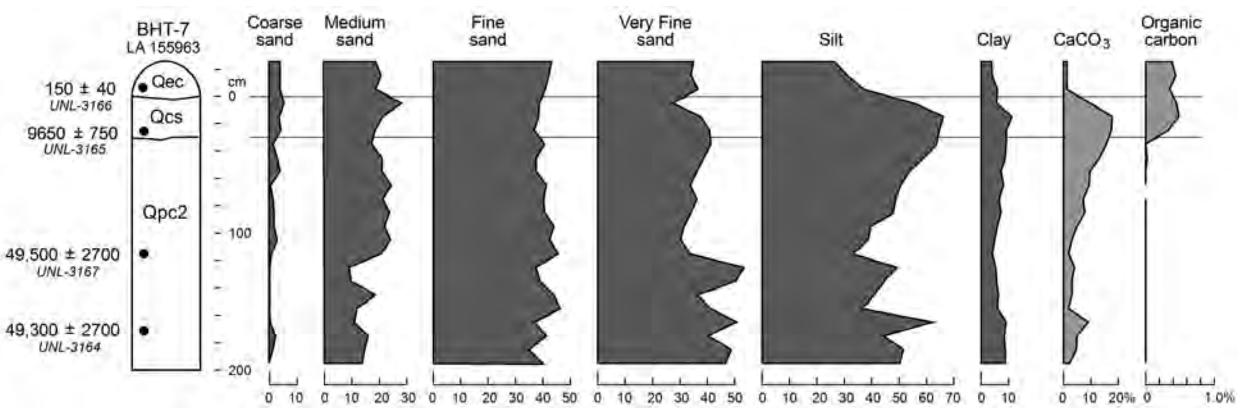

Figure 21.60. LA 155963, BHT 7, sediment diagram of coppice dune sand, cover sediment, and piedmont alluvium (data in Tables 21.23 and 21.24).

Table 21.23. LA 155963, BHT 7, sediment data.

Field/ Lab No.	Interval (cm)	Very Coarse Sand (%)	Coarse Sand (%)	Medium Sand (%)	Fine Sand (%)	Very Fine Sand (%)	Sand (%)	Silt (%)	Clay (%)	$CaCO_3$ (%)	Organic Carbon (%)	Dry Munsell Color
Qcs Cover Sediment												
164	0–10	0	5.5	27.9	38.9	27.6	37.9	55.6	6.5	9.9	0.45	7.5YR 5/4
165	20–?	0	3	21.1	38.5	37.4	23	66.2	10.8	17.8	0.48	7.5YR 6/4
166	20–30	0	3.7	19.2	36.7	40.5	25.6	64.8	9.6	17.5	0.31	7.5YR 6/4
Qpc2 Piedmont Alluvium												
167	30–40	0	1.4	17.5	40.5	40.6	26.8	63.6	9.6	15.5	0.01	7.5YR 6/3
168	40–50	0	2.9	21.4	37.2	38.4	32.9	59.1	8	12.8	0.11	10YR 6/3
169	50–60	0	4.3	21.8	37.6	36.3	39.6	53.1	7.3	9.2	<dl	10YR 6/3
170	60–70	0	0.4	24.5	41	34	41.6	50.6	7.8	9.5	<dl	10YR 6/3
171	70–80	0	1.5	21.9	40.2	36.4	44.7	48.4	7	7.2	0.05	10YR 5/3
172	80–90	0	1.8	24.1	40.6	33.5	44.8	47.9	7.2	7.8	0	10YR 6/3
173	90–100	0	1.9	22.1	44.3	31.7	55.8	38.8	5.4	4.4	<dl	10YR 6/3
174	100–110	0	3	24.2	42.6	30.2	57	38	5	2.9	0.07	10YR 5/4
175	110–120	0	0.6	20.4	45.7	33.3	63.1	32.6	4.3	1.8	0.03	10YR 5/3
176	120–130	0	0.05	9.5	37.4	53	45.4	49.4	5.1	4	<dl	10YR 5/4
177	130–140	0	0.1	10	39.4	50.4	50.3	44.4	5.3	2.8	0.08	10YR 5/4
178	140–150	0	0.5	18.8	44	36.7	52.9	41	6.1	2.7	0.04	10YR 5/4
179	150–160	0	0.03	12.2	46.2	41.6	57.6	36.8	5.6	1.9	0.01	10YR 5/4
180	160–170	0	0.5	11.6	37	50.9	28.1	62.5	9.4	8.5	<dl	7.5YR 6/4
181	170–180	0	2.6	16.5	40.9	40.1	47.8	44.3	7.9	4.9	<dl	10YR 5/4
182	180–190	0	1.1	14.9	35.2	48.8	40.4	51.2	8.4	4.6	0.01	10YR 5/4
183	190–200	0	0.3	13.3	40.1	46.3	40.9	50.7	8.4	2.2	0.36	10YR 5/4

Note : analyses by Pedology Laboratory, University of Kansas.

* <dl, below detection limit.

[a] Normalized to color categories in Munsell Color, 2009; spectrophotometer data in Table 21.2.

Table 21.24. LA 155963, coppice dune sequence.

Field/ Lab No. SP-	Interval (cm)	Very Coarse Sand (%)	Coarse Sand (%)	Medium Sand (%)	Fine Sand (%)	Very Fine Sand (%)	San d (%)	Silt (%)	Clay (%)	$CaCO_3$ (%)	Organic Carbon (%)	Dry Munsell Color
Top of Column at BHT 9												
1	-10	0.1	1	15.5	47.7	35.7	62	31	7	3.7	0.51	7.5YR 5/3
Coppice Dune at BHT 7, Measurements Up from Base of Dune												
37	-10	0.1	1.1	19.5	46.6	32.7	77	14	9	3.9	0.79	7.5YR 4/3
38	-10	0	1.3	21.3	46	31.4	77	14	9	3.5	0.5	10YR 5/3
39	-10	0.1	1.2	16.9	46.8	35	76	14	10	3.6	0.38	7.5YR 5/4
Unit Qpc2 Sediment Below Coppice Dune												
40	0–10	0.1	1.2	15.3	47.4	36	53	22	25	8.4	–	7.5YR 4/4
41	20–?	0.2	1.4	19	48.2	31.2	47	20	33	11.5	–	7.5YR 4/4
Coppice Dune at BHT 7, Measurements Down from Top of Dune												
43	8–?	0	3.4	18.6	43	34.9	70.1	26.6	3.3	0.8	0.39	10YR 5/4
44	17–?	0	4.1	20.2	42.3	33.4	64.6	31.3	4.1	1	0.42	7.5YR 5/3
45	17–24	0.3	4	18.4	40.9	36.4	56.6	37.7	5.7	1.1	0.35	7.5YR 4/3

Note : analysis of samples #1 and #37-41 are by Milwaukee Soil Laboratory; analysis of samples #43-45 are by Pedology Laboratory, University of Kansas.

[a] Normalized to color categories in Munsell Color, 2009; spectrophotometer data in Table 21.2.

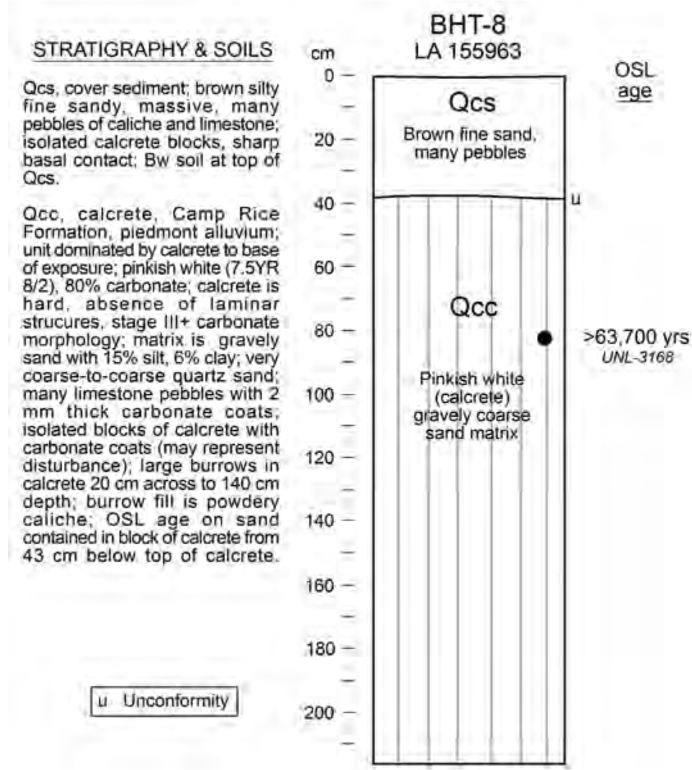

Figure 21.61. LA 155963, BHT 8, stratigraphic column of calcrete (Qcc) of the Camp Rice Formation and overlying cover sediment (Qcs) (data in Table 21.25).

Table 21.25. Paleosol calcrete (caliche) samples.

Field/ Lab No.	Locality	Very Coarse Sand (%)	Coarse Sand (%)	Medium Sand (%)	Fine Sand (%)	Very Fine Sand (%)	Sand (%)	Silt (%)	Clay (%)	$CaCO_3$ (%)	Dry Munsell Color
42	BHT 8	34.6	24.4	18.1	13.3	9.6	79	15	6	80	7.5YR 8/2
163	Outcrop LA 111429	14.3	34.2	25.1	14.5	11.9	83.5	15	1.4	85.2	7.5YR 6/3
273	BHT 10	0	5.5	27.9	38.9	27.6	37.9	56	6.5	80.5	7.5YR 8/2

Note : analyses No. 42 by Milwaukee Soil Laboratory; No. 163 and 273 by Pedology Laboratory, *University of Kansas.*

[a] Normalized to color categories in Munsell Color, 2009; spectrophotometer data in Table 21.2.

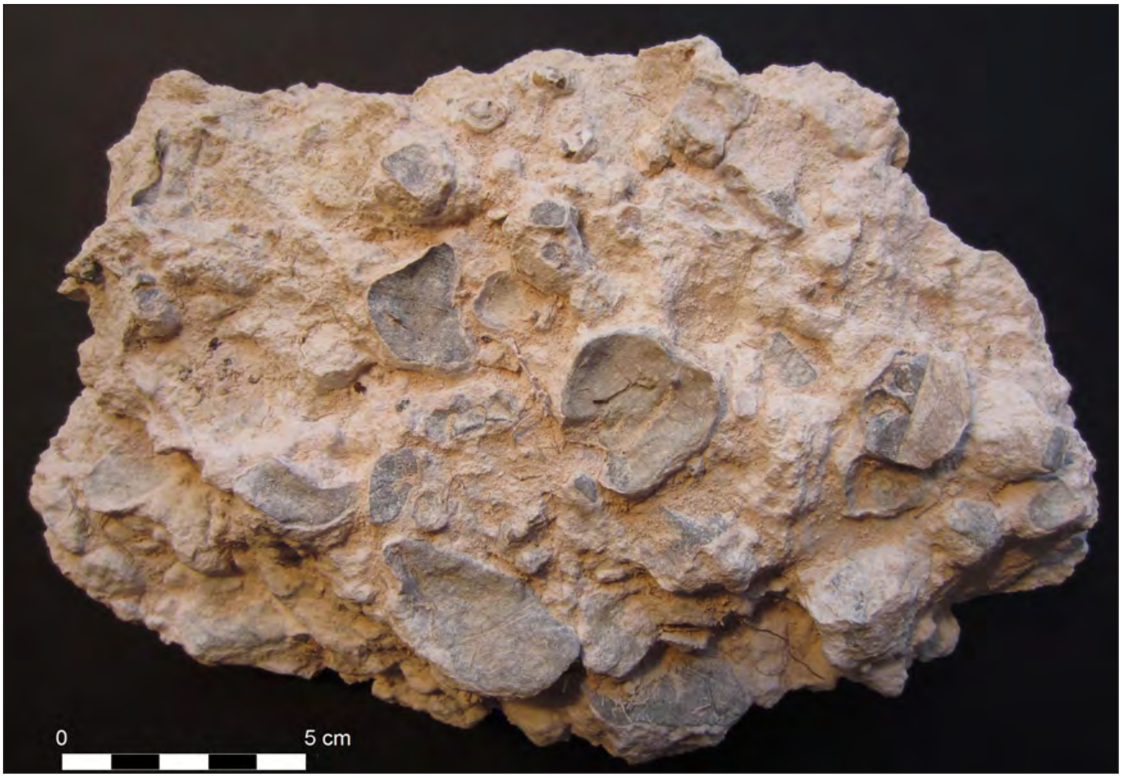

Figure 21.62. LA 155963, BHT 8, block of calcrete from Qcc with dissolved upper surfaces of gray limestone clasts, indicating an episode of solution during the formation of the thick calcrete.

percent clay (Figs. 21.63, 21.64, 21.65; Table 21.26). It is the only piedmont alluvial unit with gravel scattered throughout the 140 cm thick exposure. The gravel clasts are mostly black limestone; the clasts have 2 mm thick carbonate coats. *Qpc1* incorporates an argillic paleosol with a Bt-horizon with 35 percent clay and 0.43 percent Fe. Below the Bt is a Bk-horizon with 15 to 25 percent carbonate representing a stage I or I+ carbonate morphology. *Qpc1* is not directly OSL-dated, although the overlying unit is dated 43.2 ka.

The upper unit at BHT 9 is the upper piedmont alluvium (*Qpc2*). It is fine- to very fine-textured quartz sand with 24 to 40 percent silt. Gravel clasts are rare, in contrast to the underlying *Qpc1* unit. *Qpc2* is massive and very hard. It incorporates a well-developed argillic paleosol. A Bt-horizon occurs in the upper 60 cm of the unit with up to 35 percent clay and up to 0.80 percent Fe. The underlying Bk-horizon contains up to 24 percent carbonate with small carbonate nodules 6 to 22 mm diameter; the nodules have a soft outer layer and a hard interior. The Bk-horizon has stage II carbonate morphology. The base of *Qpc2* is OSL-dated 43,200 ± 2300 years. An OSL age from 39 cm depth is 8510 ± 410; although the age is technically robust, it seems too young in time to account for the high degree of argillic and calcic soil horizon development; based on pedogenesis, *Qpc2* should be much older. The 43.2 ka age is more in line with the observed degree of soil development.

The upper surface of *Qpc2* is eroded and is covered by a thin mantle of cover sediment (*Qcs*) in most areas, although not at BHT 9. Nearby, the base of a low-relief mesquite coppice dune (*Qec*) is OSL-dated 150 ± 50 years (Figs. 21.66, 21.67; Table 21.24).

Associated with BHT 9 is a cut through the sedimentary fill of a small ephemeral wash; the sediments have been studied and designated *Qay* (see previous discussions of this unit) (Figs. 21.68, 21.69; Table 21.27). The erosion of the gully/wash with accompanying rill and sheet erosion have strongly affected one area of LA 155963 and is discussed later.

BHT 10 and BHT 11. The stratigraphy, sedimentology, and pedology of the calcrete (*Qcc*) at the top of the Camp Rice Formation in trenches

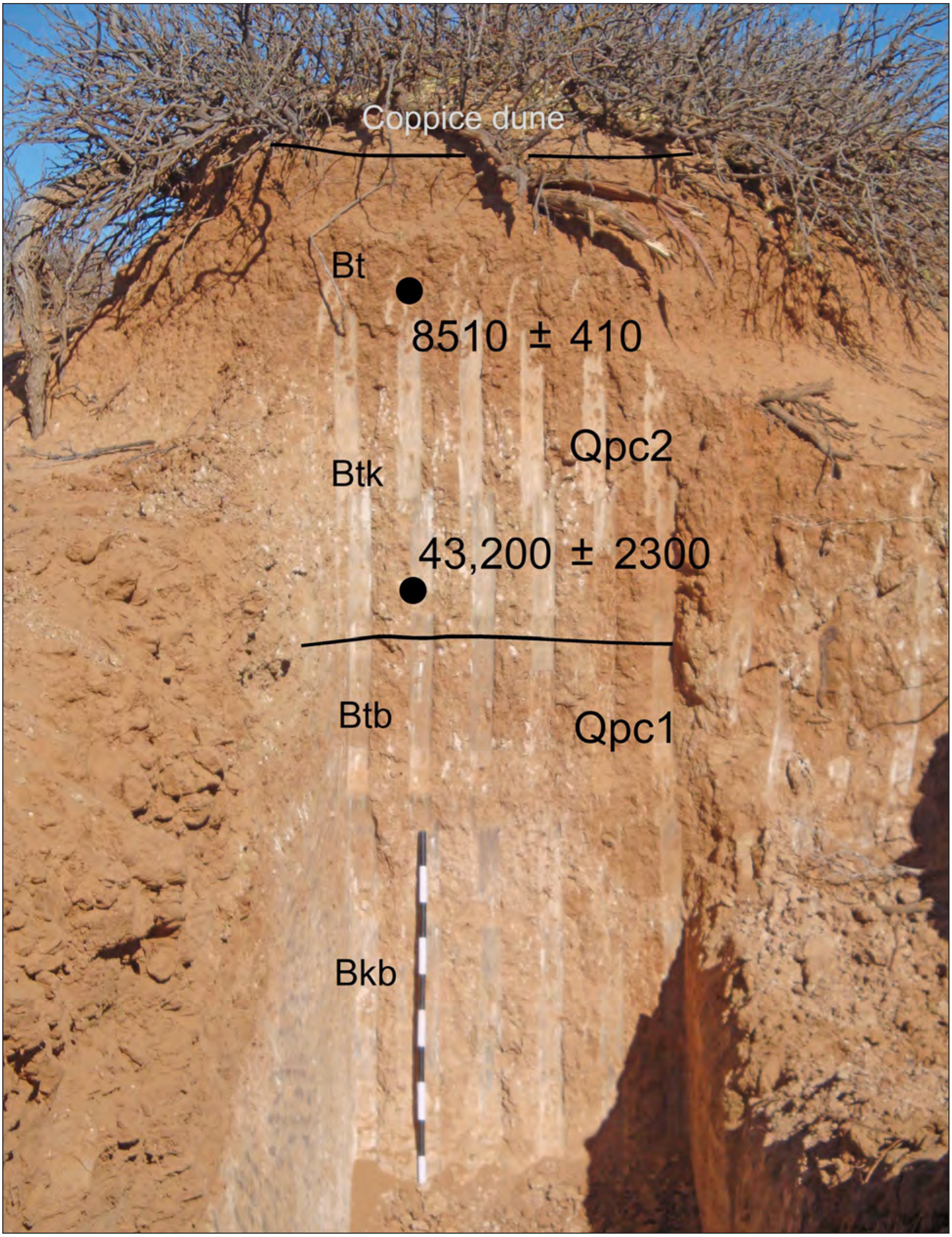

Figure 21.63. LA 155963, BHT 9, piedmont alluvium (Qpc1, Qpc2); mesquite coppice dune has protected the underlying piedmont alluvium from erosion; the coppice dune sand occurs at the top 30 cm of an erosional pillar; the 8.51 ka OSL age may be too young for the degree of soil formation in Qpc2; scale is 1 m.

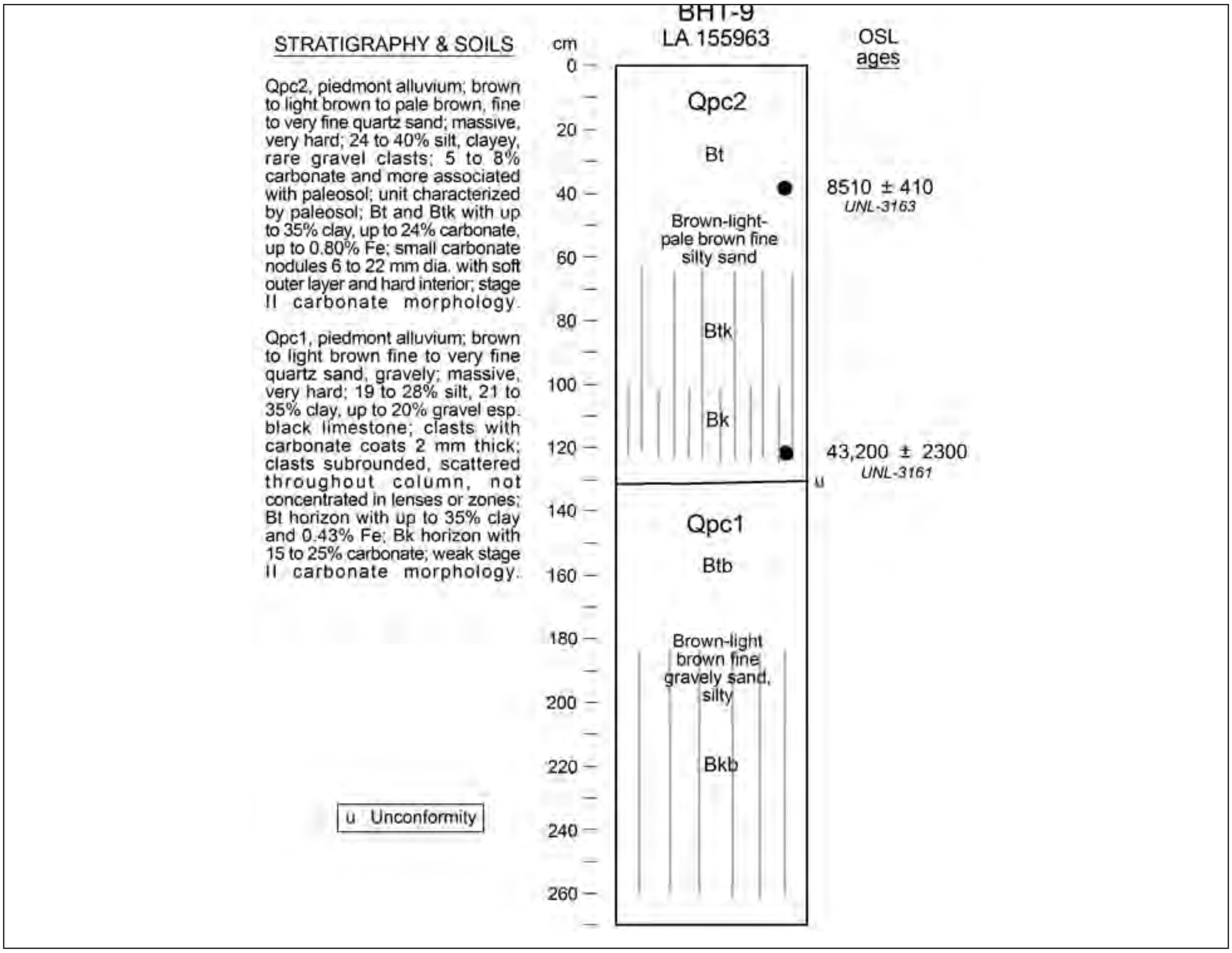

Figure 21.64. LA 155963, BHT 9, stratigraphic column of piedmont alluvium.

Figure 21.65. LA 155963, BHT 9, sediment diagram of piedmont alluvium (data in Table 21.26).

Table 21.26. LA 155963, BHT 9, sediment data.

Field/ Lab No.	Interval (cm)	Gravel (5)	Very Coarse Sand (%)	Coarse Sand (%)	Medium Sand (%)	Fine Sand (%)	Very Fine Sand (%)	Sand (%)	Silt (%)	Clay (%)	$CaCO_3$ (%)	Fe (%)	Dry Munsell Color
Qpc2, Piedmont Alluvium													
2	0–10	0	0.2	1.1	15.6	48.6	34.5	45	30	25	4.7	0.56	7.5YR 4/4
3	20–?	1	0.2	1.1	16.4	48.6	33.7	47	25	28	5.1	0.67	7.5YR 4/4
4	20–30	0	0.2	0.9	15.1	48.9	34.9	50	24	26	7.8	0.47	7.5YR 5/4
5	30–40	1	0.3	0.9	15.1	47.3	36.4	46	25	29	8.1	0.81	7.5YR 5/4
6	40–50	0	0.3	0.9	15.1	46.5	37.2	44	25	31	8.1	0.54	7.5YR 5/4
7	50–60	0	0.4	1.1	15.2	46.4	36.9	41	26	33	10.2	0.49	7.5YR 5/4
8	60–70	0	0.8	1.4	15.5	45.7	36.6	31	34	35	19.2	0.36	7.5YR 6/4
9	70–80	0	0.5	0.8	18.3	44	36.4	28	39	33	23.6	0.28	7.5YR 6/4
10	80–90	0	0.1	0.5	13.1	44.6	41.7	30	40	30	20.7	0.38	7.5YR 6/3
11	90–100	0	0.1	0.5	12.7	44.8	41.9	40	35	25	17.8	0.3	10YR 6/3
12	100–110	0	0	0.2	11	41.7	47.1	46	33	21	16.3	0.26	10YR 6/3
13	110–120	0	0.1	0.3	8.9	40.8	49.9	43	35	22	16.9	0.23	10YR 6/3
14	120–130	0	0.3	0.7	10.6	43.9	44.5	43	34	23	15.4	0.26	10YR 6/3
Qpc1, Piedmont Alluvium													
15	130–140	0	0.3	1.4	14.5	50.8	33	53	20	27	8.8	0.23	7.5YR 5/3
16	140–150	0	0.4	1.5	16.6	44.8	36.7	53	19	28	4.9	0.35	7.5YR 5/4
17	150–160	0	0.2	1	17.6	44.5	36.7	45	20	35	7.7	0.43	7.5YR 5/3
18	160–170	4	0.7	1.3	16.6	42.9	38.5	47	24	29	12.9	0.27	7.5YR 5/3
19	170–180	2	0.7	1.7	15.2	41.1	41.3	40	28	32	13.6	0.31	7.5YR 5/4
20	180–190	7	1	1.9	16.7	46.6	33.8	54	22	24	12.5	0.15	7.5YR 5/4
21	190–200	5	2	2.1	16.9	46.6	32.4	54	23	23	18.4	0.11	7.5YR 6/3
22	200–210	8	2.1	2.7	16.7	45.3	33.2	55	23	22	20.6	0.18	7.5YR 6/3
23	210–220	8	1.5	2.2	16.5	46.6	33.2	56	22	22	15.7	0.2	7.5YR 5/3

(Table 21.26, continued)

Field/ Lab No.	Interval (cm)	Gravel (5)	Very Coarse Sand (%)	Coarse Sand (%)	Medium Sand (%)	Fine Sand (%)	Very Fine Sand (%)	Sand (%)	Silt (%)	Clay (%)	$CaCO_3$ (%)	Fe (%)	Dry Munsell Color
24	220–230	8	1.8	2.3	16.2	45.5	34.2	55	23	22	16.2	0.24	7.5YR 5/3
25	230–240	13	2	2.3	15.9	45.9	33.9	54	23	23	18.3	0.11	7.5YR 6/3
26	240–250	9	2.1	2.4	16.6	46.8	32.1	54	24	22	20.5	0.1	7.5YR 6/3
27	250–260	20	2.5	2.4	16.3	46.9	31.9	56	23	21	22.1	0.18	7.5YR 6/3
28	260–270	8	2.5	2.3	16.2	47.3	31.7	56	22	22	25.3	0.13	7.5YR 6/3

Note : analyses by Milwaukee Soil Laboratory; color by Pedology Laboratory, University of Kansas.

[a] Percentages of gravel based on whole sample; percentages of sand, silt, and clay exclude gravel.

[b] Normalized to color categories in Munsell Color, 2009; spectrophotometer data in Table 21.2.

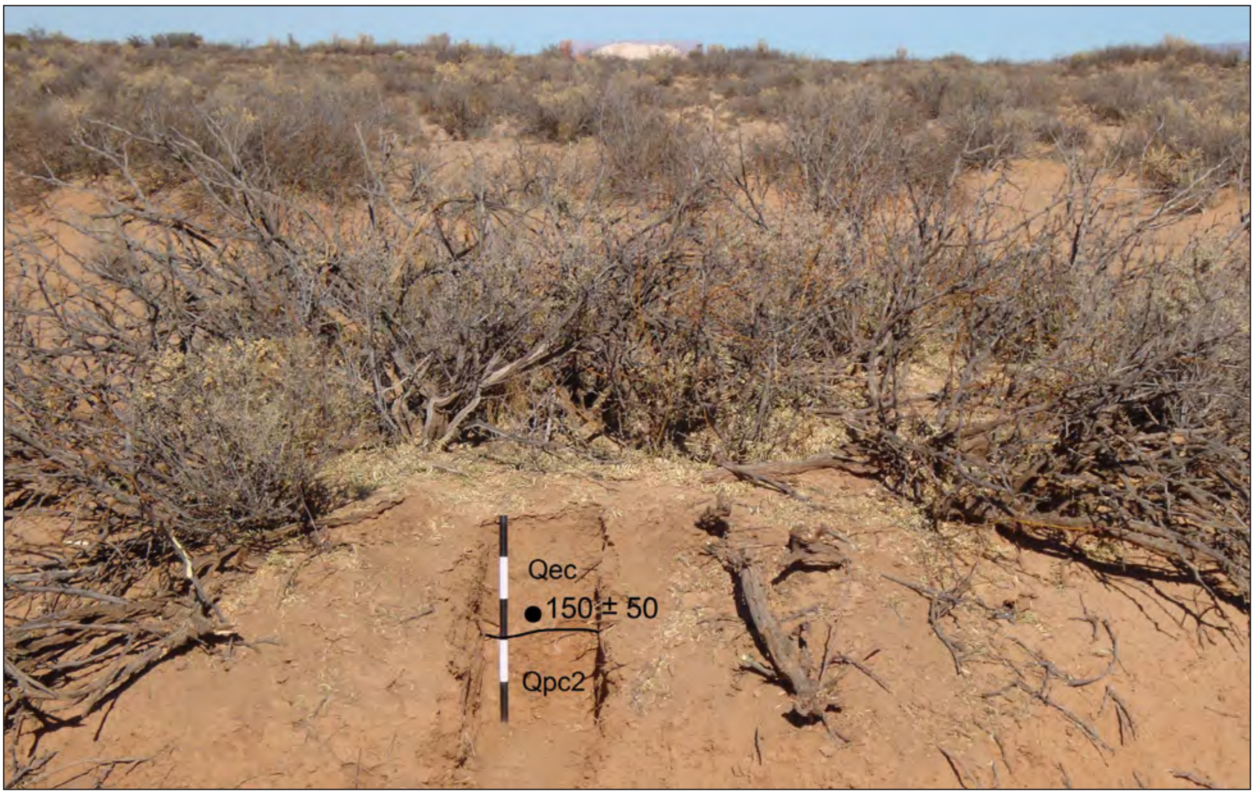

Figure 21.66. LA 155963, BHT 9, eroded mesquite coppice dune sand (Qec) overlying piedmont alluvium (Qpc2) to west of trench; 50 cm scale (photographed Dec. 2, 2010).

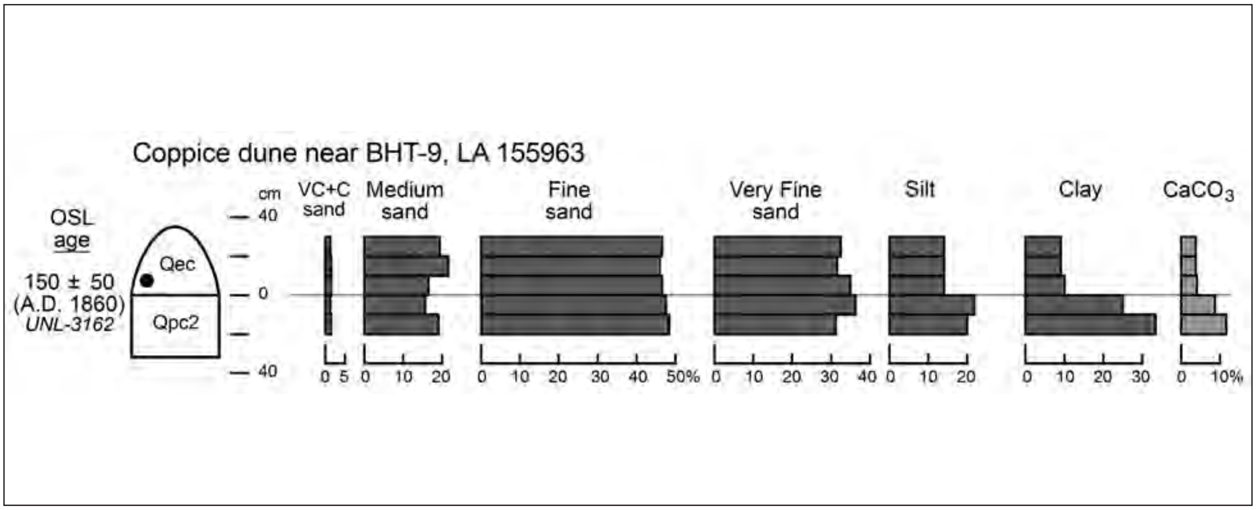

Figure 21.67. LA 155963, BHT 9, sediment diagram of mesquite coppice dune sand and underlying piedmont alluvium, west of trench (data in Table 21.24).

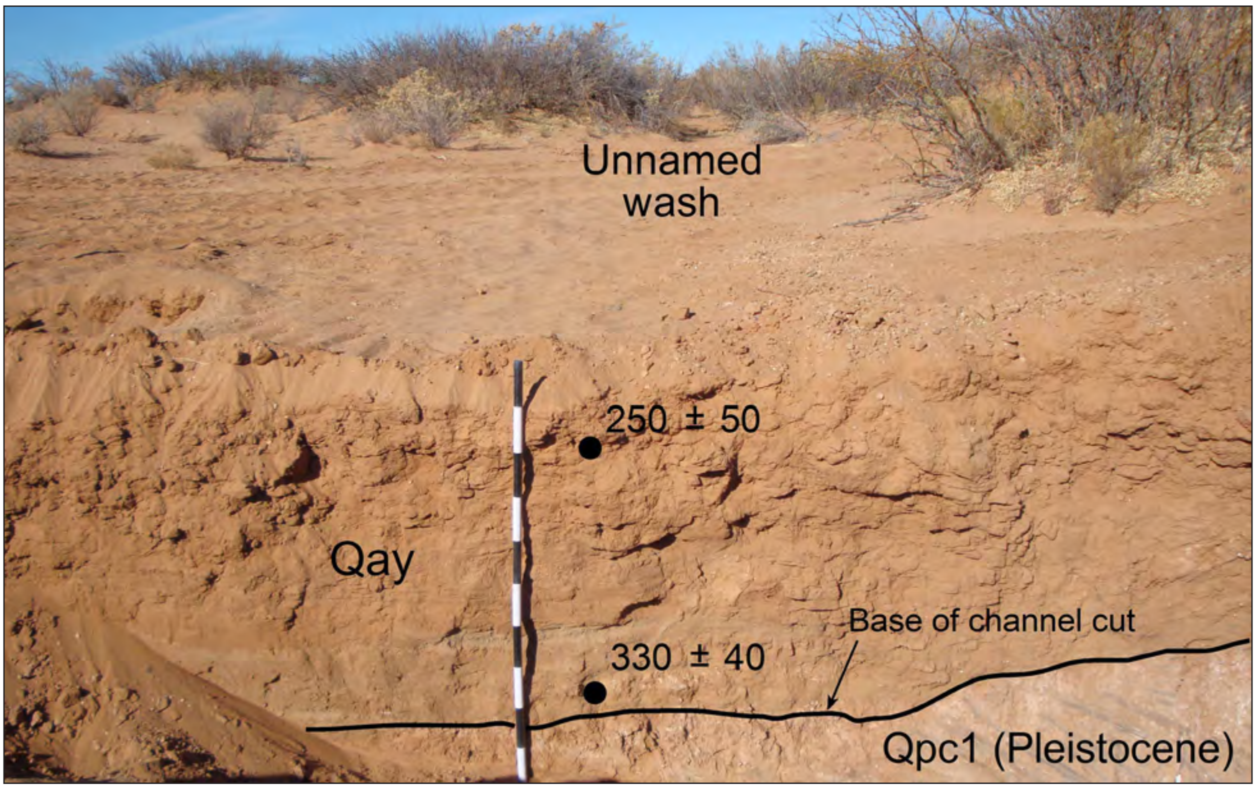

Figure 21.68. LA 155963, BHT 9, alluvial fill (Qay) in channel of unnamed ephemeral wash; channel is cut into piedmont alluvium (Qpc1); scale is 1 m; photographed December 1, 2010.

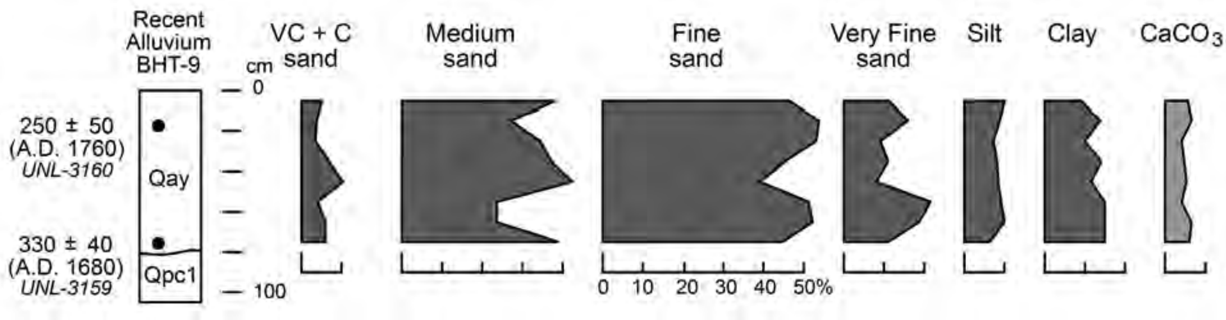

Figure 21.69. LA 155963, BHT 9, sediment diagram of young alluvium in stratigraphic section from channel of unnamed ephemeral wash (data in Table 21.27).

Table 21.27. LA 155963, BHT 9, alluvial sequence from ephemeral wash.

Field/ Lab No.	Interval (cm)	Very Coarse Sand (%)	Coarse Sand (%)	Medium Sand (%)	Fine Sand (%)	Very Fine Sand (%)	Sand (%)	Silt (%)	Clay (%)	$CaCO_3$ (%)	Organic Carbon (%)	Dry Munsell Color
Qay, Young Alluvium												
29	0–10	0.6	4.4	36.8	46.9	11.3	81	10	9	5.1	0.13	7.5YR 5/4
30	20–?	0.6	3.1	27.1	53.5	15.7	77	9	14	5.6	<dl*	7.5YR 4/3
31	20–30	0.4	2.7	34.5	53.2	9.2	83	7	10	3.7	0.12	7.5YR 4/4
32	30–40	0.9	6.2	37.1	45.2	10.6	78	8	14	4.6	0.04	7.5YR 4/3
33	40–50	1.5	8.9	42.4	39.3	7.9	80	8	12	5.2	0.09	7.5YR 5/4
34	50–60	0.4	3.5	23.5	51	21.6	76	9	15	4.2	0.04	7.5YR 4/4
35	60–70	0.6	5.3	23.1	52.2	18.8	75	10	15	6.6	0	7.5YR 5/3
36	70–80	0.5	5.1	39.1	44.7	10.6	79	6	15	5.4	<dl*	7.5YR 4.3

Note : analyses by Milwaukee Soil Laboratory; color determinations by Pedology Laboratory, University of Kansas; duplicate textural analysis for #32 and #33 provided in Table 21.3.

* <dl Below detection limits

[a] Normalized to color categories in Munsell Color, 2009; spectrophotometer data in Table 21.2.

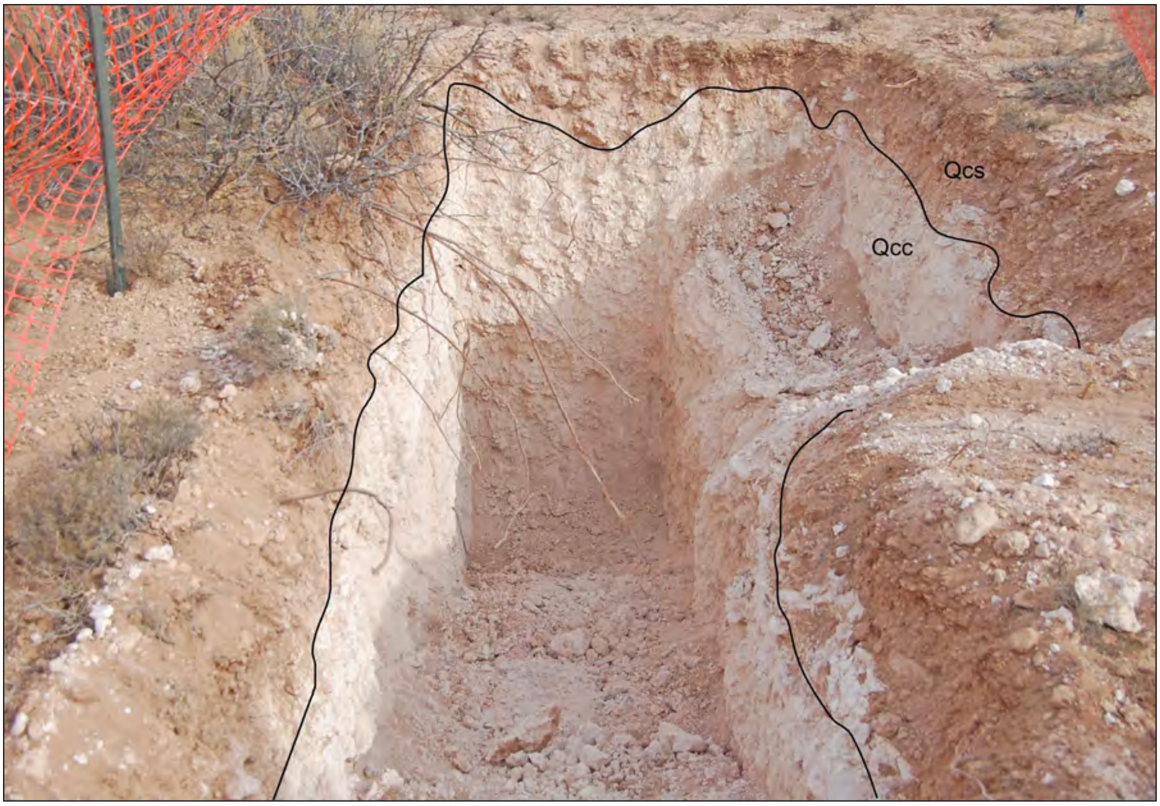

Figure 21.70. LA 155963, BHT 10, showing calcrete (Qcc) and overlying cover sediment (Qcs); exposure extends to 2.0 m depth below surface.

Figure 21.71. LA 155963, BHT 10, limestone pebbles in calcrete (Qcc); see arrows; view is about 40 cm wide.

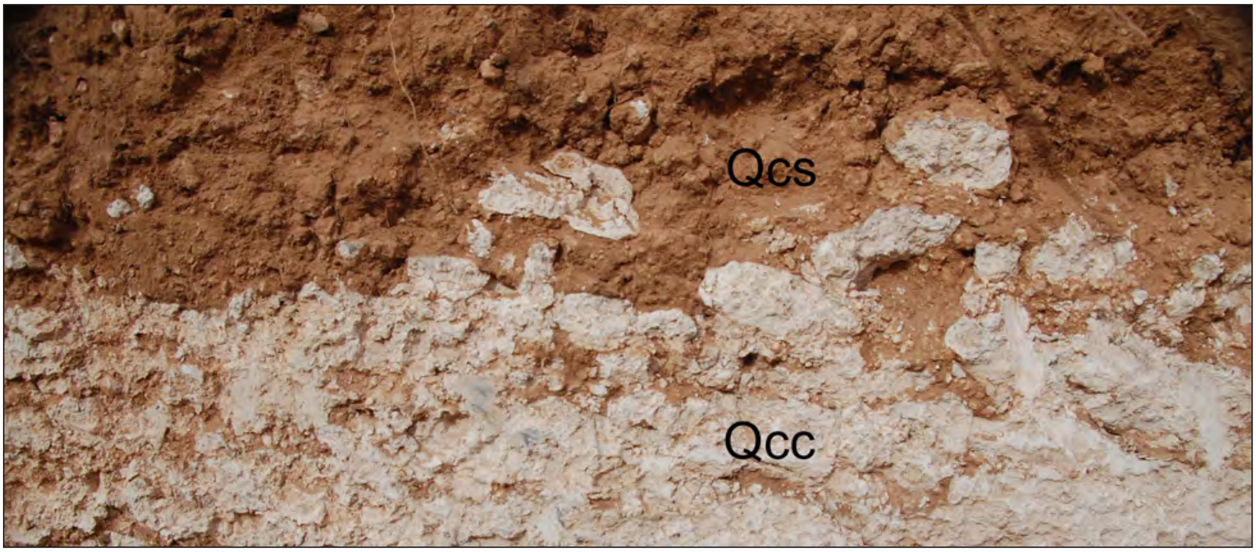

Figure 21.72. LA 155963, BHT 10, calcrete (Qcc)-cover sediment (Qcs) contact; view is about 30 cm wide.

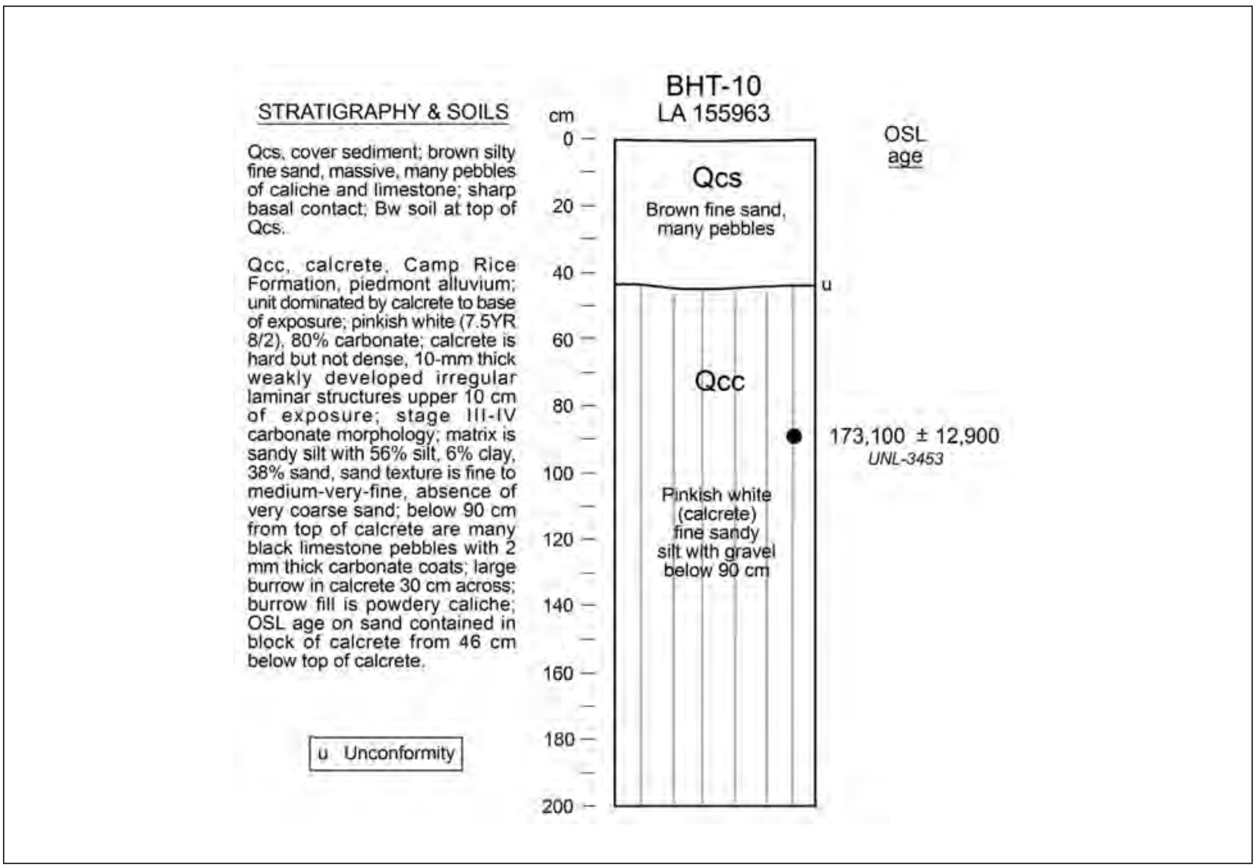

Figure 21.73. LA 155963, BHT 10, stratigraphic column of calcrete (Qcc) of the Camp Rice Formation and overlying cover sediment (Qcs); the 170,100 ± 12,900 year OSL age may be a minimum value (data in Table 21.25).

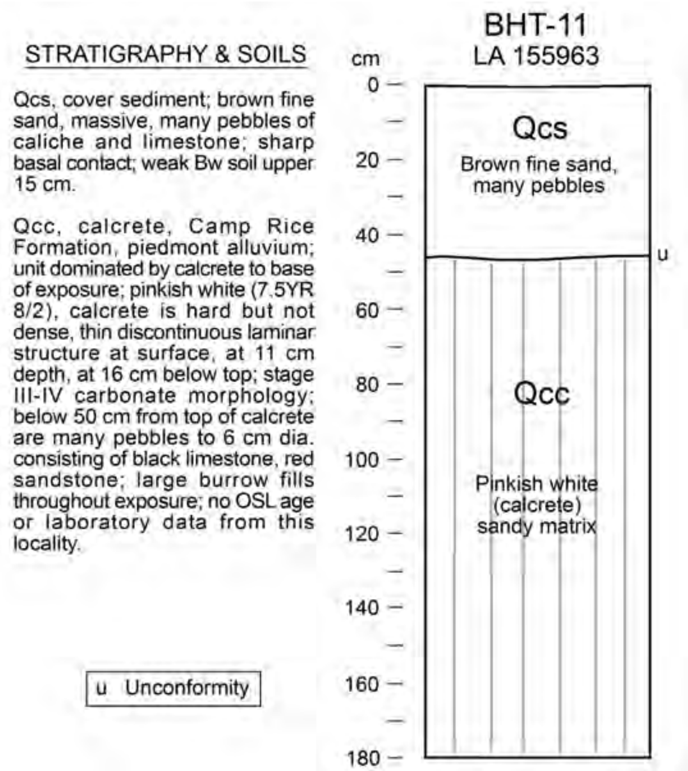

Figure 21.74. LA 155963, BHT 11, stratigraphic column of calcrete (Qcc) of the Camp Rice Formation and overlying cover sediment (Qcs); photo of disturbed calcrete is shown in Figure 21.14.

10 and 11 are similar to that already discussed in BHT 8 (Figs. 21.70, 21.71, 21.72, 21.73, 21.74; Table 21.25). In BHT 10, an OSL age on quartz sand grains from a block of the calcrete is 173,100 ± 12,900 years. Although the age is finite, it is probably a minimum age, based on the age of the Camp Rice Formation. The calcrete is mantled by 44 to 46 cm of cover sediment (*Qcs*) on the low hill. The cover sediment is silty fine sand, massive, with many pebbles of limestone and caliche derived from the underlying calcrete (Fig. 21.72). A Bw soil horizon occurs at the top of the cover sediment. The only OSL age from the cover sediment at LA 155963 is 9650 ± 750 years at BHT 7.

LA 155964

This is a small site on the broad flats of the piedmont slope just west of the Spaceport America site. One trench, BHT 12, shows the presence of piedmont alluvium (*Qpc2*) mantled by 11 cm of cover sediment (*Qcs*). The cover sediment is brown fine- to very fine-textured sand. It is massive and soft with insect burrows. The base of cover sediment forms a sharp contact with the underlying piedmont alluvium; small pebbles occur at the contact. The piedmont alluvium (*Qpc2*) is brown to light-brown silty sand and sandy silt with the texture fining upward (Figs. 21.75, 21.76, 21.77; Table 21.28). The sediment is very hard and massive with some insect burrow fills and rare gravel clasts. The alluvium is dominated by an argillic paleosol. The upper 20 cm is a Bt-horizon with 6 to 7 percent clay and 4 ppm Fe. The paleosol Bk-horizon occurs at 30 to 90 cm depth with hard carbonate nodules and 6 to 12 percent carbonate, representing a weak stage II carbonate morphology. Two OSL ages from *Qpc2* are 45,000 ± 2200 years and 23,400 ± 1400 years. The 23.4 ka age, while robust and sound, may be too young for the amount of time required for pedogenesis at this locality.

LA 155968

This small site south of Spaceport America has a large thermal feature (Feature 1) that intrudes into local deposits. Geomorphic trenching was not conducted at this site, although the local geology is piedmont alluvium (*Qpa*) (Seager 2005) with an irregular mantle of cover sediment, similar to the surface sediments described elsewhere in the study area.

A large thermal feature in the center of the site intrudes through the cover sediment (*Qcs*) and into the underlying piedmont alluvium (*Qpc2*) (Fig. 21.78). The cover sediment is a 12 cm thick, brown sandy silt resting on *Qpc2* piedmont alluvium. The cover sediment is massive, unbedded, and partly disturbed by cicada burrowing. It includes a few caliche pebbles, derived from *Qpc2*, and some small pockets of dark-gray sediment, probably colored by charred particles from the feature. The *Qpc2* unit is massive brown silt that is characterized by a dense mass of cicada insect burrow fills (Fig. 21.79). The burrow fills are gray silt, indicating that the cicada nymphs were burrowing into the dark gray-colored sediment in the feature. Carbonate is concentrated in the burrow fills, mimicking soil carbonate nodules. The large numbers of cicada insect burrow fills and carbonate concentrations are typical of the upper piedmont alluvium. The cover sediment and piedmont alluvium are not dated at this site although elsewhere in the study area these deposits are dated late Pleistocene to early Holocene age.

Five charcoal samples from Feature 1 are AMS-dated AD 656 to 887 (Table 19.2). The young age of the feature at LA 155968 is consistent with the stratigraphic intrusion of the feature into the cover sediment and underlying piedmont alluvium. Buried features will not be found at the site.

LA 155969

This small site is located at the northeastern end of the concrete runway at Spaceport America. The surface geology is mapped as older piedmont-slope alluvium (*Qpa*) by Seager (2005). Geomorphic trenching of the locality was not conducted. However, inspection of the site and associated geology suggests that the site occurs on the eroded surface of the piedmont alluvium (*Qpc2*) with some patches of cover sediment (*Qcs*). Elsewhere in the study area, the cover sediment and alluvium are late Pleistocene, the likely age as well of the deposits underlying LA 155969. The site and its artifacts occur at the present-day surface; subsurface cultural features are not present.

LA 156877

This site is located south of Spaceport America on the older piedmont-slope alluvium (*Qpa*) mapped by Seager (2005). Although geomorphic trenching was not conducted, the stratigraphy of the site is

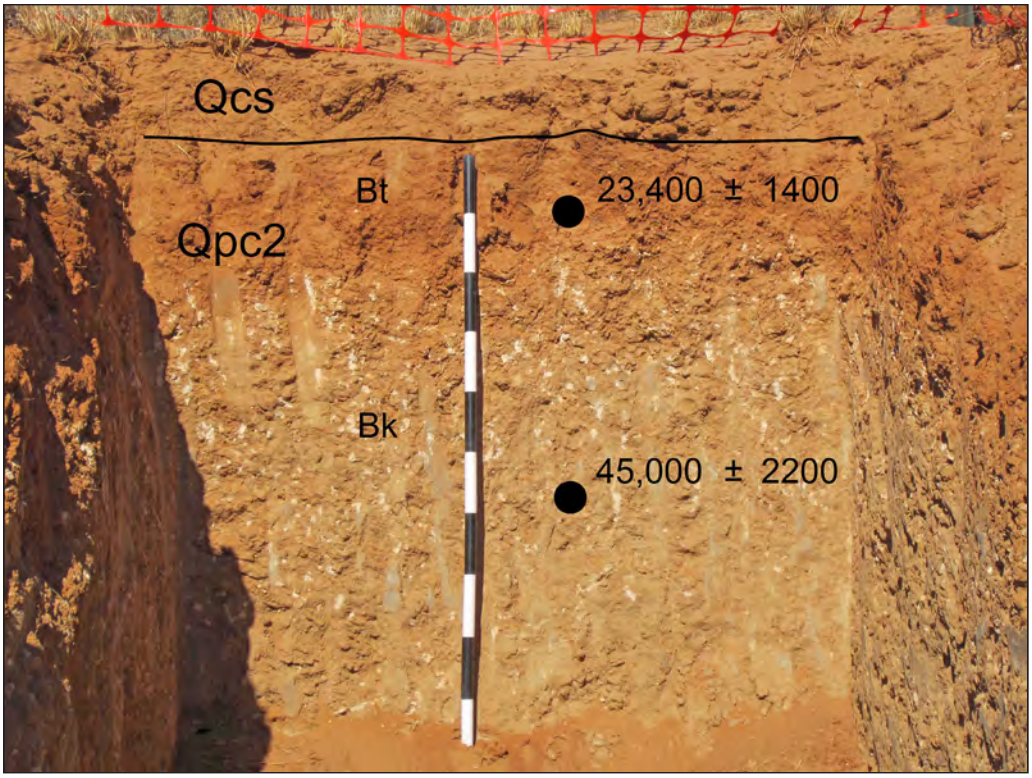

Figure 21.75. LA 155964, BHT 12, piedmont alluvium (Qpc2) and overlying cover sediment (Qcs); the 23.4 ka OSL age may be too young for the degree of soil formation in Qpc2; scale is 1 m.

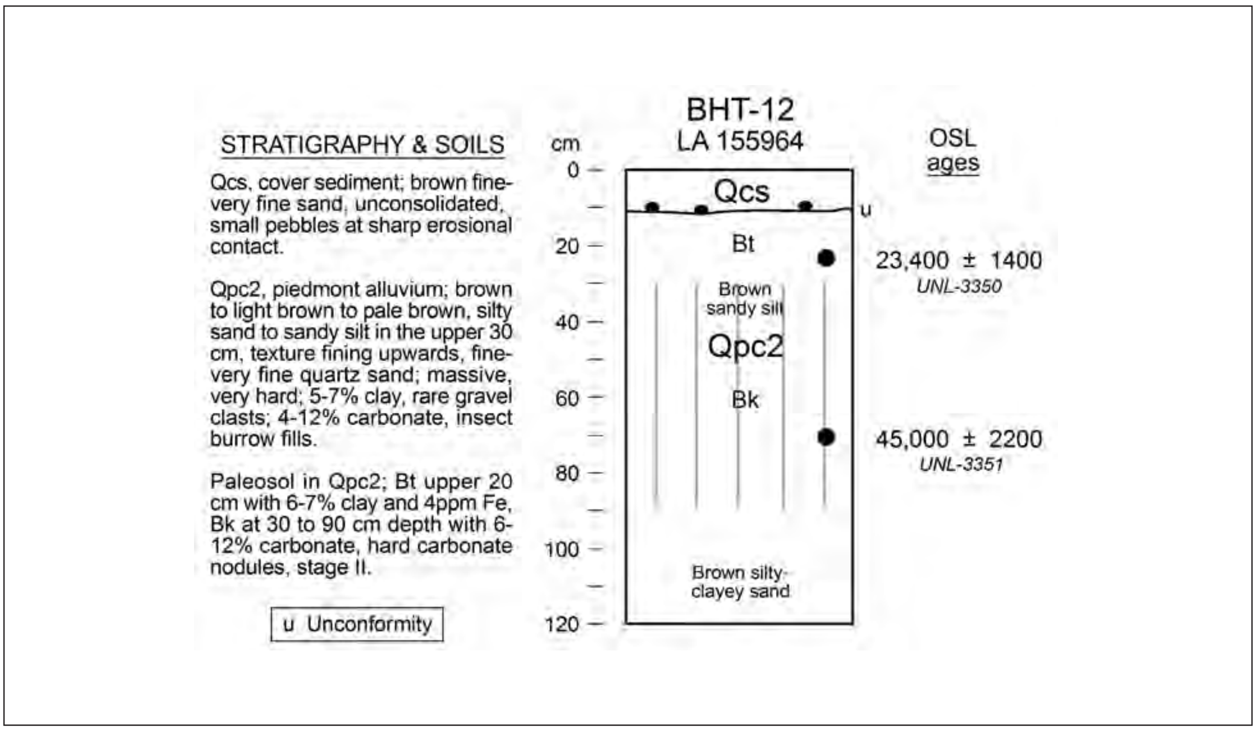

Figure 21.76. LA 155964, BHT 12, stratigraphic column of piedmont alluvium and overlying cover sediment.

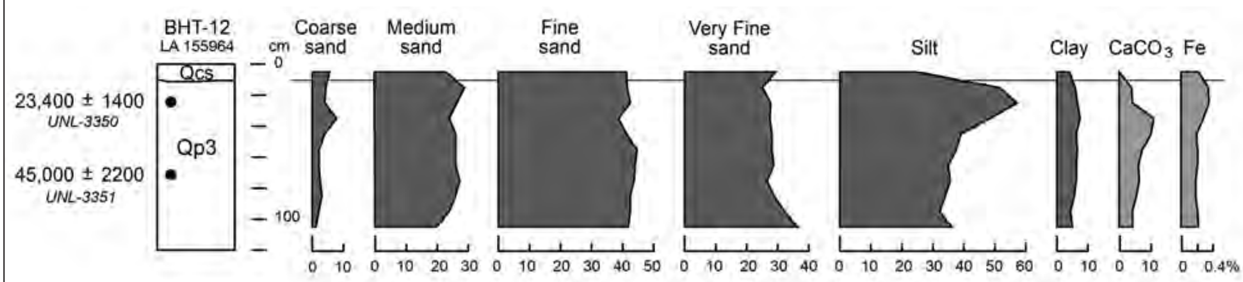

Figure 21.77. LA 155964, BHT 12, sediment diagram of piedmont alluvium and overlying thin cover sediment (data in Table 21.28).

Table 21.28. LA 155964, BHT 12, sediment data.

Field/ Lab No.	Interval (cm)	Very Coarse Sand (%)	Coarse Sand (%)	Medium Sand (%)	Fine Sand (%)	Very Fine Sand (%)	Sand (%)	Silt (%)	Clay (%)	$CaCO_3$ (%)	Fe (ppm)	Dry Munsell Color
Qcs, Cover Sediment												
115	0–10	1	5.5	22.8	41.6	29.1	71.3	25.2	3.6	0.34	2.1	7.5YR 5/4
Qpc2, Piedmont Alluvium												
116	20–?	0	4.4	29.1	41.6	24.9	42.6	51.7	5.7	3.38	3.7	7.5YR 4/4
117	20–30	0	3.2	26.7	42.2	27.9	36	57.1	7	4.85	3.6	7.5YR 5/4
118	30–40	2.1	7.6	24.1	38.7	27.4	44.7	48.1	7.2	11.51	2.9	7.5YR 6/4
119	40–50	0	3.8	26.6	41.7	27.8	54.7	39.5	5.8	10.19	2	7.5YR 6/3
120	50–60	0	1.9	26.1	44.3	27.7	56.3	37.7	6	7.42	2.1	10YR 6/3
121	60–70	0	2.2	26.2	43.2	28.5	59	35.3	5.8	5.97	2.2	10YR 5/3
122	70–80	0	2.4	27.7	43.1	26.9	58.7	35.4	5.8	6.73	1.9	10YR 6/3
123	80–90	0	2.6	26.4	42.3	28.6	60.4	34.3	5.3	5.46	1.9	10YR 6/3
124	90–100	0	2.2	23.4	42.3	32	63.2	32.1	4.7	3.89	2.2	10YR 6/3
125	100–110	0	1.2	20	41.9	36.8	58.6	36.3	5	4.19	2.1	10YR 5/3

Note : analyses by Milwaukee Soil Laboratory, and Pedology Laboratory, University of Kansas.

[a] Normalized to color categories in Munsell Color, 2009; spectrophotometer data in Table 21.2.

Figure 21.78. LA 155968, Feature 1, large thermal feature that intrudes through a thin layer of cover sediment (Qcs) and into piedmont alluvium (Qpc2); five charcoal samples from the feature are radiocarbon dated AD 700–804 (median calibrated ages; Table 19.2); photographed June 7, 2011; scale is 50 cm.

Figure 21.79. LA 155968, Feature 1, close-up of feature wall showing approximately 12 cm of cover sediment (Qcs) and underlying piedmont alluvium (Qpc2); the piedmont alluvium incorporates a dense mass of cicada insect burrow fills, some of which have a concentration of carbonate; although not dated here, elsewhere in the study area Qcs is OSL-dated 15 to 5 ka, and Qpc2 is OSL-dated 40 ka to greater than 65 ka; scale is 50 cm.

exposed in an adjacent roadcut of a county road. The site occurs on our cover sediment (*Qcs*) and piedmont alluvium (*Qpc2*) units, similar to the stratigraphy of other sites that have been documented in the study area. The present-day surface has many pebbles as a consequence of deflation and sheet erosion of the gravely surface sediments. A large feature (Feature 5) at the site is exposed in the road cut along the county road. This feature intrudes into the cover sediment and underlying piedmont alluvium. The cover sediment is 15 to 20 cm thick and everywhere overlies piedmont alluvium. The upper 40 cm of the piedmont alluvial sediments are exposed in the road cut. Although the feature is not radiocarbon-dated, it is likely young, perhaps only a few centuries in age, and post-dates the local cover sediment and piedmont alluvium through which it intrudes (Fig. 21.80). Sedimentology shows that the cover sediment and feature fill have a texture that is similar to the piedmont alluvium, indicating that the sediments in the feature are derived from the local stratigraphic deposits. The stratigraphic units and the feature sediment are brown silty fine- to medium-textured sand with 4–6 percent clay (Table 21.29). The *Qpc2* has larger amounts of carbonate (12 percent) due to the presence of a Bk soil horizon. Although the large feature intrudes into local stratigraphy, buried cultural features are not present.

Discussion of Archaeological Geology

With regard to the archeological record in the vicinity of the Spaceport America, the Jornada is an ancient landscape. The surficial geology is dominated by Pleistocene piedmont-slope alluvium that may have ended accumulation about 40 ka. Across the piedmonts, colluvial and slope processes have resulted in the formation of a thin cover-sediment that mantles the piedmont alluvium. The formation of the cover sediment coincides with the Paleoindian period, and late Paleoindian artifacts are found at its surface. Post-Paleoindian archaeology occurs as well at the surface of the cover sediment. Wind-deposited sand sheets began to accumulate in some areas of the piedmont, especially on the east side of the Jornada valley, by about 11,000 years ago. The sand continued to accumulate continuously throughout the Holocene until about 1100 years ago. Archaic and post-Archaic archaeological sites are associated with the sand sheet. Recent coppice

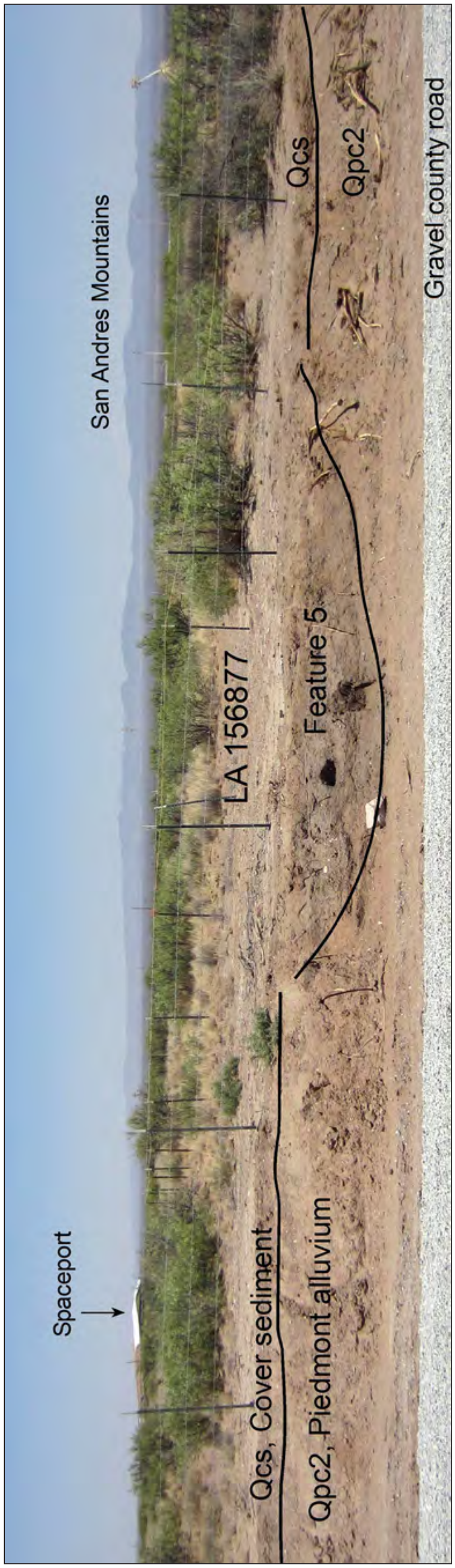

Figure 21.80. LA 156877, Feature 5 intrudes through 15–20 cm of cover sediment (Qcs) and about 40 cm of piedmont alluvium (Qpc2) along a gravel county road south of Spaceport America (sediment data in Table 21.29); photographed June 23, 2011.

Table 21.29. LA 156877, sediment data from road cut exposure.

Field/ Lab No.	Interval (cm)	Very Coarse Sand (%)	Coarse Sand (%)	Medium Sand (%)	Fine Sand (%)	Very Fine Sand (%)	Sand (%)	Silt (%)	Clay (%)	$CaCO_3$ (%)	Dry Munsell Color
84	Qpc2	1.9	16.5	26.3	29.7	25.5	41.4	52.8	5.9	12.5	7.5YR 6/3
85	Qpc2	3.7	15.5	24.3	34.3	22.1	57.9	37.6	4.5	3.46	7.5YR 5/3
86	Qcs	0	9.4	26.6	39.3	24.7	52.9	42	5	0.59	7.5YR 4/3
87	Feature fill	2.3	11.1	26.3	38.4	21.9	59.7	35.9	4.3	2.27	7.5YR 4/2

Note : analyses by Pedology Laboratory, University of Kansas.

[a] Normalized to color categories in Munsell Color, 2009; spectrophotometer data in Table 21.2.

and parabolic dunes, beginning to form in the mid-nineteenth century, occur on the surface of the sand sheet and cover sediment.

A reoccurring theme concerning the prehistoric archaeology of the Jornada is the antiquity of the present-day surface, except at localities where the eolian sand sheet is present. Sites from the Paleoindian period, Archaic period, and later periods all have the potential to occur together at the same surface as well as overlapping at the same locality. Geographic groups of sites with similar geology are discussed below.

LA 112370, LA 112371, and LA 112374

These three sites occur together on the distal end of the piedmont slope west of the San Andres Mountains. The surficial geology is our *Qps2* piedmont alluvium and, at LA 112374, the *Qcs* cover sediment (Fig. 21.81). These units pre-date the archaeological record, and sites from the Paleoindian period and all other archaeological periods will occur at the present-day surface. Even though cultural features have the potential to intrude the piedmont alluvium and cover sediment, buried features will not be present.

LA 111429

This large site also incorporates a diverse geologic record. The Paleoindian-age surface is buried by eolian sand in the eastern area of the site and is at or near the present-day surface west of the sand sheet (Fig. 21.82). Two cultural features at the large site are radiocarbon-dated about AD 85–260 (Feature 3) and AD 1620–1685 (Feature 11) (Table 19.2). The ages of the cultural features place them in the context of the upper level of the *Qes* eolian sand sheet and on the surface of the *Qah* A-horizon soil that formed on the top of the sand sheet, respectively. Late Paleoindian artifacts at the large site occur near the base of the *Qcs* cover sediment and on the weathered surface of the *Qcc* calcrete. Paleoindian and Archaic archaeology have the potential to occur at or in the lower levels of the sand sheet.

LA 111420, LA 111421, LA 111422, LA 111432, and LA 111435

This series of sites occurs along the west side of Jornada Draw on surficial geology mapped as older piedmont-slope alluvium by Seager (2005). We were able to study the surficial geology in a series of five backhoe trenches, one at each archaeological site (Fig. 21.83). The stratigraphy exposed in

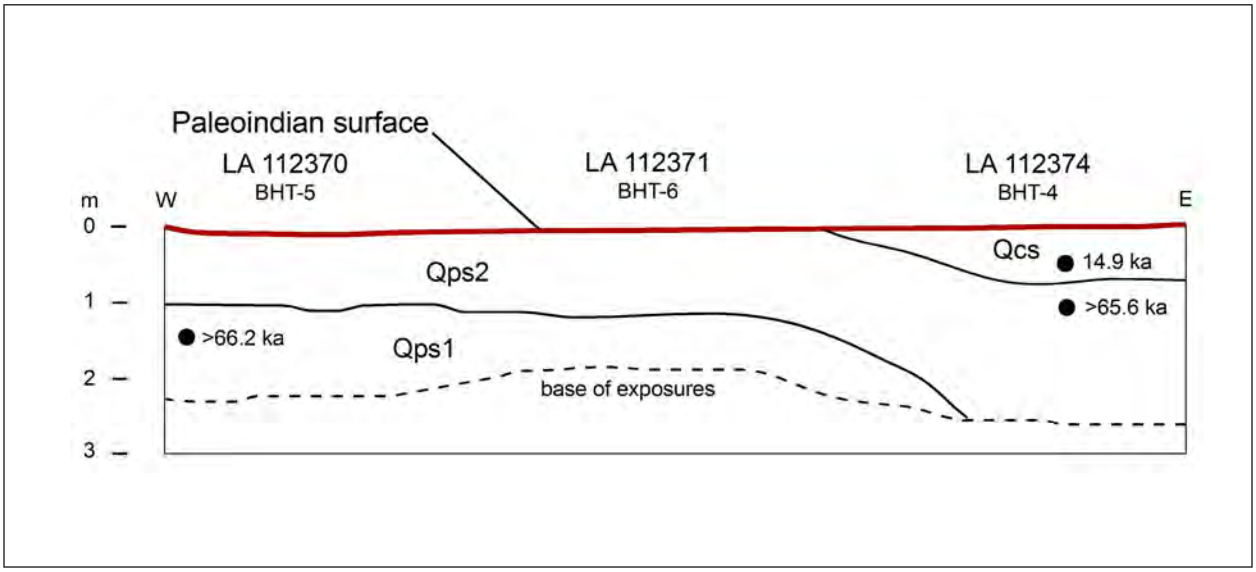

Figure 21.81. Sketch cross-section of LA 112370–LA 112371–LA 112374 at the distal end of the alluvial piedmont slope from the San Andres Mountains; the archaeological age of the present-day surface is Paleoindian; sites of all periods have the potential to occur on the surface; no horizontal scale.

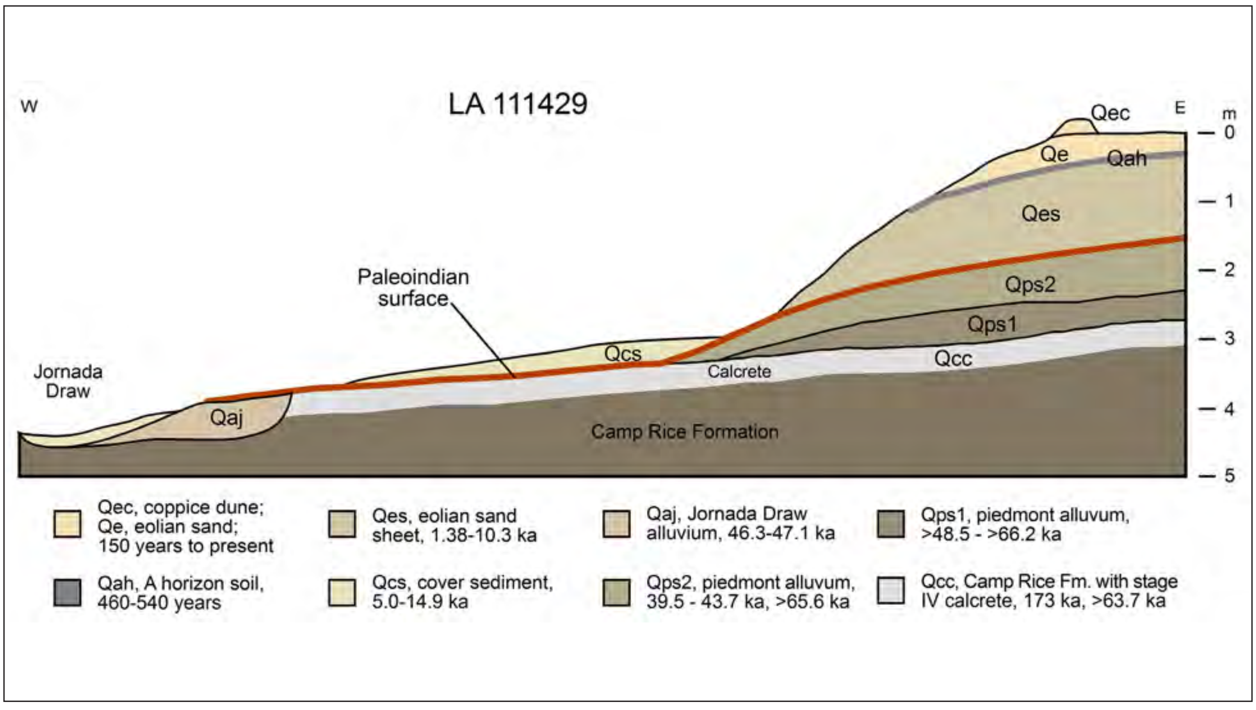

Figure 21.82. LA 111429, sketch cross-section showing the stratigraphic position of the Paleoindian surface; at other sites, the Paleoindian surface occurs at the top of the cover sediment (Qcs); the alluvial deposits in the axis of Jornada Draw are undated; no horizontal scale.

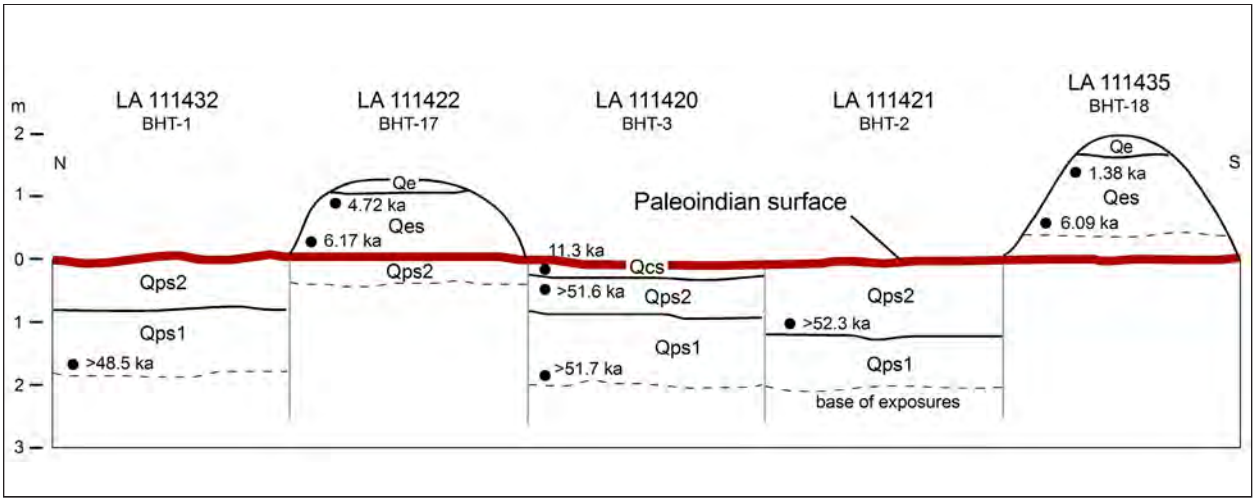

Figure 21.83. Sketch cross-section of LA 111432–LA 111422–LA 111420–LA 111421–LA 111435 along the western edge of Jornada Draw; the sites occur on piedmont alluvium and on low mounds of eolian sand; the Paleoindian surface occurs on the piedmont alluvium and cover sediment; the mounds of eolian sand overlie the Paleoindian surface; no horizontal scale.

the trenches is characterized by our *Qps1* piedmont alluvium overlain by *Qps2* piedmont alluvium, both units OSL-dated greater than about 50 ka. The *Qps2* outcrops at the present-day surface at two of the sites (LA 111432 and LA 111420). The piedmont alluvium at LA 11420 is mantled by the thin *Qcs* cover sediment with an age of 11.3 ka at this site.

Radiocarbon ages from cultural features were not obtained from LA 111420, LA 111421, or LA 111432. All three of these sites occur on the old surface of piedmont alluvium or the thin cover sediment. Sites on these surfaces are not buried. Consequently, charcoal and other similar remains are less likely to be preserved.

LA 111422 occurs on a 1.2 m high mound of eolian sand (*Qes*). Three OSL ages from *Qes* at BHT 17 range from 6170 to 4720 years, yielding a sedimentation rate of 0.46 mm/year (Fig. 21.5; Table 21.7). Given this information, the top surface of the sand mound is extrapolated to 4037 years, or 2037 BC. Two features from the site are radiocarbon-dated AD 588 and AD 618 (median calibrated ages) (Table 19.2). Thus, the age of the top surface of the mound of eolian sand is about 2600 years older than the age of LA 111422. The site, therefore, likely formed at or near the present-day surface of the sand mound, although some local deflation may have subsequently disturbed or removed some site features.

LA 111435 occurs on a 2 m high mound of *Qes* eolian sand above the surface of the piedmont slope (BHT 18; Fig. 21.47). OSL ages from the *Qes* sand range from 6090 to 1380 years with a sedimentation rate of 0.17 mm/year (Fig. 21.5; Table 21.7). Five cultural features from the site on the eolian sand are radiocarbon-dated about 2903 BC, 1101 BC, 510 BC, AD 425–478, and AD 843-939 (median calibrated ages) (Table 19.2). Using the sedimentation rate for *Qes* at BHT 18, the calculated regression depth of the five dated features is 67, 36, 26, 8, and zero cm below the top of the *Qes* sand sheet, respectively. The OSL-dated age of the top of the *Qes* is extrapolated to 1080 years or AD 930. Cultural features and surfaces or "floors" older than AD 930 should be buried in the eolian sand at the depths listed above.

The above data indicate that the *Qes* sand sheet contains buried archaeology to depths as great as 67 cm below the top of the unit. The old cultural features, however, occur on the south side of the sand mound at the present-day surface. The old in situ features are being exposed along the south side of the mound as sand is being removed by deflation and sheet erosion (Fig. 21.84). In theory, the lower a feature occurs topographically along the side of the mound, the older it should be. Also, cultural features that occur at the crest of the mound should be the youngest. This relationship holds up somewhat,

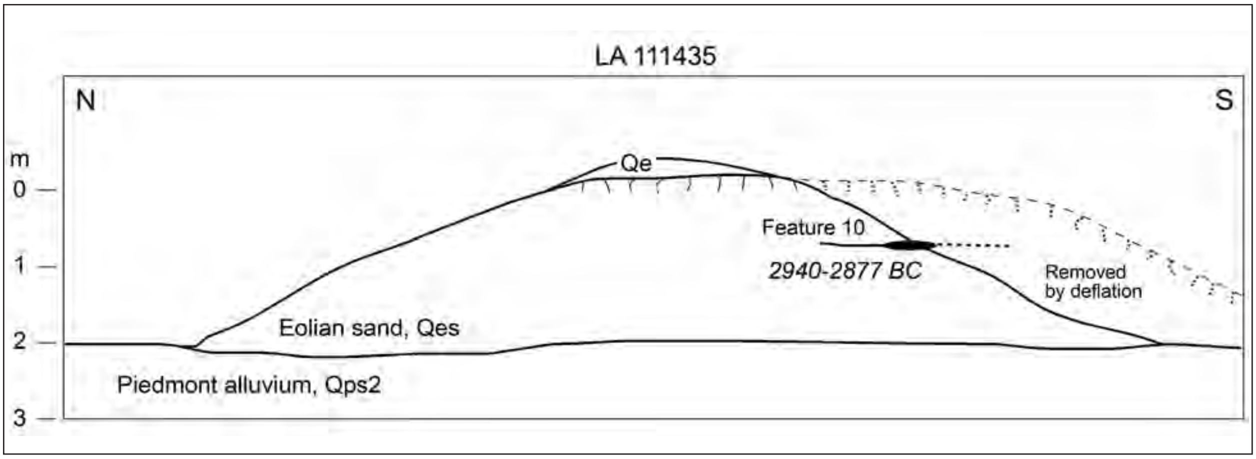

Figure 21.84. LA 111435, sketch cross-section showing deflation of south side of eolian sand and archaeology, exhuming Feature 10 that, based on sedimentation rate of Qes, occurred buried at 67 cm below the surface of the Qes. According to the local sequence of sand sheet accumulation and A-horizon soil formation, the deflation occurred after soil formation since about AD 1500. The non-dune eolian sand (Qe) at the top of the A horizon was deposited 150 to 100 years ago and was likely derived from the deflation of the adjacent Qes sand. Mesquite coppice dune sand (Qec) in the valley also may be derived from deflation of the Qes.

with some variation. Field inspection suggests that the south–southwest side of the sand mound is presently being eroded, and that wind-transported sand is accumulating in the north-northeast side of the mound, possibly burying additional archaeology.

LA 155963 and **LA 155964**

These sites are located on the piedmont slope that comes off of the Caballo Mountains on the west side of the Jornada valley. The north edge of LA 155963 also occurs on the outcrop of the calcrete (*Qcc*) at the top of the Camp Rice Formation. The entire area is mantled by the thin cover-sediment (*Qcs*) that has a local OSL age of 9.65 ka. The piedmont alluvium is OSL-dated 40 to 50 ka; two younger ages are incongruous with the degree of soil development in the alluvium. The present-day surface at these two sites is late Paleoindian age (Fig. 21.85). Consequently, sites of all ages will occur at the surface. Cultural features may intrude into the cover sediment and underlying piedmont alluvium; buried cultural horizons will not be present.

Eight cultural features at LA 155963 have been AMS radiocarbon-dated with median-calibrated ages ranging from AD 51 to AD 1857 (Table 19.2). All of these features are comparatively young and occur at the present-day surface on the Paleoindian-age cover sediment.

Five radiocarbon ages from the large rock feature (Feature 1) at LA 155964 range from AD 1800 to AD 1940 (Table 19.2). The feature occurs at the present-day surface and intrudes into the underlying cover sediment (*Qcs*) and piedmont alluvium (*Qpc2*).

LA 155968, LA 155969, and LA 156877

These three sites are geographically separated but are located on the older piedmont-slope alluvium (*Qpa*) (Seager 2005). The upper several centimeters of the surficial geology is the cover sediment (Qcs), occurring as patches of deposits across the piedmont and at the three sites. Although cultural features will intrude the surface units Qcs and Qpc2, buried or subsurface cultural features will not be present.

Gully and Sheet Erosion and Its Effects on Prehistoric Site LA 155963

Beginning about AD 1680, gully erosion was initiated in a small drainage east of Aleman Ranch, cutting through archaeological site LA 155963. Downcutting of the gully occurred to a depth of 305 cm as measured from the top of the cover sediment (*Qcs*) at the location of BHT 9 (Fig. 21.8). After the initiation of gullying, rill erosion and sheet erosion

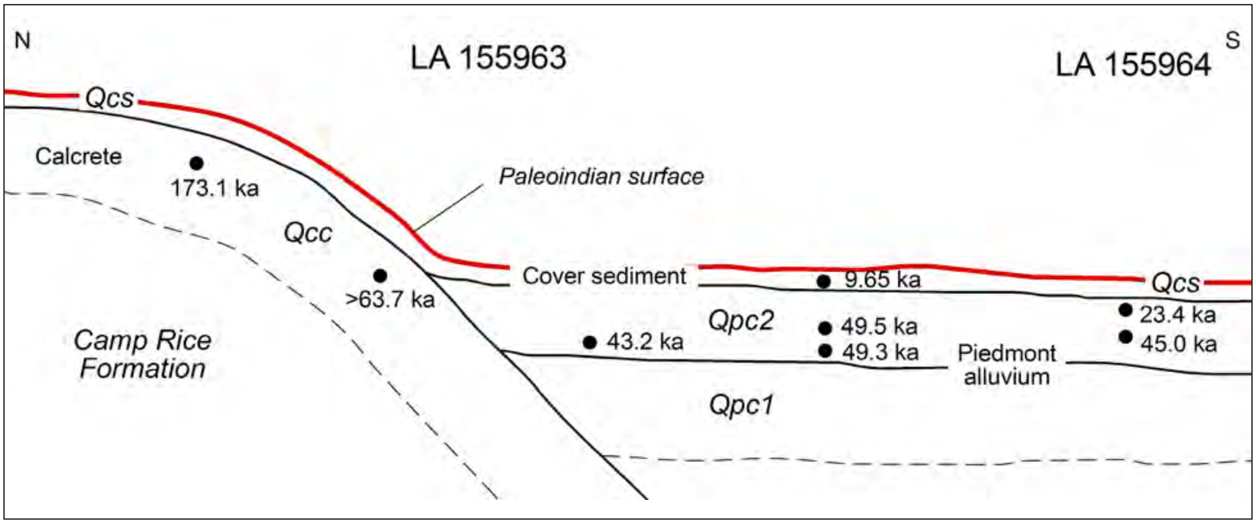

Figure 21.85. Sketch cross-section of LA 155963–LA 155964 on the piedmont slope from the Caballo Mountains and an outcrop of the Camp Rice Formation and calcrete; the Paleoindian surface occurs at the present-day surface and is associated with the cover sediment (Qcs); no scale.

resulted in the removal of the cover sediment and the underlying piedmont alluvial units (*Qpc1*, *Qpc2*). Rill and sheet erosion did not happen instantly; rather, the erosion occurred incrementally over a period of 330 years and is still occurring today. The rill-sheet erosion also removed local mesquite coppice dunes, leaving behind dried stems and exposed tap roots of the dead mesquite shrubs.

With the passage of time during the last 330 years, several rock features at LA 155963 were affected by matrix removal. The rock features are three-dimensional with stones on top of stones, tightly packed together. During the erosion process, the sediment matrix around individual stones was removed. During sediment removal, individual stones in the rock features were topographically lowered, forming a two-dimensional plane following the contour of the erosional surface on the underlying deposit. At the advanced stage of erosion, the stones were lowered as much as 50 to 100 cm, and individual stones were moved laterally, becoming spatially separated from neighboring stones (Figs. 21.86, 21.87, 21.88).

In this case, the age of the present-day surface of the cover sediment (*Qcs*) at the site is late Paleoindian. Thus, the gully-rill-sheet erosion across the area will affect sites of all cultural periods, from Paleoindian to Historic alike. If, for example, rock features of Paleoindian, Archaic, and Historic periods occurred on the present-day surface of the cover sediment, erosional processes would lower the stones from these features to the same degradational surface where they might become mixed in a quasi-lag gravel.

Artifacts associated with the rock features will become lowered to the erosional plane, similar to the stones. Small artifacts and components of the features, such as retouch flakes and charcoal, may be entirely removed during the sheet erosion process. While the cultural features are still clearly present upon erosion, the original geometry of the features and associated materials are lost.

As the processes of rill and sheet erosion continue across LA 155963 and the area of erosion expands, additional cultural features will be affected. Even though the erosion began by AD 1680, features that are younger than 1680, and those formed since that time, are still susceptible to erosion in the future.

Summary and Conclusions

The conclusions regarding the surficial geology and archaeological geology from this investigation apply specifically to the central area of the Jornada del Muerto valley in the vicinity of Spaceport America and may differ from the geology in other areas up and down the valley in south-central New

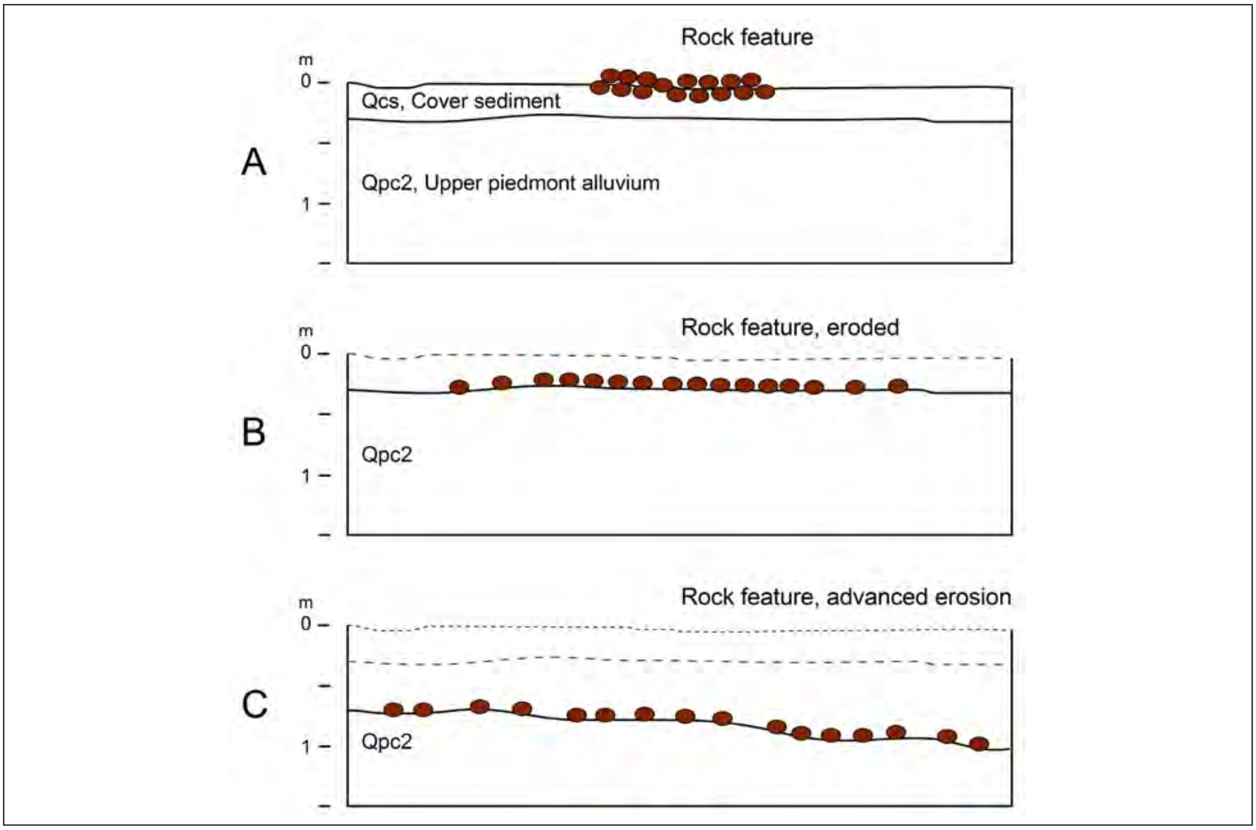

Figure 21.86. LA 155963, sketch of progressive erosion of a rock feature as observed in the field.

Figure 21.87. LA 155963, rock feature occurring in cover sediment (Qcs) with beginning stage of erosion; the rock feature is three-dimensional; the surface of Qcs is littered with small pebbles, a typical occurrence in the area; note that the mesquite coppice dunes in the background are intact and may still be accumulating sand.

Figure 21.88. LA 155963, advanced stage of erosion of rock feature; the stones have been lowered from a three-dimensional to a two-dimensional plane; the stones are separated from each other by greater distances away from the center of the feature; the exposed tap root of the nearby mesquite and another shrub indicate that 30–40 cm of sediment has been removed from this locality by sheet erosion.

Mexico. A summary of the dated stratigraphy is presented in Table 21.6.

1. The Jornada del Muerto landscape is ancient. The surficial deposits are mostly piedmont-slope alluvium from the San Andres and Caballo mountains. The piedmont alluvium is OSL-dated about 40 ka to greater than 66 ka, evidently ending deposition by 40 ka.

2. In this study, we see two piedmont alluvial units, the deposits derived from the adjacent mountains. The piedmont alluvium is sandy silt with occasional thin beds of small pebbly gravel. The older, underlying units (*Qpc1*, *Qps1*) are everywhere buried and are too old to be OSL-dated. The upper units (*Qpc2*, *Qps2*) outcrop at the present-day surface and are OSL-dated 40 to 50 ka and greater than 66 ka.

3. Alluvial silt with thin beds of small gravel (*Qaj*) along the edge of Jornada Draw was deposited at the same time as the accumulation of the late stage of piedmont alluvium, about 50 to 40 ka.

4. The present-day surface of the piedmont alluvium and some areas of Jornada alluvium are old and, accordingly, archaeological sites of all ages from Paleoindian to Historic periods have the potential to occur there.

5. In the northwestern area of the project, east of Aleman Ranch, the stage IV calcrete (*Qcc*) at the top of the Camp Rice Formation outcrops, forming a low hill. The calcrete is middle Pleistocene; an OSL age of 173 ka on sand grains from the calcrete may be a minimum age.

6. With the passage of time, the surface of the piedmont alluvium (*Qpc2*, *Qps2*) and the calcrete (*Qcc*) have weathered and become mixed by surficial processes resulting in the formation of the cover sediment (*Qcs*). The texture of the *Qcs* commonly parallels the texture of the subsurface sediments. The *Qcs* may also include silt from atmospheric dust. The *Qcs* is generally 30 to 40 cm thick and is OSL-dated about 15 to 5 ka. The age of *Qcs* may differ from area to area with the Paleoindian surface

at the base or at the top of the unit. Early and late Paleoindian sites have the potential to be buried in the cover sediment.

7. The second phase of geomorphic history of the Jornada is the deposition of the eolian sand sheet (*Qes*) on the Pleistocene surface. In this investigation, small outliers at the western edge of the broader sand sheet in the Jornada valley were studied. The sand sheet is less than 2 m thick and composed of fine- to medium- and very fine-textured sand with 31 to 44 percent silt and 5 to 8 percent clay. It commonly has a very weak Bk soil horizon. The age of the sand based on 16 OSL ages from six localities ranges from 11 to 1.2 ka, spanning most of the Holocene. Archaeological horizons are buried in the sand sheet, occurring as early as 2900 BC. Sites as early as 9000 BC have a potential to be buried at greater depth in the *Qes* sand.

8. Some of the archaeological sites in our study area occur on sand outliers at the western margin of the broad sand sheet. The eolian sand sheet (*Qes*) is the only extensive deposit in the study area containing buried archaeology (except for Paleoindian archaeology in cover sediment, discussed above). However, the *Qes* outliers exhibit a dissimilar geomorphic history with wide differences in terminal ages for sand deposition. At LA 111429 (BHT 13) sand deposition ended at 680 BC, at LA 111422 (BHT 17) sand deposition ended at 2026 BC, and at LA 111435 (BHT 18) sand deposition ended at AD 929 (Table 21.7). Whether different ages of the top of the sand sheet at different localities are related to the dissimilar duration of local sand accumulation or to local differences in erosion rates and preservation of the sand deposits is uncertain. Regardless, the archaeological significance is clear. The ages of archeological horizons at the surface of the sand sheet and buried in the sand are not the same from one *Qes* deposit to another. Based on the above data, the age of sites at the top of the sand may range from 2000 BC to AD 900, depending on the sand deposit. For example, an archaeological horizon of 1000 BC would be at the surface at LA 111422 but would be buried in the sand at LA 111435.

9. Previously buried Archaic cultural features have been exhumed by recent wind deflation and sheet erosion and occur at the present-day surface of eolian sand deposits. At LA 111435, Feature 10 occurs on the south-facing slope of the sand deposit and is dated 2940–2877 BC. Although at the present-day surface, it should be buried at a 67 cm depth, based on the sedimentation rate of the eolian sand (*Qes*). The presence of the cultural feature at the present-day surface indicates recent deflation of the sand, exposing Feature 10. The deflation occurred during the period 500 to 150 years ago; sheet erosion has also contributed to the exposure of the feature and is continuing today.

10. By about 400–500 years after the end of accumulation of the sand sheet, a grassland vegetation was established on the stable sand, resulting in the formation of an A-horizon soil (*Qah*). Today, the soil is almost entirely missing from the Jornada valley except where it is buried and preserved by younger eolian sand (*Qe*) and coppice dunes (*Qec*). The A-horizon is generally less than 20 cm thick and is distinguished in the field by a gray color from its organic content. The soil formed during a period of at least 100 years from AD 1400 to 1500 based on radiocarbon dating of the soil organic carbon and OSL dating of the sand that accumulated on the soil. The *Qah* formed during the slightly wetter climate of the middle and late stage of the Little Ice Age. *Qah* correlates with the Loco Hills soil in the Mescalero sand sheet and the McGregor soil in the Bolson sand sheet.

11. At least three cultural features at three different sites in the study area were formed during the wetter climate of Little Ice Age (AD 1300–1850) and the formation of the A-horizon soil (*Qah*).

12. After the end of the slightly wetter climate associated with the Little Ice Age, a period of renewed sand transportation and deposition occurred in the Jornada valley, beginning about AD 1860. Two eolian sand units were deposited, the non-dune eolian sand (*Qe*) and the eolian sand in mesquite coppice dunes (*Qec*). The non-dune sand (*Qe*) is thin, 10 to 30 cm, and occurs only on the surface of the sand sheet (*Qes*) and on the A-horizon soil (*Qah*). The texture of the *Qe* differs from the other units in the valley, suggesting that the *Qe* sand has a different source or has been further sorted by wind transport. Four OSL ages from *Qe* range from AD 1860 to 1911. The mesquite coppice dune sand is similar in texture to the *Qes* sand sheet, suggesting that the coppice dune sand is derived from deflation of the sand sheet. However, mesquite coppice dunes occur both on the sand sheet and on the cover

sediment in areas far from the sand sheet. Two OSL ages from coppice dunes are AD 1860 (± 40–50 years). While it is tempting to attribute the renewal of eolian activity in the Jornada valley to climate drying at the end of the Little Ice Age, the presence of American livestock on the desert grassland vegetation may have had a pronounced influence on eolian processes as well.

13. The Jornada valley is characterized by broad, gently sloping piedmont surfaces. By about AD 1680, however, the erosion of a gully and accompanying rill and sheet erosion resulted in the removal of surface sediment and lowering of the topography by as much as 2 m in the axis of the small water shed of the gully. The erosion occurred at LA 155963, resulting in the destruction of several rock features in a small area. The erosion is continuing today, and some features at the site in the vicinity of the modern wash/gully will be adversely affected into the future. However, the gully-sheet erosion observed at a small area of LA 155963 does not appear to be widespread in the Jornada valley.

14. Badgers are active burrowers, producing large burrows and zones of bioturbation. In our study, we found large burrows in seven of eighteen trenches that we attribute to badgers. None of the large burrows were observed at the surface prior to trenching. On the piedmont slope, the burrows are confined to subsurface units and are covered by the cover sediment (*Qcs*), indicating that the burrowing activity pre-dated the *Qcs* unit, prior to 15 ka. Elsewhere, burrows are in the sand sheet (*Qes*) but covered by more recent sand (*Qe*), indicating that burrowing activity occurred between about 500 and 100 years ago. Badger fossils have been recovered from caves in the region, and it is reasonable to assume that bioturbation by badgers has been ongoing throughout the Pleistocene and Holocene and into modern times.

15. Each of the 12 stratigraphic units we have described in the Jornada, as well as most prehistoric cultural features at archaeological sites, shows evidence of cicada burrowing. The upper levels of *Qps2*, especially between 30 and 100 cm depth, appear to be 100 percent bioturbated by cicada nymphs, resulting in a dense mass of burrow fills. Secondary carbonate has precipitated around the burrow fills, producing features that mimic soil carbonate nodules. The recovery of a desiccated adult specimen of the cicada *Beameria wheeleri* at 20 cm depth at LA 111435 is the first identifiable record of a cicada associated with sediments in the study area. The small size of *B. wheeleri* matches the small burrows in the stratigraphic units.

16. In our study of the late Quaternary deposits in the Jornada, particle-size analysis was conducted largely by a laser diffraction method. Early in the investigation, some sediment was analyzed by the conventional method by brass sieves and hydrometer. Five of our sediment samples were analyzed by both methods. Because of the differences in the results of the two methodologies and the long history of particle-size analysis by sieves in the geologic-soil literature, we recommend particle-size analysis by the traditional sieve-hydrometer-pipette method in future investigations.

ACKNOWLEDGMENTS

The geographic coordinates for the study localities discussed in this chapter are listed in Table 21.30. We thank Robert Dello-Russo, James Moore, Nancy Akins, and Karen Wening as well as the many individuals in the field and in the office of the Office of Archaeological Studies, Museum of New Mexico, for assistance with the organization and fieldwork of this investigation. We thank Tim McNary, USDA, APHIS, PPQ, Fort Collins, Colorado, for the identification of the cicada specimen *Beameria wheeleri* and for information on cicadas; the specimen is reposited in the C. P. Gillette Museum of Arthropod Diversity, Colorado State University, Fort Collins, Colorado. The statistical analyses of the various data were conducted by SigmaPlot 12.

Table 21.30. Locations of trenches (BHT) and OSL samples.

BHT No.	OSL Field No.	OSL Lab No. (UNL-)	Latitude (north)*	Longitude (west)*	Elevation (feet)
1	1	3352	32° 57' 24.60"	106° 56'	4531
2	2	3353	32° 57' 07.11"	106° 56'	4522
3	3	3354	32° 57' 11.29"	106° 56'	4524
3	4	3355	32° 57' 11.29"	106° 56'	4524
3	8	3451	32° 57' 11.29"	106° 56'	4524
4	5	3450	32° 56' 37.04"	106° 55'	4532
4	6	3356	32° 56' 37.04"	106° 55'	4532
4	7	3357	32° 56' 37.04"	106° 55'	4532
4	9	3452	32° 56' 37.04"	106° 55'	4532
4	10	3358	32° 56' 37.04"	106° 55'	4532
5	11	3359	32° 56' 45.16"	106° 55'	4526
6	(none)	–	32° 56' 45.29"	106° 55'	4519
7	18	3164	32° 59' 24.37"	106° 59'	4631
7	19	3165	32° 59' 24.37"	106° 59'	4631
7	20	3166	32° 59' 24.37"	106° 59'	4631
7	21	3167	32° 59' 24.37"	106° 59'	4631
8	22	3168	32° 59' 33.64"	106° 59'	4637
9	12	3159	32° 59' 33.84"	106° 59'	4638
9	13	3160	32° 59' 33.84"	106° 59'	4638
9	14	3161	32° 59' 33.84"	106° 59'	4638
W. of 9	15	3162	32° 59' 35.27"	106° 59'	4639
9	17	3163	32° 59' 33.84"	106° 59'	4638
10	23	3453	32° 59' 38.75"	106° 59'	4657
11	(none)	–	32° 59' 49.15"	106° 59'	4680
12	53	3350	32° 59' 09.68"	106° 58'	4629
12	54	3351	32° 59' 09.68"	106° 58'	4629
13	48	3345	32° 56' 56.09"	106° 55'	4534
13	49	3346	32° 56' 56.09"	106° 55'	4534
13	50	3347	32° 56' 56.09"	106° 55'	4534
13	51	3348	32° 56' 56.09"	106° 55'	4534
13	52	3349	32° 56' 56.09"	106° 55'	4534
PaleoIn.	43	3342	32° 57' 04.42"	106° 55'	4543
PaleoIn.	44	3364	32° 57' 04.42"	106° 55'	4543
PaleoIn.	45	3365	32° 57' 04.42"	106° 55'	4543
TP-3	24	3361	32° 56' 56.33"	106° 55'	4533
TP-3	25	3362	32° 56' 56.33"	106° 55'	4533
TP-3	26	3363	32° 56' 56.33"	106° 55'	4533
Vertical	16	3360	32° 57' 03.26"	106° 55'	4515
14	40	3224	32° 56' 56.75"	106° 55'	4524
14	41	3225	32° 56' 56.75"	106° 55'	4524
14	42	3226	32° 56' 56.75"	106° 55'	4524
15	46	3343	32° 57' 03.80"	106° 55'	4510
15	47	3344	32° 57' 03.80"	106° 55'	4510
16	37	3221	32° 57' 05.18"	106° 55'	4516
16	38	3222	32° 57' 05.18"	106° 55'	4516
16	39	3223	32° 57' 05.18"	106° 55'	4516

(Table 21.30, continued)

BHT No.	OSL Field No.	OSL Lab No. (UNL-)	Latitude (north)*	Longitude (west)*	Elevation (feet)
17	34	3218	32° 57' 16.26"	106° 56'	4544
17	35	3219	32° 57' 16.26"	106° 56'	4544
17	36	3220	32° 57' 16.26"	106° 56'	4544
18	27	3211	32° 56' 57.12"	106° 56'	4521
18	28	3212	32° 56' 57.12"	106° 56'	4521
18	29	3213	32° 56' 57.12"	106° 56'	4521
18	30	3214	32° 56' 57.12"	106° 56'	4521
18	31	3215	32° 56' 57.12"	106° 56'	4521
18	32	3216	32° 56' 57.12"	106° 56'	4521
18	33	3217	32° 56' 57.12"	106° 56'	4521

Note : GPS measurements taken in the field with a Magellan® eXplorist 300 receiver.
* NAD 83

22 | Integrating the Results of Archaeological and Geomorphological Studies

James L. Moore and Stephen A. Hall

Introduction

As shown in Chapter 21, archaeological data can be an important adjunct to geomorphological studies, especially when examining the later part of the Holocene. Similarly, the results of geomorphological studies can be critical to archaeological interpretations, providing important interpretive data that otherwise might not be recognized. By integrating the results of geomorphological and archaeological studies we can enhance our ability to understand aspects of the archaeology that were not clear in the field as well as improve our capacity to predict where buried archaeological horizons might occur.

This chapter begins with the general, examining the overall geomorphology of the study area and where there is potential to encounter buried archaeological horizons that lack any surface expression. This is followed by a site-by-site discussion, combining archaeological and geomorphological data to derive a better understanding of what we encountered and the potential for finding buried features and components. It should be noted that the numbers assigned to geomorphology trenches during testing were sometimes changed during the research phase, and thus the numbers used in this chapter and Chapter 21 sometimes disagree with those shown on site plans in the testing report (Akins and Moore 2011a).

The Overall Geomorphological Picture in Relation to the Archaeology

Hall and Goble's discussion of the geomorphology of the Spaceport America study area is very detailed and is not repeated here at any length. Only aspects of that study that bear upon the archaeology are covered. This begins with the sources of Pleistocene and Holocene deposits in the region, because those sources bear directly upon what types of rocks will and will not be in the local gravel deposits that were important sources for materials used in chipped and ground stone tool manufacture.

Pleistocene Deposits

An important observation made in Chapter 21 is clarification of Seager's (2005) definition of an outcrop of the Camp Rice Formation in the study area. As noted in Chapter 21, the exposure of the Camp Rice Formation (mapped by Seager [2005]) that forms the hill upon which LA 155963 occurs is actually the local equivalent of that formation, topped by a thick layer of calcrete defined elsewhere as the La Mesa surface. Rather than representing fluvial deposits of the ancestral Rio Grande, as the Camp Rice Formation does elsewhere, the local equivalent of this formation is composed of piedmont and alluvial fan deposits originating in the mountains surrounding the Jornada del Muerto. This is important to local archaeology. If these deposits had been derived instead from the ancestral Rio Grande, both Pedernal chert and Jemez obsidian might well be available in associated gravel beds, potentially making those materials locally available. Since the local expression of the Camp Rice Formation does not represent Rio Grande deposits, the closest sources for Pedernal chert and Jemez obsidian are south of Point of Rocks, about 24 km south of the study area, and the Rio Grande Valley, over 30 km to the east, with the Caballo Mountains intervening. The use of these materials obtained from fluvial deposits as indicated by cortex type becomes evidence of interaction between the study area and the Rio Grande Valley or the Point of Rocks area rather than simply the use of locally-available materials.

Except where covered by younger eolian and eolian-colluvial sands, the rest of the surface geology of the study area is formed by piedmont-slope alluvium derived from the Caballo and San Andres mountains, to the west and east, respectively. Two depositional units apiece derive from these sources. Piedmont-slope deposits originating in the San Andres Mountains are mainly on the east side of Jornada Draw. Trenches on the west side of Jornada Draw showed that these deposits are more extensive than indicated by Seager's (2005) geologic mapping, extending perhaps 0.8 km west of Jornada Draw. Nine of the sites examined at Spaceport America are on these deposits, including LA 111420, LA 111421, LA 111422, LA 111429, LA 111432, LA 111435, LA 112370, LA 112371, and LA 112374. The five remaining sites are on piedmont-slope deposits originating in the Caballo Mountains and include LA 155963, LA 155964, LA 155968, LA 155969, and LA 156877.

The lower deposit of San Andres Mountain materials (Qps1) does not occur at the surface in our study area. Other than encountering a bed of small pebble gravel near the base of this deposit in BHT 2, gravels are uncommon in this layer of sediment. The deposition of Qps1 dates to the Pleistocene, and its age is greater than 65,000 years. The upper layer of this material (Qps2) occurs at the surface in some areas, and elsewhere it is covered by later sediments. This deposit is between about 40,000 and 65,000 years old.

The lower alluvium (Qpc1) of the Caballo Mountain piedmont does not occur at the present-day surface in our study area. The alluvium includes sub-rounded pebbles, mostly black limestone, and was deposited prior to 50,000 years ago. The upper alluvium (Qpc2) of the Caballo Mountain piedmont occurs at the surface at LA 155968, LA 155969, and LA 156877, and is mantled by younger deposits elsewhere. The alluvium was deposited between about 40,000 and 50,000 years ago.

Late Pleistocene-Holocene Deposits

Four late Pleistocene-Holocene deposits are very important to this discussion. The first is the cover sediment—Qcs—which is a thin mantle of silty sand and sand silt that covers the Pleistocene piedmont alluvium in much of the study area. Deposition of these materials dates between 14,900 ± 1000 and 5,000 ± 250 years ago. The second of these is an eolian sand sheet—Qes—which mantles the piedmont slope deposits originating in the San Andres Mountains. Deposition of these materials occurred between 10,300 ± 400 and 1,380 ± 80 years ago. These are the two most widely distributed late Pleistocene-Holocene deposits.

The third important unit is an A-horizon soil (Qah) that formed during the Protohistoric period between about AD 1400 and 1500. This soil occurs sporadically on sites in the Jornada Draw area. The fourth deposit of archaeological interest is young eolian sand (Qe) and sand that forms coppice dunes (Qec), both deposits occurring at the modern surface and accumulating largely during the late nineteenth century.

Summary of Late Pleistocene and Holocene Deposits

Archaeological deposits should not occur in the Pleistocene age piedmont-slope alluvium. The presence of artifacts on the surface of these deposits may be a good indication that a site is partly to completely deflated. Features excavated into the ground may extend down into the top of the Qpc2 or Qps2 units, but will not originate within them.

All archaeological materials should be associated with Holocene deposits unless the deposits have been removed by erosion. Early Paleoindian materials can occur at the base of the cover sediment (Qcs), with late Paleoindian above them and Archaic materials occurring in upper levels to the top of this deposit. Late Paleoindian materials can occur at the base of the eolian sand sheet (Qes), with Archaic materials potentially occurring above them, and Formative period materials near and on top of this deposit. The Qah unit, representing an A-horizon soli, should contain Protohistoric materials, with early Historic-period materials potentially also occurring on the surface of this soil. Only late nineteenth- to twentieth-century cultural materials should occur within the young eolian sand deposits (Qe).

Site-by-Site Discussion

The geomorphological situation based on geomorphic trenches and archaeological observations is reviewed for each site, and the potential for containing buried deposits assessed. One of the most important procedural implications of the geomorphological study came during the testing phase. Observing the depth of test pits being excavated early in that phase and assessing the local surficial geology, the crew was made aware that hard, fine-textured sediments with carbonate concentrations (caliche) represent Pleistocene piedmont alluvium and were far too old to contain cultural materials. Thereafter in both project phases, when hard sediments with caliche were encountered, excavation stopped.

LA 111420

This site was examined during testing and was determined "eligible" to the *National Register* during Section 106 consultations following survey and prior to testing. Testing results indicated that this site retains data potential (Akins and Moore 2011aa:55), and this is corroborated by the geomorphological study. Examining the stratigraphy in BHT 3 (Fig. 21.16) showed that the cover sediment (Qcs) is about 25 cm thick at this site and sits on top of piedmont-slope deposits derived from the San Andres Mountains (Qps2). An OSL date of 11,300 ± 900 was obtained from the cover sediment in this trench.

As discussed in Chapter 14, this site contains Archaic materials, with at least two components dating to the Early and Middle Archaic periods. Five test pits were excavated at this site, and artifacts were recovered from the upper levels of four of them (Akins and Moore 2011a:54–55). The loose upper sediment that contains the artifacts corresponds to the cover sediment, and the early date derived for this stratum at LA 111420 suggests that the materials occurring on the surface have been exposed by deflation, but may retain a degree of spatial integrity. The recovery of chipped stone artifacts from subsurface contexts suggests that, in light of the OSL date, this site may contain fairly intact subsurface cultural deposits. These deposits are not thick and are mainly confined to the cover sediment, though features could extend down into the top of the piedmont alluvium and some artifacts may have been carried down into that material through bioturbation.

LA 111421

This aceramic site was examined during testing. Examination of the chipped stone assemblage in Chapter 14 suggests that a general Archaic age can be assigned based on the presence of a probable dart point preform. Four test pits were excavated at this site and a few artifacts were recovered, mainly from near the surface (Akins and Moore 2011a:59). These results were used to recommend that LA 111421 be determined "not eligible" to the *National Register* (Akins and Moore 2011a:61). This recommendation is supported by the geomorphological study, which indicates that piedmont alluvium (Qps2) is exposed on the surface of this site from which any cover sediment (Qcs) has been eroded or was not deposited at this location, as shown in BHT 2 (Fig. 21.19). Thus, intact subsurface cultural deposits are extremely unlikely, and any subsurface materials are the result of bioturbation.

LA 111422

This early Mesilla-phase site was examined during the research phase and was determined "eligible" to the *National Register* during Section 106 consultations following survey and prior to our study. While the investigated features (Fig. 6.1) yielded some information on subsistence, fuel use, and dating, none appear to be intact and all have been deflated. Surface stripping recovered numerous artifacts and there appears to be some integrity to the distribution of artifacts. BHT 17 was excavated to examine subsurface deposits (Fig. 21.22). The geomorphological study indicates that LA 111422 is on top of a 1.2 m high mound of eolian sand (Qes) that dates to 6,170 ± 260 BP near its base and 4,720 ± 240 BP near the top. An extrapolated date of 4,037 BP was suggested for the top surface of the mound (Chapter 21, this report). The Mesilla-phase features were excavated into the Qes sediment, which, as suggested by the eroded nature of the features recorded on this site, has now probably been deflated below the contemporary occupational surface. While the basal sections of features may remain, the upper sections are eroded away. Thus, while the unexcavated features may still have the ability to provide further information on the date of site use, fuel wood use, and subsistence practices, the associated artifacts have been vertically and perhaps horizontally displaced from their original depositional locations.

LA 111429

This large site was examined during both the testing and research phases and was determined "eligible" to the *National Register* during Section 106 consultations following survey and prior to testing. The results of both investigative phases confirm the potential of this site to provide information on local prehistory. Artifacts dating to the Paleoindian, Archaic, and Formative periods have been recovered, and a feature dating to the Protohistoric period was investigated during the research phase. Thus, LA 111429 represents a location attractive to short-term use by people occupying this region over a period of at least 10,000 years.

Geomorphological data were obtained from four trenches and two archaeological excavation areas (BHTs 13–16, Test Pit 3, Surface Strip 6) and exhibit some variation in deposits across the site (Figs. 7.1–7.3). BHT 13 (Fig. 21.28) was in the southern part of the site and showed that the Protohistoric A-horizon soil (Qah) is at the top of the sand sheet (Qes), which in turn overlies piedmont-slope alluvium (Qps2). In BHT 14 (Fig. 21.25), near the east edge of the site, the upper 30 cm consists of recent eolian sand (Qe). Under this is the Protohistoric A-horizon soil that occurs at the top of the sand sheet. BHT 16 was just north of the Feature Area and contains recent eolian sand on top of the Protohistoric A-horizon soil, which again covers the sand sheet. The latter is underlain by piedmont-slope alluvium (Qps2).

BHT 15 (Fig. 21.34) was near the western edge of the site and investigated subsurface deposits in Paleoindian Area 1 as well being used to define alluvial deposits at the eastern edge of Jornada Draw. However, this trench did not actually extend into Paleoindian Area 1 and so did not disturb the cultural materials in that part of the site. This trench encountered only alluvium deposited along the edge of the drainage, which was mostly too ancient to contain cultural deposits, though such would be possible in the upper levels of more recently deposited sediment. However, no evidence of cultural remains was noted.

Test Pit 3 was examined during testing (Akins and Moore 2011a); it contained 30 cm of recent eolian sand (Qe) over the Protohistoric A-horizon soil (Qah), which tops the sand sheet (Qes). Both radiocarbon and OSL dates were obtained from the A-horizon soil, and both date this sediment to the fifteenth century. Excavation in Surface Strip 6 encountered the cover sediment (Qcs) sitting on top of piedmont alluvium (Qps2). An OSL sample taken near the base of the cover sediment yielded a date of 8,830 ± 440. Two OSL samples taken from higher points in the 7profile returned dates of 6,060 ± 270 and 5,000 ± 250. A vertical OSL sample taken from the cover sediment in Paleoindian Area 1 was dated at 7,370 ± 440 years.

Thus, while the cover sediment (Qcs) was not identified in any of the geomorphological trenches, it does occur in Paleoindian Area 1 and adjacent parts of the Feature Area. The cover sediment was encountered in Surface Strips 1–3 in Paleoindian Area 1, and was labeled Stratum 1. This stratum accumulated over a long period beginning in the late Pleistocene and ending in the Middle Archaic, or about 15,000 to 5,000 years ago. Thus, Paleoindian materials occur in the lower levels and Archaic materials occur in the upper levels. The artifacts recovered from Stratum 1 in Paleoindian Area 1 came from the lower part of the cover sediment and are thought to reflect a Folsom-period occupation, based on the number of Folsom points and spurred end scrapers found along the western flank of the site. Considering the eroded nature of Paleoindian Area 1, materials from later occupations may be mixed with Paleoindian materials on the surface of this area, especially where the cover sediment has been completely removed by erosion, exposing the underlying Pleistocene piedmont alluvium.

Although geomorphic trenches were not placed in Paleoindian Area 2 and no OSL dates were obtained, Stratum 1 in this part of the site may correlate with the lower part of the cover sediment. Thus, the materials exposed in this area are also considered representative of a Folsom-period occupation. This possibility is partly supported by the character of the chipped stone assemblage and the occurrence of several spurred end scrapers—not definitive proof, but evidence for the antiquity of these remains. A similar situation prevails in Paleoindian Area 3. The possibility that the deposits encountered in that area represent the lower section of the cover sediment indicates that the materials recovered from Surface Strip 9 may have been deposited during the Paleoindian period as well.

Four archaeological strata were defined in the Feature Area and are equated with three units defined by the geomorphic study. Stratum 20 is recent eolian sand (Qe), the cover sediment (Qcs) equates to Strata 3 and 5, and Stratum 6 is Pleistocene piedmont alluvium (Qps2). Since most chipped stone artifacts recovered by excavation in this section of the site came from Stratum 5, which is the lower part of the cover sediment just above the piedmont alluvium, these materials are Paleoindian in age and probably also represent a Folsom occupation. The upper section of the cover sediment in this area is Stratum 3, which dates to the Archaic, as do the artifacts found within it. Interestingly, two fragments of the same Folsom point base were found in Stratum 3 in Surface Strip 7. While possible that this artifact was found and curated by Archaic occupants of the site, bioturbation up from Paleoindian levels is the more likely explanation. The Protohistoric date for Feature 11 combined with the deflated nature of this thermal feature indicate that the Protohistoric ground surface was 50–60 cm higher than the present-day surface, at least in the northern part of the site.

The site surface in the Ground Stone Area is partly covered by recent eolian sand (Qe), but much of this area appears to have been eroded down into the sand sheet (Qes). Since deposition of the sand sheet continued into at least the early Mesilla phase, with an A-horizon soil forming on top of it during the Protohistoric period, cultural materials found in eroded parts of the southern section of the site could date anywhere between the Late Archaic and Protohistoric period. Better discrimination is not possible without further archaeological and geomorphic studies.

This large, complicated, multicomponent site retains considerable ability to provide information on the human occupation of the region. OSL dates from artifact-bearing levels indicate that the earliest use of this site was during the Paleoindian period, mainly during the Folsom period but possibly as early as Clovis times. These materials occur near the base of the cover sediment. Upper levels of the cover sediment date to the Archaic period, and also contain cultural materials in some areas. The sand sheet began forming during the late Paleoindian period and continued accumulating until at least the early Mesilla phase. Cultural materials appear to occur near the top of the sand sheet, but this stratum was not as well investigated as the cover sediment in Paleoindian Area 1 and the Feature area were. Unfortunately, the relationship between the cover sediment (Qcs) and the sand sheet (Qes) was not established during this study; we remain uncertain whether these two units are superimposed, border on one another in the northern part of the site, or represent simultaneous deposition and blending. Further study is necessary to clarify this relationship.

While the dense scatter of artifacts along the western edge of LA 111429 represents the deflation of cultural strata (and non-cultural strata) onto the surface of the Pleistocene piedmont alluvium, excavation indicated that strata containing cultural materials continue under the sand deposits that form a low ridge in the east-central part of the site. How far these materials extend, and what occupational periods are represented, can only be established by further excavation. Whether a similar situation prevails in the southern part of the site at the base of the sand sheet is unknown.

LA 111432

This probable late Paleoindian-period site was examined during testing and was determined "eligible" to the *National Register* during Section 106 consultations following survey and prior to testing. The results of testing suggested that this site retains the potential to provide information on the late Paleoindian occupation of this region (Akins and Moore 2011a:66). However, the geomorphological study indicates that the data potential of this site may be more limited than initially thought. Examination of the stratigraphy in BHT 1 (Fig. 21.44) showed that Pleistocene piedmont alluvium (Qps2) is exposed on the surface, with Qps1 occurring 80 cm below this layer. Chipped stone artifacts were moderately common in the loose upper 5–10 cm of fill in four of the five test pits. Since the geomorphic study indicates that this loose material is actually the surface of Qps2, then any sediment deposited during the latest Pleistocene and Holocene has been removed by erosion. This presents two possible scenarios. The first is that the artifact-bearing late Pleistocene/Holocene strata have been eroded from LA 111432, depositing any artifacts they might have contained onto a stratum that predates human occupation of the New World. The second possibility is that the late Pleistocene/Holocene layers were never deposited here, with artifacts of all ages occurring at the surface with some being worked into the upper sediment by weathering processes. The latter is thought to be more likely. The occurrence of artifacts in the upper few centimeters of Qps2 is due to weathering and bioturbation in either case. Thus, while many more artifacts may be available from subsurface fill at this site, they have been vertically and perhaps horizontally displaced from their original depositional contexts.

LA 111435

This Mesilla phase/Archaic multicomponent site was examined during the research phase (Figs. 8.1–8.2) and was determined "eligible" to the *National Register* during Section 106 consultations following survey. While the excavated features yielded information on subsistence, fuel use, and dating, none were intact and all were deflated. Surface stripping recovered numerous artifacts, and there appears to be some horizontal integrity to their distribution. BHT 18 (Fig. 21.47) was used to examine the geomorphology of this site; this trench was near the northwestern edge of the site, near the crest of the sand bench the site sits upon, outside the artifact scatter. The upper 30 cm in this trench was recent eolian sand (Qe), covering a Protohistoric A-horizon soil (Qah). Below this to the bottom of the trench was the sand sheet (Qes). OSL dates from the sand sheet suggest deposition from the early Middle Archaic into the Late Archaic. No trenches were excavated into the badly deflated southeastern half of the site, but most if not all of the sand sheet appears to have been eroded away there, suggesting there is little potential for intact cultural deposits.

Archaeological investigations focused on the western half of the site on the southern slope of the sand bench. While the lower sections of thermal features exposed in this area can be comparatively intact, their upper sections have eroded away and associated rock elements are scattered. Thus, cultural deposits and features on the south slope of the sand bench have suffered from a significant amount of erosion. Several excavated features that occur at similar elevations date to the Middle Archaic, Late Archaic, and early Mesilla phase. This indicates that the recent eolian sand and Protohistoric A-horizon soil are missing, and the upper section of the sand sheet has been eroded away, removing the tops of the Mesilla-phase features and exposing Archaic features. Mesilla-phase artifacts are therefore vertically and perhaps horizontally displaced from their original locations, potentially mixing with Archaic artifacts on the present-day deflated surface.

Preservation of the Protohistoric A-horizon soil under a mantle of recent eolian sand near the top of the sand bench suggests that buried cultural deposits and/or features may exist where erosion has not removed later deposits, especially in the western half of the site. Since Archaic features would have been buried more deeply than those of the Mesilla phase, other such features may still be concealed under a mantle of later deposits. Thus, though the Mesilla-phase deposits have been severely affected by erosion, the same may not be true of Archaic remains.

LA 112370

This site, which is of unknown date, was examined during testing. BHT 5 was used to investigate the geomorphology and was in the south-central section of the site (Akins and Moore 2011a:67). This trench showed that the cover sediment is absent and artifacts lie directly on piedmont alluvium (Qps2). Since cultural materials occur directly on Pleistocene alluvial deposits, the results of the geomorphic study agree with the archaeological conclusions that this site has limited data potential and should be determined "not eligible" for inclusion in the *National Register* (Akins and Moore 2011a:70).

LA 112371

This site, which is of unknown date, was examined during testing. BHT 6 was used to investigate the geomorphology and was in the east-central section of the site (Akins and Moore 2011a:72). This trench showed that the cover sediment is absent and artifacts lie directly on piedmont alluvium (Qps2). Although cultural materials occur directly on Pleistocene alluvial deposits, the archaeological work concludes that this site retains some data potential and should be determined "eligible" for inclusion in the *National Register* (Akins and Moore 2011a:70). Since the artifacts recovered by excavation at LA 112371 were actually in the upper part of the Pleistocene piedmont alluvium, they undoubtedly reached that level through weathering. Thus, artifacts at this site are displaced vertically and probably horizontally, and LA 112371 actually has very little further research potential.

LA 112374

This site, which is of unknown age, was examined during testing. BHT 4 was used to investigate the geomorphology and was near the southern edge of the site (Akins and Moore 2011a:77). This trench showed that the surface stratum is a 70 cm thick layer of cover sediment (Qcs), which occurs above piedmont alluvium (Qps2). An OSL date of 14,900 ± 1000 was obtained from a sample taken just below the midpoint of the cover sediment. The cover sediment was only 4–10 cm thick in the test pits excavated at LA 112374 and yielded no artifacts, nor other cultural deposits. Thus, despite the thickness of the cover sediment in the geomorphology trench, the results of this study do not negate the archaeological conclusion that this site has limited data potential and should be determined "not eligible" for inclusion in the *National Register* (Akins and Moore 2011a:80).

LA 155963

This large site was examined during both the testing and research phases. LA 155963 was determined "eligible" to the *National Register* during Section 106 review following survey and prior to testing. The results of both phases confirm its potential to provide information on the prehistory of this region, and it has yielded materials dating to the Paleoindian, Archaic, Formative, Protohistoric, and Historic periods. Thus, LA 155963 is a location that was attractive for short-term use over at least 10,000 years.

Meshing the results of archaeological and geomorphological studies is difficult for this site because few of the geomorphological trenches were in or near excavation areas. Five trenches (BHT 7–BHT 11) were used to explore subsurface sediments during testing (Figs. 9.1–9.4). BHT 7 (Fig. 21.58) was in the southern part of the site, near Datum 1, 100+ m southeast of Area B. This trench showed that coppice dune sand (Qec) occured above 30 cm of cover sediment (Qcs), which in turn overlies piedmont alluvium (Qpc2). An OSL sample near the base of the cover sediment in this trench returned a date of 9,650 ± 750 BP. BHT 8 (Fig. 21.60) was in the northern part of Area B near Datum 3, and contained about 40 cm of cover sediment above Camp Rice Formation calcrete (Qcc), which occurred to the floor of the trench. BHT 9 (Fig. 21.63) was 40-50 m west of BHT 8 and examined deposits in a deep gully that cuts through the southern part of the site. Outside the gully cut, piedmont alluvium (Qpc2) was exposed at the surface and, at a depth of about 130 cm, a second unit of piedmont alluvium (Qpc1) was present. BHT 10 (Fig. 21.69) was about 100 m south of Features 18–20 in an area that contains a very sparse scatter of surface artifacts and no visible cultural features. Similarly to BHT 8, about 45 cm of cover sediment was at the surface in BHT 10 above Camp Rice Formation calcrete that extended to the floor of the trench. Finally, BHT 11 (Fig. 21.70) was in Area A North, slightly east of the areas excavated in that part of the site during the research phase. About 45 cm of cover sediment occurred at the surface in this trench, overlying calcrete of the Camp Rice Formation, which extended to the base of the trench.

The long-term stability of the long sloping hill that LA 155963 occupies is undoubtedly due to the Camp Rice calcrete, which is considerably older than the piedmont alluvium, so this hill was already in existence when the latter was being deposited. The cover sediment was encountered at the surface in each trench, indicating that parts of the surface in this area have been relatively stable since the end of the Pleistocene. However, since all of the trenches were in the western half of LA 155963, the geomorphology of the eastern half remains to be similarly explored. For the most part, the eastern half of the site appears to have suffered from more extreme erosion and the cover sediment is only expected to occur in patches separated by piedmont alluvium exposed at the surface. A similar situation exists in the part of Section B adjacent to a small arroyo that drains the interior of the site (see Fig. 9.3). Much of this area is badly eroded by sheet and rill erosion, which has removed the cover sediment from large areas, eroding and exposing the numerous cultural features that cluster in this part of the site. Uneroded features may exist in areas beyond the small watershed of the arroyo that have not yet been affected by sheet erosion and are partly stabilized by mesquite shrubs and coppice dunes.

BHT 11 was between Artifact Clusters 1 and 2 in Area A North, just east of Surface Investigation Area 6. There was a thicker layer of cover sediment in the vicinity of this trench than was encountered in either of the nearby excavation areas, probably because the latter were located just below the crest of the hill in an area that is eroded by sheet wash. Stratum 1 in Surface Investigation Areas 5 and 6 represents the cover sediment, and was 4–12 cm thick. Since this represents the base of the cover sediment, the artifacts recovered from this zone date to the Paleoindian period, consistent with the Folsom date assigned to these materials based on the surface occurrence nearby of three Folsom points. While no trenches were excavated near Area A South, this part of the site is between BHT 10 and BHT 11, with the former about 100 m south and the latter about 160 m north. In both of these trenches, about 45 cm of cover sediment occurs above calcrete. Surface Investigation Area 4 in Area A South was in an eroded zone adjacent to a small gully, and the cover sediment was expected to be thinner. Indeed, Stratum 1 in this area was between 5 and 36 cm thick and also equates to the cover sediment. While the artifacts recovered from Surface Investigation Area 4 are assigned an Archaic affinity based on the occurrence of ground stone tools in the same general vicinity, their actual date remains uncertain and they could as easily represent another Paleoindian locus. However, the occurrence of numerous chipped stone artifacts on the surface of this excavation area in addition to those recovered from subsurface contexts may indicate either the deflation of Archaic materials downward or mixing of Archaic and possibly earlier materials in both surface and shallow subsurface contexts.

The trench nearest Surface Investigation Areas 2 and 3 in Area B is BHT 7, located 140 m to their southeast. BHT 8 and BHT 9 are about 170 m to the north. Thus, no trenches are close enough to Surface Investigation Areas 2 and 3 to be of use in discussing the subsurface geology of that part of the site. Stratum 17 was 2 to 14 cm thick in Surface Investigation Areas 2 and 3, and was directly on top of a harder-packed stratum that probably represents piedmont alluvium. Artifacts were found throughout Stratum 17, and three fire pits were exposed at the base of Stratum 17 that had been excavated into the underlying sediment. The large number of artifacts recovered from these excavation areas suggests a discard zone rather than an activity area, despite the presence of fire pits. Thus, Stratum 17 may mostly reflect an anthropogenic origin, augmented by eolian processes.

Trenches were not placed near Area C (in the southeastern part of the site). Comparison with the results of the geomorphic study are possible to some extent, however, using excavation data from Surface Investigation Area 1. The cover sediment was eroded from much of Area C, exposing what appears to be piedmont alluvium. Mesquite coppice dunes occured in places throughout this part of the site and two dunes in the vicinity were OSL-dated AD 1860 (± 40-50 years). The light-brown silty sand that comprised the loose artifact-bearing fill in Excavation Area 1 was most likely a mixture of more recent eolian sand and the top of the piedmont alluvium rather than the base of the cover sediment, especially considering the Mesilla-phase date for the artifacts it contains.

The connection between the geomorphic study and the deposits removed during excavation is not as clear for LA 155963 as it is for the other sites. Except for the excavations in Area A, the sediments that contain cultural materials do not appear to be the cover sediment, but their exact origin is uncertain. The trenches used to examine the geomorphology of this site were excavated during testing and were aimed at eliciting information about that aspect of LA 155963 rather than the archaeological deposits. Still, comparison of the results of both studies is important to the interpretation of cultural remains in Area A and provides some information pertaining to archaeology in Area B and interpreting the situation in Area C. Future archaeological investigations at LA 155963 would certainly benefit from geomorphic collaboration.

LA 155964

This early Historic site with a possible prehistoric component of unknown date was examined during the research phase and was determined "eligible" to the *National Register* during Section 106 consultations following survey. If there was an earlier component, its integrity has suffered from erosion. However, Feature 1, which was part of the early Historic-period component, was well preserved and appeared to have suffered from only minor amounts of erosion (Fig. 10.1). BHT 12 was used to examine the subsurface stratigraphy and was excavated near the southeastern edge of the site (Fig. 21.72). This trench showed that the cover sediment is thin at LA 155964, about 11 cm thick in the vicinity of the trench, and overlies piedmont alluvium. Feature 1 was excavated through the cover sediment and into the piedmont alluvium, and exhibits a high degree of preservation despite evidence for rodent and insect disturbance.

The cover sediment appears to be eroded from much of LA 155964, and the piedmont alluvium forms much of the site surface. This is especially true for the western part of the site where Features 6–8 are located (Fig. 10.1). More recent eolian sediment occurs in the vicinity of Feature 1 and yielded a considerable number of artifacts associated with the Historic period use of that feature. Further excavations in that area have the potential to provide more information about the early Historic occupation of this site. Otherwise, the amount of erosion suggests that if an earlier component is present, associated materials have been displaced vertically and probably horizontally, and retain little integrity for site structure studies.

LA 155968

LA 155968 was examined during the research phase and was determined "eligible" to the *National Register* during Section 106 consultations following survey. This site contains at least three components, the earliest and most widespread of which dates to the Folsom period. A second component dates to the Mesilla phase and appears to be less expansive. The third component is represented by a single Historic chipped stone artifact that may not be associated with any of the other materials at the site. Although no trench was excavated to facilitate geomorphic evaluation, a cross-section of the upper meter and a half of fill was visible in a road cut at the southern edge of the site, allowing examination of the upper sediments in this area (Fig. 11.1). This exposure showed that a 12 cm thick layer of cover sediment occurs above the piedmont alluvium.

Further data comes from the excavation of three exploratory grid units. Three strata were defined in EGU-1. Stratum 1 is recent eolian sediment, while Stratum 2 is the cover sediment. Most of the artifacts recovered from this unit came from Stratum 2. Despite the presence of a few artifacts in the underlying Stratum 3, Stratum 2 is the top of the piedmont alluvium and exhibits a high degree of bioturbation. Only eolian sediment (Stratum 1) over the piedmont alluvium (Stratum 3) was encountered in EGU-2, and the cover sediment was missing. The artifacts in Stratum 1 were eroded out of the cover sediment and deposited on top of the piedmont alluvium, then covered by more recent eolian sediment. All three strata were encountered in EGU-3.

Definition of the cover sediment in the road cut as well as in two of the three exploratory grid units indicates that the lower levels of that unit occur sporadically at this site. This is consistent with the Folsom date assigned to the artifacts eroding out of this level, and suggests that there may be some vertical and perhaps horizontal integrity to the artifacts in the remaining sections of cover sediment. Chipped stone artifacts from the Folsom component were common on the surface in areas where the cover sediment has eroded away. Areas in Figure 11.1 that lacked surface artifacts or in which they were sparsely distributed may still contain buried Folsom materials. Thus, despite the eroded nature of this site, it retains the ability to provide further important information.

LA 155969

This site was examined during the research phase and was determined "eligible" to the *National Register* during Section 106 consultations following survey. Based on the occurrence of a single arrow point, LA 155969 can only be dated sometime after the beginning of the Mesilla phase. No trench was excavated to examine the geomorphology, and all such observations are made from surface examination and limited archaeological excavation (Fig. 12.1). Surface inspection of LA 155969 indicated that most of the cover sediment has been eroded away, exposing the top of the piedmont alluvium. However, some small patches of cover sediment may occur. Excavation showed that 1–9 cm of loose sediment (Stratum 1) occurs in grass-stabilized areas. This stratum may equate to the cover sediment, and if so a very thin layer of this material remains in small patches. However, Stratum 1 could also be recent eolian sand, in which case this area has suffered from extreme deflation. Archaeological examination indicates that LA 155969 retains little potential to provide further information, and the geomorphic observations suggest that this is indeed the case.

LA 156877

This site was examined during the research phase and was determined "eligible" to the *National Register* during Section 106 consultations following survey. LA 156877 appears to be a multicomponent site containing a mixture of Archaic and Formative period artifacts. Though no trench was excavated to facilitate the geomorphic study, a cross-section of the upper 1.5 m of fill was visible in a road cut at the southern edge of the site, allowing examination of the upper sediments (Fig. 13.1). This exposure showed that a layer of cover sediment a few centimeters thick occurred above piedmont alluvium. Further data comes from surface stripping around Feature 1. The cover sediment probably equates to Stratum 1 in this excavation area, and was only 2–4 cm thick. Feature 1 was completely deflated, with no structural elements remaining in place. Mesquite-anchored coppice dunes occur sporadically across the site. Except for the coppice dunes, the surface of LA 156877 was deflated and this site appears to have little potential for yielding buried artifacts. However, the discovery of Feature 5 in the road cut suggests that this site actually could contain other buried features that were otherwise invisible on the surface.

Summary and Conclusions

The archaeological and geomorphological studies complement one another at most sites. The cover sediment (Qcs) is an important factor in the archaeology of the study area. This unit has the potential to contain Paleoindian remains near its base and Archaic remains at higher levels. Even though the cover sediment seems to be comprised of a mixture of eolian sand and materials weathered from the parent piedmont alluvium, as discussed in Chapter 21, it is easily distinguished from the more recently eroded surface of the piedmont alluvium, as was the case at LA 111432. The Qcs dominates in parts of the study area away from Jornada Draw and the sand ridges that line both sides of that shallow valley. The eolian sand sheet (Qes) is widespread, especially on the east side of the valley, and in our study area it occurs on the east side of Jornada Draw and in small, isolated patches on the west side of the draw. While the cover sediment was noted archaeologically at LA 111429, it was missing from the geomorphic trenches at that site and at LA 111422 and LA 111435, and was apparently eroded away from LA 111421 and LA 111432. The geomorphic and stratigraphic relationships between the cover sediment (Qcs) and the eolian sand sheet (Qes) are not entirely clear, although these uncertainties have not impeded the archaeological work.

Wherever the cover sediment or eolian sand sheet occur there is potential for buried archaeological remains that may or may not be marked by surface artifacts. In both cases the base of the deposit can potentially contain Paleoindian remains—early through late for the cover sediment and middle through late for the eolian sand sheet. Higher levels in the cover sediment can contain Archaic remains as late as the early part of the Middle Archaic. Similar levels in the eolian sand sheet can contain Archaic through early Formative-period remains.

The only other unit with the potential to contain cultural remains is the Protohistoric A-horizon soil (Qah), which is widespread through the Jornada Draw section of the study area. The soil occurs at the top of the eolian sand sheet and represents the remains of a 500–600 year old topographic surface, with at least one feature in probable association with it (Feature 11 at LA 111429).

Wherever prehistoric cultural materials lie directly upon piedmont alluvium, we must assume that those sites have either suffered from extreme deflation or, at the very least, that artifacts are probably displaced and may not retain any of their original relationship to one another. These sites include LA 111421, LA 111432, and to a somewhat lesser degree LA 155964, LA 155969, and LA 156877. When the cover sediment or eolian sand sheet is either completely or mostly missing, sites may have limited data potential. However, depending on the date of such sites and whether or not materials from multiple periods of occupation are mixed together, some potential may be retained.

OSL dating of sediments is a valuable way in which to approximately date Paleoindian components that otherwise lack materials amenable to absolute dating. On this basis, the location of artifacts near the base of the cover sediment is tied to the Folsom period, as suggested by the occurrence of projectile points diagnostic of that period in adjacent areas at LA 111429 and LA 155963. The occurrence of the Folsom component at LA 155968 with associated Folsom and Midland points helps to confirm this assumption.

Combining geomorphic studies with archaeology is a fruitful avenue by which to gain a fuller understanding of what artifact-bearing strata mean. It also can provide dates for archaeological deposits that may otherwise lack temporally diagnostic artifacts or charcoal for radiocarbon dating. Understanding geomorphic formation processes adds another dimension to archaeological interpretation. It is also useful in determining the information potential of a site. On a more mundane level, knowing which deposits pre-date the human occupation of the New World provides a marker for where to stop digging, thus preventing unnecessary excavation. In the current study, geomorphology added critical information and enhanced our understanding of the sediment deposits in which archaeological remains occur.

23 | Chipped Stone Material Type Collection

James L. Moore

Introduction

In order to determine where some of the materials used for chipped stone reduction and tool manufacture on Spaceport America archaeological sites were obtained, comparative rock samples were collected from three locations in the general project area, including Prisor Hill, Yost Escarpment, and gravel deposits on LA 155963, as well as from gravel beds near Truth or Consequences in the Rio Grande Valley for comparative purposes. Prisor Hill and Yost Escarpment were selected for sampling because they are the closest locations to our study area known to contain significant gravel deposits. LA 155963 was selected because gravel deposits occur at the northern end of the site and represent a potential source for some of the chipped stone materials used there and at other sites in the area. While the study area is quite a distance from the Rio Grande Valley, material samples were also collected from areas in and around Truth or Consequences to help determine whether exotic materials acquired from the Rio Grande gravels could have been used at the sites examined at Spaceport America. As the study progressed and it became evident that materials deposited by the ancestral Rio Grande (which coursed through the Jornada del Muerto Basin) might also occur in or near the study area, the Truth or Consequences samples became evidence of materials that could also feasibly occur in other gravels deposited closer to the study area by the ancestral Rio Grande.

A total of 90 samples were collected, including 23 from Truth or Consequences, 20 from Prisor Hill, 28 from LA 155963, and 19 from Yost Escarpment. Information on the potential of all of these areas except the Rio Grande Valley to contain various tool stones was obtained from a draft copy of the USGS Prisor Hill 7.5′ topographic quadrangle and an accompanying paper that discusses the geology of that area (Seager 2005). Descriptions of all local rock formations used in this discussion are taken from Seager (2005) unless otherwise specified. Descriptions of the material samples collected from these locations are shown in Table 23.1.

Prisor Hill

Prisor Hill is a distinct promontory situated just south of LA 111429. Jornada Draw runs along the western edge of Prisor Hill, and has probably transported materials away from that location to the north, perhaps making them available for some distance downstream. Five significant rock formations are exposed at Prisor Hill, including the Bell Top, Hayner Ranch, Palm Park, Camp Rice, and Uvas Basaltic Andesite formations (Seager 2005).

The Palm Park Formation is stratigraphically the lowest of these formations, is late Eocene in age, and is mostly buried under a thin mantle of piedmont gravels. This formation is widely spread across south-central New Mexico. Only a very small exposure of the Palm Park Formation is found at the northern end of Prisor Hill near the base of the promontory (Seager 2005). As Seager (2005) notes, this formation is thought to represent slope and lowland deposits associated with one or more volcanoes. The Palm Park Formation consists primarily of lahar deposits, which were formed by a mixture of pyroclastic material, rocky debris, and water flowing down from a volcano, typically along a river valley. It also includes andesitic intrusive rocks, lava, and ash-flow tuff (Seager 2005). The likelihood that the small exposure of this formation yielded any knappable materials is low. However, since Seager (2005) indicates that clasts of porphy-

Table 23.1. Descriptions of comparative materials collected from Prisor Hill, Yost Escarpment, and LA 155963.

Sample No.	Collection Area	Matype No.	Material	Color	Cortex Type and Color	Texture	Inclusions	Flaws
P-01	Prisor Hill	21	brown chert	dominantly brown with light gray masses	uncertain; brown to white	fine	small crystalline inclusions along healed cracks	small voids and crystalline inclusions, healed cracks
P-02	Prisor Hill	360	coarse welded ash-flow tuff	Dominantly gray with small areas of white and pink	waterworn; light gray	coarse	small crystals of white and pink	none visible
P-03	Prisor Hill	345	rhyolite	reddish-gray with white masses	waterworn; lighter reddish gray than interior	fine	numerous white crystalline masses, mostly in voids, some white phenocrysts	numerous crystal-lined voids
P-04	Prisor Hill	58	dark gray chert	dark gray, lighter gray rind below cortex	waterworn; tan to white	fine	small clear quartz inclusions	none visible
P-05	Prisor Hill	360	coarse welded ash-flow tuff	dominantly gray with small round white masses	waterworn; brownish gray	coarse	small white round crystalline inclusions fairly common	none visible
P-06	Prisor Hill	36	yellow-brown chert	dominantly yellow-brown with tan streaks	waterworn; same color as interior	fine	quartz crystal inclusions along cracks	numerous voids, some cracks
P-07	Prisor Hill	20	gray chert	dominantly dark gray with patches of light gray	waterworn; light gray	fine	small clear quartz crystalline inclusions	none visible
P-08	Prisor Hill	58	dark gray chert	Dark gray with small yellowish-brown spots, some lighter gray below the cortex	waterworn; reddish brown	fine	none visible	none visible
P-09	Prisor Hill	44	red and gray chert	mottled red and gray	waterworn; gray to reddish brown	medium; sugary	none visible	cracks
P-10	Prisor Hill	360	coarse welded ash-flow tuff	dark gray	waterworn; reddish brown	coarse	none visible	many voids
P-11	Prisor Hill	57	gray and white chert	mottled gray and white	waterworn; brown	fine	none visible	numerous large voids
P-12	Prisor Hill	20	gray chert	dominantly gray, with very small areas of yellow-brown	waterworn; reddish brown	fine	small white crystalline inclusions fairly common	none visible
P-13	Prisor Hill	25	white chert	translucent white with white below cortex, some swirls of different shades of white	waterworn; white to red brown	fine	none visible	none visible

(Table 23.1, continued)

Sample No.	Collection Area	Matype No.	Material	Color	Cortex Type and Color	Texture	Inclusions	Flaws
P-14	Prisor Hill	361	welded ash-flow tuff	gray-brown with masses of gray	waterworn; same color as interior	fine	small crystals, multicolored	none visible
P-15	Prisor Hill	55	black and tan chert	dominantly dark gray with small yellowish-brown areas	uncertain; tan to brown	fine	none visible	voids moderate in yellowish-brown areas
P-16	Prisor Hill	20	gray chert	light gray dominant with yellow-brown mottles	waterworn; reddish brown	fine	none visible	none visible
P-17	Prisor Hill	342	rhyolite	reddish-brown	waterworn; light brown	fine	white, red, and clear phenocrysts	none visible
P-18	Prisor Hill	59	reddish-gray chert	dominantly gray with reddish-brown areas	waterworn; light brown	fine	none visible	fissures and small voids
P-19	Prisor Hill	342	rhyolite	reddish-brown	waterworn; pinkish brown	fine	phenocrysts of white, black, and clear	none visible
P-20	Prisor Hill	60	coarse gray chert	light gray with white masses, small areas of yellow-brown	waterworn; tan to light grayish tan	coarse	none visible	none visible
S-01	LA 155963	50	gray and brown chert	dominantly brown with streaks of yellow	waterworn; brown to reddish brown	medium; sugary	none visible	a few small voids
S-02	LA 155963	513	metaquartzite	dominantly brown with small spots of pink	waterworn; same color as interior	fine	none visible	none visible
S-03	LA 155963	41	pink and white chert	dominantly white (striped) with pink occurring adjacent to the pink cortex and as stripes	waterworn; pink	fine	none visible	none visible
S-04	LA 155963	343	aphanitic rhyolite var. 2	dominantly dark gray with light red masses, probably phenocrysts	waterworn	fine	light red phenocrysts	none visible
S-05	LA 155963	50	gray and brown chert	dark gray with some brownish masses, tan	waterworn; tan and reddish brown	fine	none visible	none visible
S-06	LA 155963	511	meta-quartzite	yellow	uncertain; yellow brown	fine	none visible	small voids
S-07	LA 155963	410	limestone	dark gray	waterworn; brownish gray	fine	none visible	none visible
S-08	LA 155963	410	limestone	mottled gray and reddish brown	waterworn; reddish brown to gray	fine	none visible	fissures and voids
S-09	LA 155963	100	silicified wood	brown with white stripes	waterworn; tan to light brown	fine-to-coarse	none visible	laminar structure

(Table 23.1, continued)

Sample No.	Collection Area	Matype No.	Material	Color	Cortex Type and Color	Texture	Inclusions	Flaws
S-10	LA 155963	61	black and red chert	gray and pink	waterworn; gray and pink	fine-to-medium	quartz crystalline inclusions	voids
S-11	LA 155963-109	100	silicified wood	brown to gray	waterworn; light to dark gray	fine	none visible	cracks
S-12	LA 155963-135	20	gray chert	light to medium gray	waterworn; light to medium gray	fine	small crystalline	small voids
S-13	LA 155963-137	25	white chert	white	waterworn; light gray to white	fine	none visible	none visible
S-14	LA 155963-411	20	gray chert	medium gray with small light brown blotches	waterworn; gray with light brown blotches	fine	none visible	none visible
S-15	LA 155963-412	20	gray chert	light to medium gray	waterworn; gray	fine	none visible	none visible
S-16	LA 155963-412	25	white chert	white to very light whitish gray	waterworn; light gray to tan	fine	none visible	none visible
S-17	LA 155963-418	20	gray chert	medium gray, tan just below cortex	waterworn; gray to tan	fine	none visible	none visible
S-18	LA 155963-419	100	silicified wood	Tan to brown	waterworn; tan to brown	fine	none visible	laminar structure
S-19	LA 155963-419	22	tan chert	tan	waterworn; tan	fine	none visible	none visible
S-20	LA 155963-421	20	gray chert	light to dark gray	waterworn; light to dark gray	fine	small angular light crystals	none visible
S-21	LA 155963-421	49	tan and gray chert	light gray to tan	waterworn; light gray to tan	fine	none visible	none visible
S-22	LA 155963-421	20	gray chert	light gray with small white masses	waterworn; light gray to white	fine	small white fossils	none visible
S-23	LA 155963-424	57	gray and white chert	medium gray with white streaks	waterworn; gray with white streaks	fine	none visible	none visible
S-24	LA 155963-424	24	cream chert	cream	waterworn; light to dark cream	fine	none visible	none visible
S-25	LA 155963-426	25	white chert	white	waterworn; white	fine	none visible	none visible
S-26	LA 155963-427	57	gray and white chert	mostly white with light gray masses	waterworn; cream to light tan	fine	none visible	none visible
S-27	LA 155963-428	50	gray and brown chert	mottled dark brown, yellow-brown, and light gray	waterworn; brown	fine	none visible	none visible
S-28	LA 155963-428	57	gray and white chert	mostly light gray with some white areas	waterworn; yellowish-gray	fine	none visible	none visible

(Table 23.1, continued)

Sample No.	Collection Area	Matype No.	Material	Color	Cortex Type and Color	Texture	Inclusions	Flaws
T-01	Truth or Conse-quences	28	white and black chert	dominantly white with small black and some clear inclusions	waterworn; white	fine	small black and clear inclusions in a white matrix	occasional small voids
T-02	Truth or Conse-quences	20	gray chert	gray	waterworn; white to brown	fine	small black, white, and red inclusions	cracks
T-03	Truth or Conse-quences	65	pink and yellow chert	dominantly pink with streaks of yellow to yellow-pink	none	fine	small-large gray and black crystalline inclusions	cracks
T-04	Truth or Conse-quences	44	red and gray chert	dominantly red with areas of gray and pinkish gray	waterworn; same color as interior	medium	none visible	small voids occasionally
T-05	Truth or Conse-quences	61	black and red chert	Red to red-brown	waterworn; same color as interior	medium; sugary	very small white crystalline inclusions, occasional	small cracks
T-06	Truth or Conse-quences	361	welded ash-flow tuff	dominantly dark gray, some greenish specks	waterworn; light gray	fine	none visible	none visible
T-07	Truth or Conse-quences	26	red chert	dominantly light red to red with small to medium masses of gray	waterworn; same color as interior	medium	occasional small white crystalline inclusions	small voids common, as are microcracks
T-08	Truth or Conse-quences	18	white and black chert	dominantly gray with small masses of white	waterworn; white to dark gray	fine	small clear to white crystalline inclusions common	none visible
T-09	Truth or Conse-quences	44	red and gray chert	dominantly gray with small areas of red-to-pink	waterworn; same color as interior	medium; sugary	small clear crystalline inclusions common	occasional small voids
T-10	Truth or Conse-quences	100	silicified wood	brown-to-yellow brown	waterworn; same color as interior	medium	none visible	laminar structure
T-11	Truth or Conse-quences	20	gray chert	dominantly reddish gray to gray	waterworn; red cortex	fine	small white crystalline inclusions fairly common	small voids fairly common
T-12	Truth or Conse-quences	41	pink and white chert	pink and white	waterworn; white to reddish brown	fine-to-medium	small clear crystalline inclusions	a few small voids
T-13	Truth or Conse-quences	518	meta-quartzite	brown to red-brown with occasional gray streaks	waterworn; same color as interior	fine	none visible	occasional filled cracks

(Table 23.1, continued)

Sample No.	Collection Area	Matype No.	Material	Color	Cortex Type and Color	Texture	Inclusions	Flaws
T-14	Truth or Conse-quences	64	mottled red, pink, and yellow chert	Dominantly red-to-pink, with areas of yellow and gray	waterworn; same color as interior	medium; sugary	small-to-medium dark crystalline inclusions	some voids, cracks, and crystals
T-15	Truth or Conse-quences	342	aphanitic rhyolite	reddish-gray	waterworn; light purple to tan	fine	small phenocrysts of yellow	none visible
T-16	Truth or Conse-quences	53	red and white chert	swirled red and white-gray	waterworn; light gray	fine	none visible	cracks
T-17	Truth or Conse-quences	45	pink chert	dominantly pink with small red spots	waterworn; white; some red	fine	occasional small clear crystalline inclusions	crystal-filled cracks
T-18	Truth or Conse-quences	350?	andesite?	dark gray-to-black	waterworn; dark gray	fine	none visible	none visible
T-19	Truth or Conse-quences	62	mottled red, gray, and brown chert	mottled brown, red, yellow, and gray	waterworn; white to yellow red	fine	numerous small crystalline inclusions	cracks, crystalline inclusions
T-20	Truth or Conse-quences	2	Pedernal chert	dominantly gray with some brown and yellow, white cortex	waterworn; white	fine	none visible	some cracks, a few voids
T-21	Truth or Conse-quences	512 var. 2	meta-quartzite	reddish-gray with small rust-colored spots	waterworn; reddish brown to tan	fine	none visible	none visible
T-22	Truth or Conse-quences	512 var. 3	meta-quartzite	gray	waterworn; reddish gray	fine	none visible	none visible
T-23	Truth or Conse-quences	343	rhyolite	gray	waterworn; reddish brown	fine	yellow-green phenocrysts	none visible
Y-01	Yost Escarpment	20	gray chert	gray with some white lines	waterworn; reddish	medium; sugary	small clear quartz inclusions	cracks
Y-02	Yost Escarpment	513	meta-quartzite	brown	waterworn; lighter brown than interior	fine	none visible	none visible
Y-03	Yost Escarpment	20	gray chert	mottled gray and dark gray, with small yellow-brown masses	waterworn; pinkish brown	fine	yellow-brown crystalline inclusions	crystalline inclusions, voids, cracks
Y-04	Yost Escarpment	512	meta-quartzite	gray with numerous clear quartz crystals	waterworn	very fine	clear quartz inclusions	none visible
Y-05	Yost Escarpment	36	yellow-brown chert	yellow with dark brown-gray stripes	waterworn; gray to tan	fine	none visible	none visible

(Table 23.1, continued)

Sample No.	Collection Area	Matype No.	Material	Color	Cortex Type and Color	Texture	Inclusions	Flaws
Y-06	Yost Escarpment	360	coarse welded ash-flow tuff	dominantly gray with small yellow-brown inclusions	waterworn; light brown	coarse	none visible	none visible
Y-07	Yost Escarpment	510	meta-quartzite	pink	waterworn	medium	none visible	none visible
Y-08	Yost Escarpment	102	silicified wood	brown	waterworn; same color as interior	fine	none visible	small cracks
Y-09	Yost Escarpment	514	meta-quartzite	yellow with gray masses	waterworn	fine	none visible	none visible
Y-10	Yost Escarpment	57	gray and white chert	dominantly gray with some white streaks, a few smaller yellow masses	uncertain; brown	fine	none visible	cracks
Y-11	Yost Escarpment	512	meta-quartzite	dominantly gray with small yellow and brown areas	waterworn; light brown	fine	none visible	none visible
Y-12	Yost Escarpment	513	meta-quartzite	brown	waterworn; lighter brown than interior	fine	none visible	none visible
Y-13	Yost Escarpment	513	meta-quartzite	brown	waterworn; light brown	fine	none visible	none visible
Y-14	Yost Escarpment	512	meta-quartzite	dominantly gray, grading to yellow-brown in one area	waterworn; reddish	fine	small crystals of various colors	none visible
Y-15	Yost Escarpment	410	limestone	gray, some clear bands	waterworn; brown	fine	clear bands	none visible
Y-16	Yost Escarpment	410	limestone	gray	waterworn; reddish brown	fine	none visible	none visible
Y-17	Yost Escarpment	410	limestone	brown	waterworn; reddish brown	fine	none visible	none visible
Y-18	Yost Escarpment	410	limestone	gray	waterworn; reddish brown	coarse	none visible	none visible
Y-19	Yost Escarpment	360	coarse welded ash-flow tuff	gray and brown	waterworn; light reddish brown	coarse	none visible	none visible

ries are common in this formation, it may have provided materials for use as fire-cracked rock or the manufacture of ground stone tools.

The Bell Top Formation is above the Palm Park Formation and is Oligocene in age. These materials occur as a narrow band along the north and northwest sides of Prisor Hill, near the base of the promontory. The Bell Top Formation contains sediments and flows that once filled an extensive broad, shallow basin that stretched from west of Las Cruces to the Caballo Mountains and Prisor Hill (Seager 2005). This fill consists of alluvial fan and fluvial sediments, volcanic materials reworked by sedimentary processes, tuffaceous sandstones, and ash-flow tuff. At the base of this formation is a deposit of welded ash-flow tuff forming a ridge. Above the ash-flow tuff are deposits of tuffaceous sandstone and conglomerate, the latter being of most interest to this discussion because it represents a potential source for knappable materials. The conglomerate contains boulders and cobbles of ash-flow tuff, porphyries, and some limestone. More ash-flow tuff occurs near the middle of the sedimentary deposits, and also tops off the formation. Locally, some flows of Uvas Basaltic Andesite occur below the upper layer of ash-flow tuff. Potentially knappable materials from this formation include the lower ash-flow tuff, which is densely welded, the Uvas Basaltic Andesite, and limestone from the sedimentary deposits within the formation.

The Uvas Basaltic Andesite overlies the Bell Top Formation, and is Oligocene in age. This formation is mostly exposed along the southeast flank of Prisor Hill. Much of this material is vesicular, but some flows are massive and dense (Seager 2005). Some sandstone and conglomerate deposits can be interbedded with the volcanic materials in places. Of primary interest in this deposit are the vesicular and dense, non-vesicular forms of basaltic andesite. The former would have been a good material for making ground stone tools as well as for use in thermal features, while the latter may have been knappable and could also have been used for ground stone tools and in thermal features.

The Hayner Ranch Formation is of late Oligocene–early Miocene age. Seager (2005) notes that this formation uncomformably overlies the Bell Top Formation at Prisor Hill, and is interpreted as representing the fill in paleovalleys cut into the Bell Top and Uvas Basaltic Andesite Formations. The Hayner Ranch Formation forms the principal rock exposures at Prisor Hill, everywhere except along the southeast flank, where the Uvas Basaltic Andesite Formation is exposed, as discussed above. While Seager (2005) indicates that the materials in the Hayner Ranch Formation consist entirely of angular to sub-angular clasts of Uvas Basaltic Andesite and Bell Top ash-flow tuffs, this is not actually the case. As samples were gathered for the type collection, several other material types were found in this deposit, including several varieties of chert. However, the non-volcanic materials in this formation are uncommon, and the volcanics dominate by far.

The Camp Rice Formation is the latest of those exposed at Prisor Hill, and is of Pliocene to middle-Pleistocene age. Seager (2005) notes that, while this formation is mainly composed of axial/fluvial deposits of the ancestral Rio Grande in the Rio Grande Valley and adjoining basins, piedmont-slope alluvium is also an important component. In the Spaceport America study area, the Camp Rice Formation is entirely derived from local alluvial fan deposits. The nearest outcrop of axial/fluvial deposits of the ancestral Rio Grande is south of Point of Rocks (Stephen Hall, personal communication, 2013; Seager 2005). Thus, none of the non-local cherts or obsidians that can be found in ancestral Rio Grande deposits occur within the study area. The top of the Camp Rice Formation is known as the La Mesa surface, and is marked by a Stage IV or V petrocalcic paleosol, which was encountered in several of the soil pits that were mechanically excavated during testing (Akins and Moore 2011a). No samples were collected from this formation in the Prisor Hill area.

Description of Prisor Hill Samples

Twenty material samples were collected from along the east flank and top of Prisor Hill, and included 13 chert, four welded ash-flow tuff, and three rhyolite. Ten types of chert were defined in this sample. Varieties of gray chert dominate, with nine samples falling into this classification. Light- to moderate gray shades comprised three samples, two of which exhibited small areas of yellow-brown, while the third graded to a lighter shade just below the cortex. Two samples were dark gray, grading to a lighter gray layer just below the reddish-brown to tan cortex. One of the dark gray samples contained small yellow-brown spots, while the other did not.

The four remaining gray chert samples included a specimen that is dominantly dark gray with small yellow-brown areas, one that is mottled gray and white, a third that is dominantly gray with reddish-brown areas, and one that is mottled red and gray. There is an interesting similarity among these specimens, suggesting that most came from the same geological formation. The only likely exceptions to this are the mottled gray and white specimen and the mottled red and gray specimen. The other chert specimens appear to represent materials from different rock formations than was the case for most of the grays, though this is not certain. They include a specimen that is dominantly brown with light gray masses, one that is translucent white grading to solid white just below the cortex, and a third that is yellow-brown with tan streaks. Cortex on 11 of the chert specimens is waterworn, while in the last two cases the type of cortex was uncertain but probably waterworn. Thus, all of these cherts represent materials that were washed into paleovalleys by fluvial activity.

Two of the rhyolite samples appear to represent materials from the same flow, are reddish-brown in color and aphanitic, and contain similar phenocrysts of white, red, clear, and black minerals. The third specimen is reddish-gray and aphanitic, and contains numerous white crystalline masses, mostly in voids, with some white phenocrysts. The cortex on all three of these specimens is waterworn, indicating that they were washed into paleovalleys by fluvial activity.

Two main varieties of welded ash-flow tuff are represented in the collection. Three specimens are classified as coarse, welded ash-flow tuff and are not suitable for chipped stone reduction. All three of these specimens are gray, two are a moderate shade while the third is dark gray. The fourth sample is a fine-grained, probably densely welded material that is gray-brown with masses of gray. This specimen represents a grade of welded ash-flow tuff that is probably knappable. The cortex on all four samples of welded ash-flow tuff is waterworn, indicating that they were washed into paleovalleys by fluvial activity.

Yost Escarpment

Yost Escarpment runs along the western edge of Yost Draw to the west of the study area, and is primarily covered by alluvium of Quaternary age. However, outcrops of much earlier deposits are exposed along the east edge of the escarpment, and those outcrops were the focus of sample collection. Samples from Yost Escarpment were collected where County Road AO13 crosses Yost Draw and south along County Road AO13 for perhaps a kilometer.

The primary rock formation of interest in this area is the Love Ranch Formation, which represents Laramide (latest Cretaceous to Eocene) basin fill. Elsewhere in the study area the Love Ranch Formation underlies the Palm Park Formation, which was the lowest exposure at Prisor Hill. Materials in the Love Ranch Formation grade in fineness as one goes upward, beginning with coarse-grained alluvial fan deposits at its base, grading upward into fluvial conglomerate and sandstone, with fine-grained alluvial plain and playa deposits at the top of the sequence. Seager (2005) notes that within his study area (the Prisor Hill and Upham Hills USGS 7.5′ quadrangles) the Love Ranch Formation is covered at the surface by pediment gravels, and occurs in scattered exposures along Yost and Aleman draws. This formation contains clasts of Paleozoic limestone and sandstone, as well as Precambrian granite and porphyries that are probably of Cretaceous age. Initial uplift of the southern San Andres–Organ area caused erosion of earlier deposits and deposition of materials in the Jornada del Muerto basin, forming the earliest layers of the Love Ranch Formation (Seager 1981:41). As uplift and erosion continued, more Love Ranch materials were deposited in the basin, eventually burying earlier deposits in the region. The pediment gravels that cover the top of the exposures of Love Ranch Formation appear to represent materials eroded from the upper part of the formation.

Description of Yost Escarpment Samples

Nineteen material samples were obtained from pediment gravels along Yost Escarpment, representing the surface expression of the Love Ranch Formation as noted above. They include four samples of chert, one of silicified wood, two of coarse, welded ash-flow tuff, four of limestone, and eight of metaquartzite. Three of the cherts are dominantly gray; one sample contains some white lines, the second is mottled gray and dark gray with some small yellow-brown masses, and the third contains some white streaks and a few smaller yellow masses. The last sample is yellow with dark gray-brown stripes. Despite the variation in the gray cherts, they could easily all have derived from the same sedimentary rock formation, while the fourth specimen is most likely from another source.

The single sample of silicified wood is brown, and is mostly definable as such from its cortex, which has a distinct wood-like appearance. In places, the original structure of the "wood" is visible, but elsewhere it is not. Thus, this material could easily be mistaken for chert. Both specimens of welded ash-flow tuff are coarse-grained and dominantly gray with some small yellow-brown inclusions. Three of the limestone specimens are gray, and one of these exhibits a few clear bands probably representing thin deposits of selenite. Two samples are fine-grained and display a conchoidal fracture indicating that they could be used for reduction, while the third is coarse-grained and is probably unsuitable for reduction. The fourth limestone specimen is brown, fine-grained, and also breaks with a conchoidal fracture.

The metaquartzite specimens are of particular interest because they mostly reflect varieties observed on our sites during field analysis. The eight samples of metaquartzite are assigned to four different, but not necessary exclusive, categories based primarily on texture and color. One specimen is unique, and is a medium-grained pink metaquartzite that was initially mistaken for a coarse chert. All other specimens are fine- to very fine-grained. Three samples are dominantly gray. Two of these specimens contain areas of yellow-brown and have light-brown to reddish cortex, while the third specimen is gray with numerous clear quartz crystal inclusions. Three specimens are brown, while the last sample of metaquartzite is yellow with gray masses. Though there is quite a bit of variation in the metaquartzite samples, with the exception of the pink specimen, they all probably derive from the same geological formation.

All 19 samples collected from Yost Escarpment have waterworn cortex, indicating that they were transported from their original outcrops and redeposited by alluvial activity. Considering the nature of the Love Ranch Formation deposits, as discussed above, this was expected.

LA 155963

LA 155963 was the largest and northernmost of the sites investigated during this study, and is located not far to the east of Aleman Draw. Gravel deposits occur at the northwest end of LA 155963 that represent potential sources for some of the materials that were reduced at this location and nearby. Thus, samples were collected opportunistically during fieldwork, primarily focusing on the range of cherts available but also taking samples of other materials that seemed knappable, when encountered. Ten samples were obtained in this manner. Small non-cultural chert pebbles were also found during the analysis of chipped stone artifacts from Surface Strips 5 and 6 at the north end of the site, and had been collected in the field because they resembled artifacts. While not all of these chert pebbles were large enough for characterization, a number of them were. Eighteen additional samples were collected in this manner, and they represent a broader cross-section of knappable materials available in gravels at this site. Because of the small size of these pebbles, their descriptions are more abbreviated than are those of the larger specimens that were collected.

According to Seager (2005), three geological formations are exposed at LA 155963. Most of the site occupies an exposure of what Seager (2005) mapped as Camp Rice Formation, the only extensive exposure of this formation in the study area proper. The exposure of this formation at LA 155963 is considered to represent piedmont slope deposits that contain conglomerate, gravel, conglomeritic sandstone, pebbly sand, and sand and silt (Seager 2005). The rocks in these deposits are thought to have been mostly locally derived, but can also include limestone from the Caballo or San Andres mountains (Seager 2005). However, geomorphic examination of this area during the course of this project and OSL dates derived from soil pits indicate that the surface sediments that cover LA 155963 are too young to be part of the Camp Rice Formation, and actually represent a much later formation. Hall's analysis of these later materials suggests that they are alluvial fan deposits, probably derived from the Caballo Mountains (see Chapter 21). Limestone pebbles and cobbles, presumably from that source, were fairly common at LA 155963 and represent a potentially important lithic resource. If the Camp Rice Formation does exist at LA 155963, it is buried under a mantle of later sediments and may only be exposed around the edge of the promontory that the site sits upon.

The second (or third) formation consists of older piedmont-slope alluvium, which is the dominant surface formation elsewhere in the study area. These materials are deposits of gravel, sand, and silt that formed on valley slopes, as piedmont veneers, and as large alluvial fans. This formation does not appear to have been a source for materials used in chipped stone reduction.

The third (or fourth) formation is an exposure of the Love Ranch Formation along the west edge of LA 155963, and this was the source for most of the samples collected at this site. This formation was described for the samples collected from Yost Escarpment, and represents the best source for higher quality tool stone at LA 155963. As discussed for the Yost Escarpment samples, the Love Ranch Formation appears to have provided a selection of cherts and metaquartzites that were important raw materials for chipped stone reduction.

Description of LA 155963 Samples

The 28 material samples from LA 155963 include 20 chert, 3 silicified wood, 1 aphanitic rhyolite, 2 limestone, and 2 metaquartzite. The cortex on all samples from this source is waterworn, reflecting their deposition by alluvial activities.

Multiple varieties of chert were assigned the same material type code in several cases, but it remains uncertain how many actually represent the same materials. Six specimens were classified as gray chert, which was considered a general category during analysis within which a range of color variations was included. Two samples are light to medium gray with similar gray cortex and small crystalline inclusions, and probably represent the same variety. A third sample may also represent this variety, though its color ranges from light to dark gray, as does the color of its cortex. Another sample is light gray with a light gray to white cortex, and it contains small white fossils. The fifth sample of gray chert is medium gray with small light brown blotches with similarly colored cortex. The final sample of gray chert is medium gray shading to tan just below the cortex, which is gray to tan in color. Thus, the general category of gray chert contains at least four and possibly five different varieties.

Three samples were classified as white chert, and the range in internal color and cortical color is similar enough to suspect that only a single variety is represented. Gray and brown chert is represented by three samples including dominantly brown with streaks of yellow, dark gray with some brown masses and a tan-brown cortex, and mottled dark brown, yellow-brown, and light gray with a brown cortex. Though classified together, these samples represent three different varieties. Three samples were classified as gray and white chert: medium gray with white streaks and similarly colored cortex, mostly white with light gray masses and cream to light tan cortex, and mostly gray with some white areas and yellowish-gray cortex. These samples differed enough that they appear to represent distinct varieties.

Other varieties of chert include specimens that are tan with similarly colored cortex, cream with light to dark cream cortex, light gray to tan with similarly colored cortex, dominantly white with pink occurring as stripes and adjacent to the pink cortex, and gray and pink with quartz crystalline inclusions. One sample of silicified wood was initially classified as chert, and is thus easy to misidentify. This material is brown with white stripes, and ranges from fine- to coarse-grained within the same piece. The other two samples of this material were brown to gray and tan to brown, both with similarly colored cortex. Because of the very small sizes of these specimens it was not possible to determine whether a single or multiple varieties are represented.

The sample of aphanitic rhyolite differed from other samples of this material collected elsewhere, and was dominantly dark gray with light red masses that are probably phenocrysts. While the limestone samples differ significantly in appearance, they both probably derived from the same geologic formation. One limestone sample is dark gray with a brownish gray cortex, while the second is mottled gray and reddish-brown with a reddish-brown cortex.

The two samples of metaquartzite are both fine-grained and are similar to those found on Yost Escarpment, and they probably originated in the same source. One metaquartzite sample is yellow while the second is dominantly brown with small pink spots.

With the exception of the limestone samples, these materials were obtained from gravels belonging to the Love Ranch Formation. The limestones came from the upper sediments, and are a common component of that formation, with many nodules appearing in the soil pits that were mechanically excavated during testing (Akins and Moore 2011a).

Truth or Consequences

The samples collected near Truth or Consequences were mostly obtained from gravel deposits along Cuchillo Negro Creek, an east-flowing tributary of the Rio Grande at the north end of the city. Samples were collected opportunistically, and were included in this study to provide ancillary information on material availability. While their inclusion in this collection is not meant to infer that some of the materials used in the study area were obtained from this rather distant location, they are presented to amplify the collections from the study area and represent materials that could feasibly appear on some of our sites, providing there was contact or movement between their inhabitants and the Rio Grande Valley. Also, since the samples collected from Truth or Consequences came from gravels deposited by the ancestral Rio Grande, they can be cautiously used to amplify the suite of materials that might have been available from related deposits closer to the study area.

Hawley (1975:145) notes that ancestral Rio Grande deposits that comprise the bulk of the upper Santa Fe group in south-central New Mexico can be traced along the river valley from Socorro to south of Las Cruces, and are nearly continuous. The Camp Rice Formation is the major Quaternary unit through this area, and is the youngest subdivision of the Santa Fe group. In the Rio Grande Valley, the Camp Rice Formation is mainly composed of sand and gravels deposited by the ancestral Rio Grande. Chapin and Seager (1975:317) note that widespread deposition of the Camp Rice Formation ended in the late middle Pleistocene, and after that time the Rio Grande eroded deeply into its earlier deposits. Axial fluvial facies of the Camp Rice Formation are also exposed south of Point of Rocks and may contain similar, though not identical, material variation. This is because some deposits in the Camp Rice Formation reflect the localized deposition of materials by tributary streams that can differ from the suite of materials carried along the course of the ancestral river.

Description of the Truth or Consequences Materials

The 23 samples examined for the Truth or Consequences area constitute the largest collection of specimens made for this study. Most of these samples—15 specimens—are cherts, one is silicified wood, two are rhyolite, one is a welded ash-flow tuff, three are metaquartzite, and one is probably andesite. Except for two samples where cortex is not evident, only waterworn cortex occurs on these specimens, which is indicative of their recovery from secondary gravel deposits.

One sample is a piece of gray, brown, and yellow Pedernal chert with white, waterworn cortex. This specimen, which would have originated in the Chama Valley in north-central New Mexico, illustrates how far materials were moved downstream by the ancestral Rio Grande. Another specimen that may have moved nearly as far resembles Madera chert; it is mostly red, with areas of gray and pinkish gray. If this specimen is truly Madera chert, it was probably transported to the Rio Grande via the Santa Fe River. Two specimens are classified as gray chert; one is gray with small white, black, and red inclusions, while the second is reddish-gray to gray, with red cortex. One specimen of white chert with black and clear inclusions was collected from an area about two miles west of Truth or Consequences, rather than from gravel beds along Cuchillo Negro Creek. Other color varieties of chert include: light-red to red with gray masses; pink and white; gray with areas of red to pink; gray with small masses of white; swirled red and white-gray; red to red-brown; red to pink with areas of yellow and gray; pink with streaks of yellow to yellow-pink; and one specimen that is mottled brown, red, yellow, and gray.

The single specimen of silicified wood is brown-to-yellow brown and has a laminar structure, so it would not be very suitable for reduction. One of the rhyolite specimens is aphanitic, and is reddish-gray with small yellow phenocrysts. The second specimen is fine-grained, though not aphanitic, and is gray with yellow-green phenocrysts. The specimen identified as welded ash-flow tuff is dark gray with greenish specks, but the type identification for this specimen is questionable. Similarly, the identification of the andesite specimen is questionable and it could actually be basalt. This sample is dark gray-to-black and is fine-grained.

Of the three metaquartzite samples, only one resembles the varieties observed thus far in Spaceport chipped stone assemblages. That specimen is brown to red-brown with occasional streaks of gray. A second metaquartzite sample (variety 2) is reddish-gray with small rust-colored spots, while the last (variety 3) is gray.

One of the chert samples resembles a type described by Banks (1990:78) that occurs in the Palomas gravels along the Rio Grande east of the Black and Cuchillo ranges and is thought to have originated in those mountains. The type described by Banks (1990:78) is a light gray chert with dark, dusky-red splotches and veins, and may correspond to a specimen in our sample described as dominantly gray with small areas of pink to red. Since Banks (1990:78) notes that the chert he describes occurs as debitage on Mogollon sites in the vicinity of Palomas Arroyo, cultural use of this type is definitely indicated. Other specimens in the Truth or Consequences sample may also match types described by Banks (1990), but descriptive variation made this possibility uncertain.

Discussion

This survey of some of the materials available in nearby geologic formations provides important information for the interpretation of chipped stone assemblages from the Spaceport America sites, and especially helps determine potential locations where certain types of materials could have been procured for reduction. There was a very wide range of tool stones available in various sources near the study area, all of which are secondary rather than primary sources. Materials suitable for chipped and ground stone tool manufacture were available in formations deposited by both fluvial and alluvial processes. Perhaps the most important of these sources was the Love Ranch Formation, outcrops of which are exposed along Yost Escarpment and Aleman Draw (though we did not examine the latter) as well as at LA 155963. A variety of geologic formations are exposed at Prisor Hill and, since that promontory is adjacent to Jornada Draw, materials from the formations exposed there have probably been carried downstream, potentially making them more widely available.

Since the materials that are most suitable for chipped stone reduction, and that occur within the study area, are all found in gravel deposits. As such, only waterworn cortex can be expected to occur on most of the higher quality materials, especially cherts, metaquarzites, and possibly obsidians. Specimens that exhibit non-waterworn cortex probably represent acquisition from non-local sources, and if any such occur they can be considered exotics.

It should be noted, however, that just because a type of material might occur in local deposits and has waterworn cortex, the actual location of its acquisition cannot be determined with any degree of certainty. For example, even though a sample of metaquartzite from LA 155963 may be identical in appearance to an artifact from the same site, we cannot conclude that the nodule from which that artifact derived had to have come from gravel deposits at that site. Rather, since this type of metaquartzite probably occurs across the area in which the Love Ranch Formation is exposed, it could have been obtained as raw material on Yost Escarpment, along Aleman Draw, or in an even a more distant location and carried to LA 155963. Thus, while the hypothetical artifact would be considered representative of a locally available material, in reality we would have no idea where it was originally obtained. This is the nature of secondary gravel deposits, especially those related to the Rio Grande. Since materials can be carried downstream for several hundred kilometers from their original sources, no exact source location can be pinpointed for their acquisition—they could have been procured anywhere along the river below the point where the material entered the gravel deposits. This is different for materials acquired from primary geological formations, where the distribution tends to be much more restricted. The most accurate statement that can be made concerning the source of materials with waterworn cortex is that they were probably procured from local gravel deposits. Since even the igneous materials used in the project area were deposited by fluvial or alluvial processes, they also cannot be traced to a more specific source using macroscopic appraisals only. Locations like Prisor Hill, Yost Escarpment, and the Love Ranch Formation gravels at LA 155963 are the most likely sources for most of the suite of materials used in chipped-stone tool manufacture at our sites.

Most of the geologic formations exposed at or near the modern surface were formed by fluvial and alluvial processes, with many of the materials they contain being derived from the mountain ranges that border this section of the Jornada del Muerto. In particular, those ranges include the San Andres and Caballo Mountains. Seager's (2005) geologic study supplies an idea of which of the more recent valley fill formations contain materials from those mountain sources. The Love Ranch Formation contains basin-fill materials eroded from the Rio Grande uplift, including the southern San Andres–Organ area (Seager 1981:41). The Hayner Ranch Formation contains colluvial and alluvial materials that originated in the Caballo Mountains, while the Camp Rice Formation contains alluvial fan materials originating in both the Caballo and San Andres Mountains as well as in more distant locations to the north that were drained by the ancestral Rio Grande. This suggests that, while the types of tool stones in the Camp Rice Formation are probably dominated by materials from not too distant locations, materials from some very distant sources could also be represented. However, since little of the Camp Rice Formation is actually exposed in the study area and the main exposure mapped by Seager (2005) at LA 155963 either represents an entirely different younger deposit or is covered by those younger materials, few tool stones originating much further north in the Rio Grande watershed can be expected.

Banks (1990:79) notes that the Caballo Mountains are not known as major sources for tool stone, but discusses a study by Kelly and Silver (1952) that identified several cherts in that range. Two of the types that Banks (1990:79) mentions could match samples from some of our collection areas. These include a light gray to white (on fresh surfaces) chert and a dark gray to black chert. Gray to dark gray cherts are among the most common types found in each sample area, and Banks' (1990:79) discussion suggests that some could have originated in rock formations in the Caballo Range.

Silver (1955) provides more detailed descriptions of some of the cherts found in the Caballo Mountains. Chert from the Sierrite limestone is brown-weathering (Silver 1955: 147), indicating that specimens from this source would have a brown cortex. A medium gray chert from the Bat Cave Formation weathers light to dark brown, and would thus also have a brown cortex (Silver 1955:147). Chert is common in the Aleman Formation and is mottled light and dark gray, weathering to white, brown, and black (Silver 1955:148–149). The Alamogordo member of the Lake Valley Formation contains numerous chert nodules, and this material is medium gray to white and weathers to pink (Silver 1955:150). Other, less well-described cherts occur in the Red House Formation, the Nakaye Formation, and the Bar B Formation (Silver 1955).

The San Andres Mountains also contain numerous types of potentially useful materials, as described by Kottlowski (1955, 1975), who notes the occurrence of cherts and other potential tool stones in numerous rock formations. For example, cherts occur in the Upham dolomite, Aleman dolomite, several members of the Lake Valley Formation, the Las Cruces Formation, and the Rancheria Formation. In addition, basal beds of Pennsylvanian-age deposits are primarily a cherty conglomerate, Missourian age beds are described as massive and cherty, and limestone of Demoinesian age is cherty. A light gray quartzite occurs at the top of the Precambrian deposits (Kottlowski 1975), and extensive deposits of Precambrian quartzite occur in the northern San Andres Mountains (Budding and Condie 1975:92).

Though Banks (1990:70–71) notes that the distinctive fingerprint chert commonly known as San Andres chert is not well reported in the geologic literature, he suggests that it occurs sporadically in the San Andres Formation. Kottlowski (1955) describes a black-and-white banded chert in the Andrecito Canyon member of the Lake Valley Formation. The only other chert described by Kottlowski (1955) is a white to light-gray variety that outcrops in the Nunn member of the Lake Valley Formation. In his study of the Jicarilla Mountains, Budding (1964:81) notes that the San Andres Formation in that area is chert-bearing, but does not describe the chert. However, this does suggest that San Andres chert could be locally abundant in different parts of the formation. The lack of San Andres chert in our samples could indicate that this material is not commonly found in local gravel deposits though, considering that specimens of this material were identified during analysis of the collections recovered from multiple sites, it probably occurs in small quantities.

Both the Hayner Ranch and Camp Rice Formations are exposed at Prisor Hill, but samples were only collected from the former. This suggests that most of the materials collected from this source probably originated in the Caballo Mountains. Thus, we might expect to mainly find gray to dark-gray cherts in these gravels. Examining the materials collected from Prisor Hill, we find that, as expected, gray to dark-gray varieties tend to dominate the chert assemblage, though a specimen of translucent white chert also occurs and could represent another type discussed by Banks (1990) from the Caballo Mountains. Using the colors of the cherts and their cortex provided by Silver (1955), we can suggest that at least five chert specimens in our sample from Prisor Hill probably originated in the Caballo Mountains.

The primary formation exposed at Yost Escarpment is the Love Ranch, which formed in a basin filled by materials from the nearby Rio Grande uplift (Seager 2005). Unlike the other formations from which collections were made, metaquartzites were common in the Love Ranch materials. While some gray and dark-gray cherts were found, our impression was that they were not as common in the Love Ranch Formation as they were in the Hayner Ranch and Camp Rice Formations. Using the colors of the cherts and their cortex provided by Silver (1955), we can suggest that one or two chert specimens in our sample from Yost Escarpment probably originated in the Caballo Mountains. Other cherts and possibly the metaquartzites could have originated in formations in the northern San Andres Mountains, though this remains undemonstrated.

LA 155963 contains an exposure of the Love Ranch Formation along the west flank of the site, as discussed earlier. This suggests that there should be some similarities between the samples collected at LA 155963 and those from Yost Escarpment, where the Love Ranch Formation is also exposed. This indeed appears to be the case, with two to three cherts that may have originated in the Caballo Mountains and metaquartzites similar to those found on Yost Escarpment occurring in gravels at LA 155963.

We should note that just because chert is geologically available in many formations, not all varieties might be suitable for use as tool stone. Still, the number of potential sources for cherts in the mountain ranges surrounding the study area suggests that most of the materials reduced at our sites probably originated in those mountains and other uplifted areas that rim the Jornada del Muerto. Rather than exploiting sources in the mountains, most of the materials used at our sites were probably obtained from secondary sources in local alluvial and fluvial deposits like those described earlier. This can and will be tested during analysis of the chipped stone assemblages by monitoring cortex type.

The main conclusion that can be drawn from this study is that nearly all of the potential high quality tool stones—cherts and silicified woods—found within the study area were carried into the Jornada del Muerto by various fluvial and alluvial processes, and originated at moderate to long distances from the study area. This means that only a few of the exotic materials found on our sites could be considered evidence of extensive trade networks. An example of this is Alibates chert (silicified dolomite), which comes from the Texas Panhandle and could not have been carried into the study area by any natural process. This cannot be assumed for other potential exotics such as Pedernal chert, Madera chert, or some types of obsidian. All of these tool stones were probably available in exposures of the Camp Rice Formation, which was deposited by the ancestral Rio Grande and can contain materials originating far to the north. Since a sample of Pedernal chert was collected from the Camp Rice Formation near Truth or Consequences, as was a dominantly red chert with gray and pinkish-gray areas that resembles Madera chert, this is a very real possibility. Though no obsidian specimens were collected, obsidian is known to occur in Rio Grande gravels as far south as the Mexican border. Thus, the exposure of Camp Rice Formation in the Rio Grande Valley was a potential source for all three of these otherwise "exotic" materials, which may also have been available in limited quantities in Camp Rice Formation sediments near the study area.

In order to correctly determine whether certain materials represent locally available or imported tool stones, at least some knowledge of local geology is necessary. Though most of the tool stones used at the Spaceport America sites originated at moderate to large distances from the study area, most cannot be assumed to be imports because geologic processes resulted in their deposition in local gravels. This is especially true of potentially exotic materials with waterworn cortex, because the character of their cortex indicates that they were transported away from where they outcrop by fluvial processesAt the very least, gravel deposits that are exposed on the surface or in arroyo cuts in the study area contain materials derived from the Caballo Mountains to the west, the San Andres Mountains to the east, and potentially from more distant locations to the north that were drained by the ancestral Rio Grande, including the Sangre de Cristo, Jemez, Sandia, and Manzano Mountains. Thus, materials from any of these areas can only be determined to represent imports if they exhibit non-waterworn cortex. Otherwise, they must be assumed to be of local origin. This approach is at odds with many earlier studies, which tended to consider materials that do not outcrop near the sites where they were used as exotics, without taking into account their potential procurement in local gravel beds. However, it also provides a more accurate view of potential prehistoric trade and exchange networks for tool stones.

24 | Large Roasting Features and Brush Shelters

Nancy J. Akins

Two types of features encountered during the research-oriented investigations at Spaceport America are discussed further here. Small fire pits with and without fire-cracked rocks are ubiquitous throughout southern New Mexico and probably served a number of functions. The focus in this chapter is on features that are not as common: large roasting features and brush shelters. This chapter explores whether there are regional commonalities for these, in terms of construction, materials used, dates, subsistence remains, and wood use.

Large Roasting Features

Researchers have long recognized that some large thermal features are different from the smaller camp and domestic fire pits and have speculated about how they were used. For this discussion, thermal features that have a diameter of 70 cm or larger are considered "large" (see also Cribbin 2008: 281–282; Railey et al. 2002:747–748). Six of the Spaceport features are large thermal pits, presumably used for roasting plant parts (see Appendix 5: Table App5.1). These occur at five sites and include three that had virtually no rock in the fill, one that had tightly packed pieces of caliche, and two that were filled with fire-fractured cobbles of a wide variety of materials. The smallest had a diameter of 0.70 m, and was relatively shallow, while the largest was 2.8 m in diameter. All but the smallest and possibly deflated feature (0.10 m), were fairly deep (0.39–0.63 m) and contained charcoal- and ash-stained soil. The earliest (LA 111429, Feature 3) dates to the Late Archaic–Mesilla-phase transition and was about 1.8 m in diameter and 0.52 m deep, with only a cluster of large rocks near one edge that resembled a pot rest. Three date to the Mesilla phase. Feature 6 at LA 111435 and Feature 1 at LA 155968 were also rockless, measuring 1.1 and 1.4 m in diameter and 0.39 and 0.56 deep respectively. The third is the small cobble-filled Feature 14 at LA 155963. Feature 11 at LA 111429 and Feature 1 at LA 155964 are the largest (2.2 and 2.8 m in diameter and 0.52 and 0.56 m deep respectively). Both were tightly packed with rock—one with caliche, the other with cobbles—and both date to the Historic era. Feature 11 at LA 111429 was used during the Spanish Colonial period while the LA 155964 feature dates to the 1800s or early 1900s. Saltbush is the only fuel wood common to all of the features. The two largest (and latest) features also have mesquite, as does one of the Mesilla-phase features (Feature 1 at LA 155968). Cholla, yucca, and tarbush were also used as fuel. A variety of potential plant food remains was found. Prickly-pear parts were found in three, grass and goosefoot in two, and single instances of spurge, hedgehog cactus, amaranth, bugseed, aster, and yucca were found in four of the features. Two had no potential food plants (Appendix 5: Table App5.1).

The admittedly small sample of large roasting features at the Spaceport suggests that earlier features (Transition and Mesilla phase) may have been used differently than the later ones, based on the absence of rock-fill in three of the earlier features and presence of abundant rock in the later two. Feature 14 at LA 155963 was shallow and may be more like a regular fire pit than a roasting pit. The plant remains in the pits provide little information on what was roasted, although the starch residue (Appendix 5: Table App5.1) suggests that a bed of wet grass was used in at least the two larger pits.

Regional Large Roasting Pits

To determine whether the number and types of features found at the Spaceport are similar to that in the region, a sample of (mainly cultural resource management [CRM]) reports was examined for descriptions of thermal features with at least one dimension that was 0.70 m or greater. This review found 56 sites that report a fair number of large roasting features (n = 184) in southern New Mexico and adjacent parts of Texas (Appendix 5: Table App5.1). Not all of these reports contained details on subsistence remains or dating results, but most report the size, nature of fill, and the presence or absence of rocks. Except for a few such features that have essentially no or sketchy information, Appendix 5: Table App5.1 provides the following data for these features: general geographic location; site number; feature number; type of rocks in the fill and whether it was burned (e.g., cobbles, caliche, or the more generic "rock"); feature dimensions; fill details (e.g., charcoal-stained soil; rock base; ring-midden pit); types of fuel wood found; types of food remains found; and associated ^{14}C date ranges. Unreported information is considered unknown as opposed to absent. "Absent" was used when flotation or wood from a feature is reported and that taxon is not on the list. When the feature description and the paleoethnobotanical report does not indicate that a sample was taken or processed, it is considered unknown. Pollen information was not used, however the presence of corn phytoliths or lipids was considered evidence of corn. In other instances, information such as the presence or absence of rock or nature of the fill was simply summarized (e.g., most of these features were rock-filled or had charcoal-stained fill) without information on an individual feature. These had to be treated as unknown unless a profile or photo provided that information.

Table 24.1 provides a regional overview for a sample of large roasting pit features, comparing those from the Spaceport sites with the results from our literature review. A large number of features date to the Archaic period (46.2 percent), and mainly to the Late Archaic (34.0 percent). Both Mimbres and Mogollon sites from southwestern New Mexico are included in the sample. Early Pithouse and Mesilla-phase features are more common (17.8 percent) than Late Pithouse and Doña Ana and El Paso features (9.6 percent). Protohistoric to Historic roasting features are the least common (4.6 percent). Unfortunately, a good number are not dated (21.8 percent). As for area, the Spaceport features comprise only 3.0 percent of this regional total. The rest are fairly evenly distributed between the Tularosa Basin (27.4 percent), southeastern New Mexico (25.9 percent), southwestern New Mexico (24.9 percent), and the Fort Bliss/El Paso area (18.8 percent).

Regional Roasting Pits by Area

Before assessing the features by time periods, the areas were examined for indications that some differences were due to environment or location rather than time period (Appendix 5: Table App5.1). The Fort Bliss/El Paso area has the most features that are not dated (48.1 percent), followed by southeastern New Mexico (26.5 percent). The other areas in this sample have no (Spaceport) or few (southwestern New Mexico 5.9 percent, Tularosa Basin 2.7 percent) undated features.

The presence, absence, amount, and type of rock in the fill was always or almost always reported for all but the Tularosa Basin features, where nearly a third (32.4 percent) of the features have no indication as to whether an individual feature had rock in the fill. Little or no fire-cracked rock was recorded for features in the Tularosa Basin (52.0 percent), Spaceport (50.0 percent), southwestern New Mexico (32.0 percent), Bliss/El Paso (27.0 percent), and southeastern New Mexico (14.3 percent). In areas other than the Spaceport, rock was generally reported only as "rock." However, "cobbles" were specified for the Spaceport (33.3 percent), southeastern New Mexico (18.4 percent), Fort Bliss/El Paso (9.3 percent), and southwestern New Mexico (2.0 percent). Reports of caliche are less common for all areas except for southwestern New Mexico, but then there are only three features from that area with the rock type reported. Southeastern New Mexico (8.2 percent) and the Spaceport (16.7 percent) have the most reports of caliche rock fill.

"Rock-filled pits" were reported for the Spaceport (n = 3, 50.0 percent), southeastern New Mexico (n = 13, 26.5 percent), and Fort Bliss/El Paso (n = 4, 7.4 percent) features. "Ring midden" was specified for a few from southeastern New Mexico (n = 5, 10.2 percent) and southwestern New Mexico (n = 1, 2.0 percent). Others were rock-lined (one from southeastern New Mexico, five from Fort Bliss/El Paso,

Table 24.1. Dates and locations of regional large roasting pits.

	Spaceport		SW New Mexico		Tularosa Basin		Fort Bliss/ El Paso		SE New Mexico		**Total**	
	Count	Col. %	Count	Col. %	Count	Col. %	Count	Col. %	Count	Col. %	Count	Col. %
Early Archaic	–	–	2	3.9%	–	–	–	–	–	–	2	1.0%
Middle Archaic	–	–	–	–	7	18.9%	4	7.4%	4	8.2%	15	7.6%
Late Archaic	–	–	30	58.8%	9	24.3%	7	13.0%	21	42.9%	67	34.0%
Late Archaic/ Early Formative	1	16.7%	2	3.9%	1	2.7%	1	1.9%	1	2.0%	6	3.0%
Archaic	–	–	–	–	–	–	–	–	1	2.0%	1	0.5%
Early Pithouse	–	–	8	15.7%	–	–	–	–	–	–	8	4.1%
Early Mesilla	2	33.3%	–	–	10	27.0%	2	3.7%	1	2.0%	15	7.6%
Mesilla/Pithouse	–	–	1	2.0%	–	–	1	1.9%	2	4.1%	4	2.0%
Late Mesilla	1	16.7%	1	2.0%	1	2.7%	5	9.3%	–	–	8	4.1%
Late Pithouse	–	–	3	5.9%	–	–	–	–	–	–	3	1.5%
Early Dona Ana	–	–	–	–	1	2.7%	–	–	1	2.0%	2	1.0%
Dona Ana	–	–	–	–	6	16.2%	3	5.6%	1	2.0%	10	5.1%
Late Dona Ana	–	–	–	–	1	2.7%	1	1.9%	1	2.0%	3	1.5%
El Paso	–	–	–	–	–	–	1	1.9%	–	–	1	0.5%
Protohistoric	–	–	1	2.0%	–	–	1	1.9%	2	4.1%	4	2.0%
Protohistoric/ Spanish	–	–	–	–	–	–	1	1.9%	1	2.0%	2	1.0%
Spanish Colonial	1	16.7%	–	–	–	–	–	–	–	–	1	0.5%
Historic	1	16.7%	–	–	–	–	1	1.9%	–	–	2	1.0%
Unknown	–	–	3	5.9%	1	2.7%	26	48.1%	13	26.5%	43	21.8%
Total	6	100.0%	51	100.0%	37	100.0%	54	100.0%	49	100.0%	197	100.0%

and one from southwestern New Mexico), had rock bases (four from southeastern New Mexico, two from southwestern New Mexico), or had rock edges (one each from southeastern New Mexico and Fort Bliss/El Paso).

A quarter of the features lacked fill descriptions; these were mainly from the Tularosa basin (59.9 percent) and southwestern New Mexico (56.9 percent). When fill was recorded, the majority (80.8 percent) had ash- and charcoal-stained soil, while a few had only flecks of charcoal (17.1 percent), rock only (1.4 percent), or post-occupational fill (0.7 percent). Southeastern New Mexico had the fewest features with stained-soil fill (63.3 percent), but had all of the rock-only and post-occupational fill features.

When the type of fuel wood was specified (Table 24.2), southwestern New Mexico has the greatest variety, mainly due to the more diverse environmental settings. The Spaceport sites all had saltbush, half had mesquite, and others had cholla and tarbush. The distribution for the Tularosa Basin is most similar to the Spaceport, with large proportions containing mesquite and saltbush. In the southeastern New Mexico sample, juniper is the most common wood while more of the Fort Bliss/El Paso features had mesquite followed by equal numbers with saltbush and creosote. The southwestern features also tended to have more mesquite and saltbush but nearly as many had juniper. Cholla, oak, and mountain mahogany were also reported for these features.

A variety of potential food remains are reported for the large roasting features (Table 24.3). None occur with any great frequency given the number of features with flotation sample results (n = 114). This could be due to what was cooked in features since plants such as succulents are less likely to leave burned plant parts than are seeds that are parched or roasted (O'Laughlin 1980:120). This along with poor preservation provides little indication of how these pits were used.

Table 24.2. Summary of fuel wood in regional large roasting pits; count and percent of features with that fuel.

Area	Spaceport		SE New Mexico		Fort Bliss/ El Paso		Tularosa Basin		SW New Mexico	
Fuel Wood	Count	%	Count	%	Count	%	Count	%	Count	%
Mesquite	3	50.0	3	10.3	17	42.5	8	72.7	14	46.7
Saltbush	6	100.0	2	7.1	7	17.9	8	72.7	12	40.0
Juniper or pine	–	–	10	34.5	1	2.6	–	–	11	36.7
Cholla	2	33.3	–	–	–	–	–	–	1	3.3
Tarbush	2	33.3	1	3.2	–	–	–	–	–	–
Oak	–	–	2	7.1	–	–	–	–	2	6.7
Mountain	–	–	–	–	–	–	–	–	7	23.4
Creosote	–	–	–	–	7	17.9	–	–	–	–
Buckhorn	–	–	3	9.7	–	–	–	–	–	–

Table 24.3. Summary of burned plant material in regional large roasting pits; count and percent of features with that fuel.

Area	Spaceport		SE New Mexico		Fort Bliss/ El Paso		Tularosa Basin		SW New Mexico	
Burned Material	Count	%	Count	%	Count	%	Count	%	Count	%
Yucca	1	16.7	–	–	2	5.1	–	–	–	–
Agave	–	–	4	11.8	2	5.3	–	–	1	3.3
Prickly pear cactus	3	50.0	–	–	1	2.6	–	–	–	–
Hedgehog cactus	1	16.7	–	–	–	–	–	–	–	–
Cheno-Am	2	33.3	–	–	–	–	2	28.2	8	26.7
Purslane	1	16.7	–	–	1	2.6	2	28.6	1	3.3
Grasses	2	33.3	1	3.0	3	7.9	1	14.3	2	6.7
Aster	1	16.7	–	–	–	–	–	–	–	–
Sunflower	–	–	–	–	1	2.6	–	–	–	–
Spurge	1	16.7	3	8.8	–	–	–	–	–	–
Mesquite seeds	–	–	3	8.8	–	–	–	–	2	6.7
Corn parts	–	–	–	–	2	5.3	1	14.3	6	19.8
Corn phytolith or lipid	–	–	–	–	1	2.6	–	–	2	6.7
Juniper seeds	–	–	–	–	1	2.6	–	–	1	3.3
Mustard	–	–	–	–	–	–	1	14.3	–	–
Walnut	–	–	–	–	–	–	–	–	2	6.7
Rabbit bone	–	–	–	–	1	2.6	–	–	4	10
Mussel	–	–	3	8.8	–	–	–	–	–	–

Regional Roasting Pits by Time Period

While it is hard to judge whether the dated features are a representative sample of the somewhat overlapping areas and the region as a whole, the feature data are examined for potential trends in distribution and characteristics that could provide information on the regional subsistence practices of mobile and increasingly sedentary groups. Combining some of the time periods (Table 24.4) suggests the distribution varies over time (Fig. 24.1). Overall, the graph suggests that the frequency of large roasting features peaked in the Late Archaic then rapidly declined, particularly in the southwestern and southeastern New Mexico feature areas. In the Tularosa Basin, and to a lesser extent the Fort Bliss/El Paso area, the distribution is more even with the later peaking in the Late Mesilla–El Paso period. However, when the number of years covered by a particular time period is considered, the Early to Middle Archaic period with the longest time span (about 4800 years, or over 70 percent of the years covered by these sites) has a small proportion of the large roasting pits (11.1 percent), indicating that: (1) features dating to this early period are not well preserved, or (2) large roasting pits were rarely used to process food during this period.

Removing these early features from the overall total due to the considerable difference in the number found and time period involved shows that the proportion of large roasting pits and the proportion of years in a period are similar for the remainder of the time span (Fig. 24.2). The Late Archaic period (about 1500 years or 46.9 percent of the time span) accounts for 49.3 percent of the features. While the graph (Fig. 24.1) suggests a decline in large roasting features during the Late Archaic/Early Formative transition period, this relatively short (about 600 years or 18.6 percent of the time span) accounts for 24.3 percent of the roasting features and indicates that they may have increased slightly. The greatest difference (10.9 percent less than the previous period) is in the Late Mesilla–El Paso group. Covering about 800 years or 25 percent of the time span, the proportion of roasting pits is smaller (19.8 percent) than the percent for the time span, suggesting the presence declined slightly and continued to do so in the last two time periods (6.3 and 3.1 percent of the time span and 5.1 and 1.5 percent of the features).

To summarize, the number of large roasting features in this sample is closely related to the number of years in the time period when the earlier Archaic samples are excluded from the sample (Pearson's correlation = 0.987, significance = 0.004). In relative terms, the Transition and Late Archaic periods have slightly more features than expected for the length of the time period. The drop in the following period, when groups were more sedentary, is probably a significant indication of reduced mobility. These findings are consistent with an analysis of radiocarbon dates by Miller and Kenmotsu (2004) who note increases in thermal features with rock and structures during the transition from the Archaic to the Formative period and suggest it shows a link between changes in demographic patterns and the use of cultigens that indicates a more intensive land use pattern and a decrease in group mobility. Trends for the Late Mesilla–El Paso periods indicate relatively low numbers of rock-lined thermal features after the transition until about AD 900, when the frequencies increase, peaking between about AD 1225 and 1275, and declining and peaking again at about AD 1375 (2004:230–231, 235, 243).

Roasting Pit Types

Turning to the feature characteristics, the features in the sample were assigned to a type based on size (diameter), depth, and the presence of rocks. First, the diameter (length times width divided by two) was plotted against the feature depth. The resulting distribution was used to define four groups: "small" are those less than 1.0 m in diameter; "large" are those 1.0 m and greater in size; "shallow" includes those less than 0.30 m deep; and "deep" are those 0.30 m and greater in depth. These were further divided by whether they had rock or not ("not" includes none and traces only). This resulted in eight types of roasting features that will be referred to as: "small shallow with rock," "small shallow rockless," "large shallow with rock," "large shallow rockless," "small deep with rock," "small deep rockless," large deep with rock," and "large deep rockless." These types could have been used for different quantities and types of food. Rocks serve as heat reservoirs and are used to attain a moderate to high temperature for an extended period (Wandsnider 1997:24) so we might expect that the larger roasting pits filled

Table 24.4. Large roasting pits by area and combined time groups.

Period	Spaceport		SE New Mexico		Fort Bliss/ El Paso		Tularosa Basin		SW New Mexico		Total	
	Count	Col. %	Count	Col. %	Count	Col. %	Count	Col. %	Count	Col. %	Count	Col. %
Early to Middle Archaic	–	–	4	11.4%	4	14.3%	7	19.4%	2	4.2%	17	11.1%
Late Archaic	–	–	21	60.0%	7	25.0%	9	25.0%	30	62.5%	67	43.8%
Late Archaic/Early	3	50.0%	4	11.4%	4	14.3%	11	30.6%	11	22.9%	33	21.6%
Late Mesilla - El Paso	1	16.7%	3	8.6%	10	35.7%	9	25.0%	4	8.3%	27	17.6%
Protohistoric - Spanish Colonial	1	16.7%	3	8.6%	2	7.1%	–	–	1	2.1%	7	4.6%
Historic	1	16.7%	–	–	1	3.6%	–	–	–	–	2	1.3%
Total	6	100.0%	35	100.0%	28	100.0%	36	100.0%	48	100.0%	153	100.0%

with rock were used to process foods that take longer to cook, while the smaller rock-free pits were used for foods that required less processing or cooking.

When the distribution of the feature types is examined by area (Fig. 24.3, Table 24.5), southwestern New Mexico and the Tularosa Basin have similar proportions of feature types, as do the Fort Bliss/El Paso area and southeastern New Mexico. Features in southwestern New Mexico and the Tularosa Basin are more often "small shallow with rock," while the southeastern New Mexico and Fort Bliss/El Paso features are more likely to be "large shallow with rock." Deep features are relatively rare, except in the small Spaceport sample. Features with rock are far more common but this may be at least partially due to higher visibility, which made excavation more likely. This seems to be confirmed by correlation coefficients that indicate the number of features with rocks correlates with the total number of features, regardless of whether the earlier Archaic sample is included (Pearson's correlation = 0.955, significance = 0.003) or excluded (Pearson's correlation = 0.953, significance = 0.012). The same is not true of the rockless features (for all periods combined: Pearson's correlation = 0.670, significance = 0.149; excluding the earliest period: Pearson's correlation = 0.656, significance = 0.229).

Looking at pit characteristics, regardless of where a pit occurred, or whether it is dated, fill is nearly always ash- or charcoal-stained. Fewer of the "small shallow with rock" and "large shallow with rock" pits have this fill type (65.9 and 66.7 percent), while most of the "small shallow rockless" (94.4 percent) and "large deep with rock" (85.7 percent) mainly have ash or charcoal fill. The other pits all have this fill type. By size alone, slightly more of the large (vs. small) pits have ash or charcoal fill (82.4 and 79.2 percent) while considerably more of the deep (vs. shallow) pits have ash or charcoal fill (94.9 and 75.7 percent). Whether the pit was rock-filled makes it even more likely to have ash or charcoal fill (97.9 with and 71.3 percent without). It appears that shallow roasting pits are less likely to retain their fill, due to either deflation or exposure, but that the presence of rock somewhat mitigates those factors.

The set of features identified as ring-middens (n = 6) are more often large (n = 4) and equally divided between shallow and deep. They date to the Early–Middle Archaic (n = 3), Late Archaic (n = 2), and

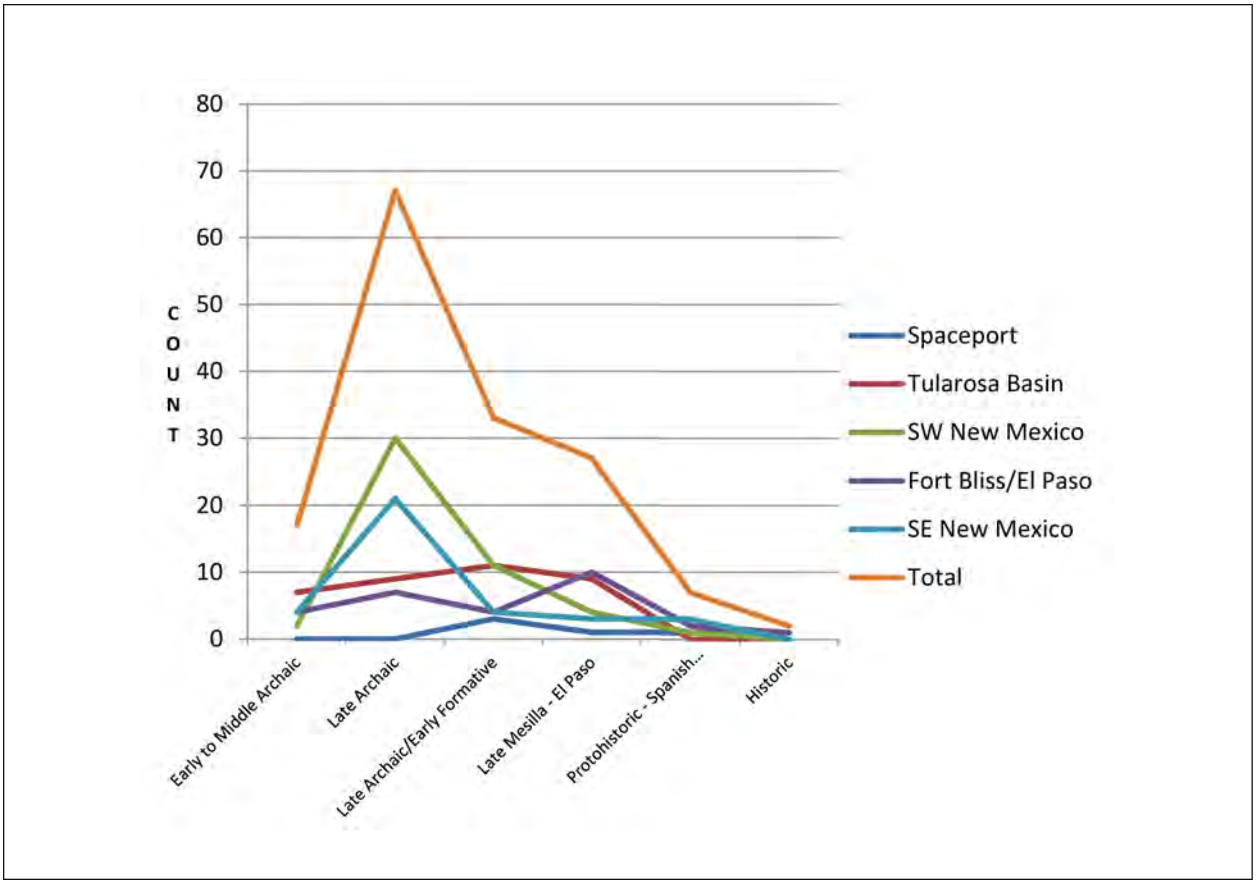

Figure 24.1. Number of large roasting features by time period and area.

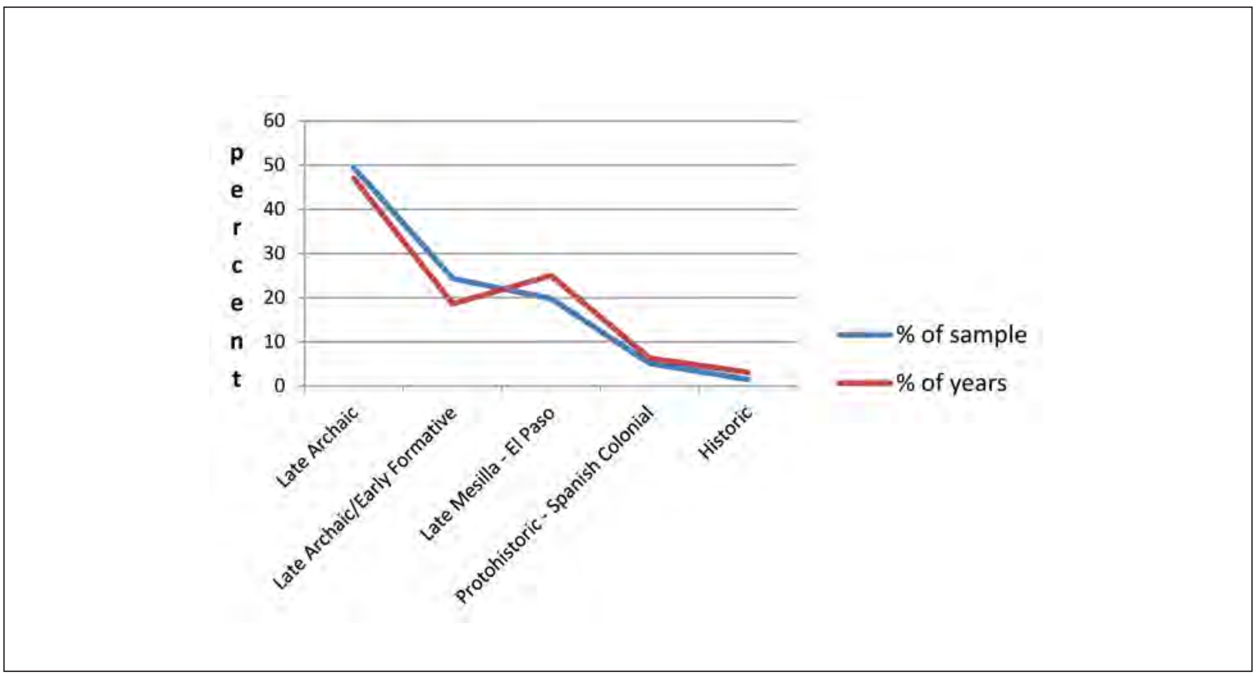

Figure 24.2. Comparison of the percent of features with the percent of years represented by that time period.

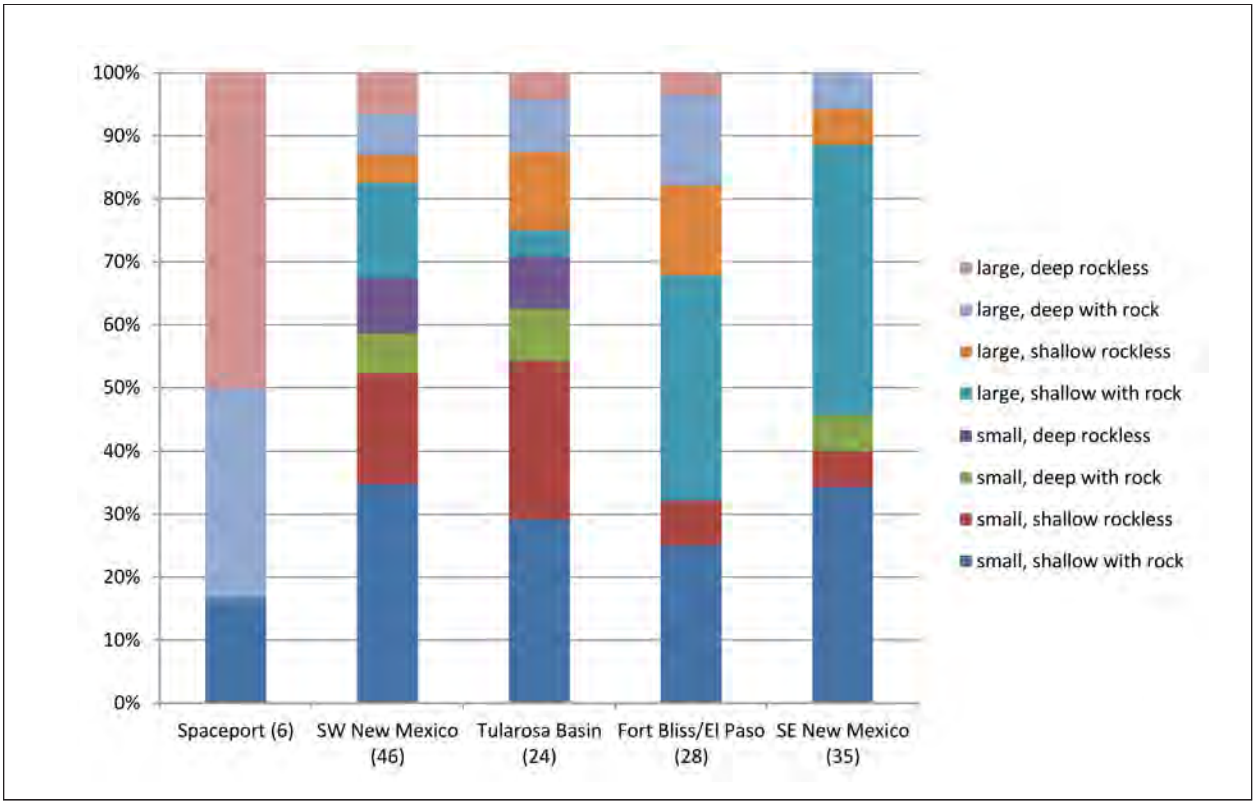

Figure 24.3. Proportion of roasting pit type by area.

Protohistoric (n = 1). Rock associated with these features is described as cobbles (n = 4) or rock (n = 2). Diameters range from 0.68 to 2.70 m and depths from 0.17 to 0.70 m. Half of the ring-middens have fill described as ash or charcoal and the rest as charcoal-flecked. When fuel woods are reported, half (2 of 4) had mesquite, none had saltbush, and most (3 of 4) had juniper. Agave parts were found in most (3 of 4), while the only other possible food remains were mussel shells, which were found in two of the ring-middens.

Mesquite fuel-wood was reported from just over a third of the features (36.6 percent). With the exceptions of the "small shallow with rock" and "large shallow with rock" groups, percentages with mesquite fuel-wood are at least 50 percent, with a maximum of 69.2 percent for the "large deep with rock" group. Slightly more of the large pits held mesquite (41.7 versus 35.7 percent of the small pits); more of the deep (than shallow) features (51.7 and 34.5 percent) did as well; and rock trumped rockless features (52.6 and 28.4 percent) for mesquite contents. Thus, when available, this hot and long-burning (Church and Sale 2003:124) fuel appears to have been favored for large, deep, rock-filled roasting pits.

The only other potentially large fuel wood reported with any frequency is pine or juniper (19.8 percent of the features), which is found mainly in the southeastern New Mexico and southwestern New Mexico samples (Table 24.2). Features with larger percentages include the "small deep rockless" (50.0 percent) and "large deep with rock" (30.8 percent) types. Slightly more large than small features have this fuel type (20.3 and 17.9 percent), as do more deep ones than shallow ones (27.6 and 16.3 percent), and there are more with rock than without (24.3 and 10.8 percent).

Saltbush, a low energy but usually abundant fuel wood, was reported for 30.7 percent of the features, including 85.7 percent of the small sample of "large deep rockless" features (n = 7), 60 percent of the "small shallow rockless," and 50 percent of the "small deep rockless" features. A tendency to be

Table 24.5. Feature type by time period and area.

	Small Shallow with Rock		Small Shallow without Rock		Large Shallow with Rock		Large Shallow without Rock		Small Deep with Rock		Small Deep without Rock		Large Deep with Rock		Large Deep without Rock		**Total**	
	n=	%	n=	%	n=	%	n=	%	n=	%	n=	%	n=	%	n=	%	n=	%
Early to Middle Archaic																		
SE New Mexico	2	50.0	–	–	1	25.0	–	–	–	–	–	–	1	25.0	–	–	4	100.0
Fort Bliss/El Paso	1	25.0	1	25.0	2	50.0	–	–	–	–	–	–	–	–	–	–	4	100.0
Tularosa Basin	1	33.3	–	–	–	–	–	–	–	–	–	–	1	33.3	1	33.3	3	100.0
SW New Mexico	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2	100.0	2	100.0
Period Total	4	30.8	1	7.7	3	23.1	–	–	–	–	–	–	2	15.4	3	23.1	13	100.0
Late Archaic																		
SE New Mexico	5	23.8	2	9.5	10	47.6	2	9.5	1	4.8	–	–	1	4.8	–	–	21	100.0
Fort Bliss/El Paso	1	14.3	1	14.3	3	42.9	1	14.3	–	–	–	–	1	14.3	–	–	7	100.0
Tularosa Basin	2	28.6	1	14.3	1	14.3	–	–	2	28.6	–	–	1	14.3	–	–	7	100.0
SW New Mexico	15	51.7	1	3.4	6	20.7	–	–	3	10.3	2	6.9	2	6.9	–	–	29	100.0
Period Total	23	36	5	7.8	20	31.3	3	4.7	6	9.4	2	3.1	5	7.8	–	–	64	100.0
Late Archaic/Early Formative																		
Spaceport	1	33.3	–	–	–	–	–	–	–	–	–	–	–	–	2	66.7	3	100.0
SE New Mexico	2	50.0	–	–	1	25.0	–	–	1	25.0	–	–	–	–	–	–	4	100.0
Fort Bliss/El Paso	–	–	–	–	3	75.0	1	25.0	–	–	–	–	–	–	–	–	4	100.0
Tularosa Basin	3	42.9	4	57.1	–	–	–	–	–	–	–	–	–	–	–	–	7	100.0
SW New Mexico	1	10.0	5	50.0	1	10.0	2	20.0	–	–	1	10.0	–	–	–	–	10	100.0
Period Total	7	25.0	9	32.1	5	17.9	3	10.7	1	3.6	1	3.6	–	–	2	7.1	28	100.0
Late Mesilla–El Paso																		
Spaceport	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	100.0	1	100.0
SE New Mexico	1	33.3	–	–	2	66.7	–	–	–	–	–	–	–	–	–	–	3	100.0
Fort Bliss/El Paso	5	50.0	–	–	2	20.0	–	–	–	–	–	–	2	20.0	1	10.0	10	100.0
Tularosa Basin	1	14.3	1	14.3	–	–	3	42.9	–	–	2	28.6	–	–	–	–	7	100.0
SW New Mexico	–	–	2	50.0	–	–	–	–	–	–	1	25.0	–	–	1	25.0	4	100.0
Period Total	7	28.0	3	12.0	4	16.0	3	12.0	–	–	3	12.0	2	8.0	3	12.0	25	100.0
Protohistoric–Spanish Colonial																		
Spaceport	–	–	–	–	–	–	–	–	–	–	–	–	1	100.0	–	–	1	100.0
SE New Mexico	2	66.7	–	–	1	33.3	–	–	–	–	–	–	–	–	–	–	3	100.0
Fort Bliss/El Paso	–	–	–	–	–	–	1	50.0	–	–	–	–	1	50.0	–	–	2	100.0
SW New Mexico	–	–	–	–	–	–	–	–	–	–	–	–	1	100.0	–	–	1	100.0
Period Total	2	29	–	–	1	14.3	1	14.3	–	–	–	–	3	42.9	–	–	7	100.0
Historic																		
Spaceport	–	–	–	–	–	–	–	–	–	–	–	–	1	100.0	–	–	1	100.0
Fort Bliss/El Paso	–	–	–	–	–	–	1	100.0	–	–	–	–	–	–	–	–	1	100.0
Period Total	–	–	–	–	–	–	1	50.0	–	–	–	–	1	50.0	–	–	2	100.0
Total																		
Total	43	30.9	18	12.9	33	23.7	11	7.9	7	5.0	6	4.3	13	9.4	8	5.8	139	100.0

more common in small rather than large pits (36.4 and 25.4 percent), in deep rather than shallow (48.3 and 24.7 percent) pits, and in those without rather than with rock (48.6 and 17.8 percent) suggests a use different than for the longer burning woods.

None of the other fuel woods occur with any frequency. Creosote, found in seven of the features, was in three "small shallow with rock," two "large shallow with rock," and two "large deep with rock" features, again suggesting it was probably an expedient choice.

Very few of the features that had flotation sample results report finding identifiable plant parts (6.2 percent). As a result, the consistent presence of a food plant in a feature type might be considered good evidence that it was processed in, or consumed around, that type of feature. Probably the best example in this feature sample is agave, where three of the seven features with this plant are ring-middens. Other feature types with agave include a "small shallow with rock" pit, two of the "large shallow with rock" types, and one identified as "large deep with rock," some of which could also be ring-middens but were not specifically identified as such. Another potential food plant with an interesting distribution is mesquite beans. These are more likely to be found in smaller features (4 of 5), in shallow features (5 of 5), with no real difference in those with and without rock (3 and 2). Cheno-ams were reported for all features types except the 13 "small shallow rockless" features. Otherwise, more small than large (13.0 and 8.3 percent), more deep than shallow (16.7 and 8.3 percent), and in equal proportions rock-filled and rockless features (10.8 and 10.5 percent) contained cheno-ams. Corn parts were reported for nine features and phytoliths or lipids for another three. Plant parts were found in single instances of "small shallow rockless," "large shallow with rock," and "small deep with rock" features. The small shallow with rock, small deep rockless, and large deep with rock had two reports each. Phytoliths or lipids were reported for one each small shallow with rock, large shallow with rock, and large deep with rock. Small pits were more likely to produce corn parts than were large pits (n = 6 and 3; n = 1 and 2 for phytoliths or lipids) and near equal numbers were reported for shallow and deep pits (n = 4 and 5 and 2 and 1 for phytoliths or lipids). The presence of rock may have contributed to preservation since twice as many of the features with corn parts, and all with corn phytoliths or lipids, had rock.

Summary of Regional Roasting Pits by Feature Type

Dated small shallow with rock features (n = 43) averaged 0.78 m in diameter and 0.16 m deep, with relatively little variation by time period (Table 24.6). These date to all time periods except Historic, and account for less than a third of the roasting pit samples for all but the Late Archaic period where it is slightly more (Table 24.5). More are found in southwestern New Mexico than in any other area. When all of the small shallow features with rock are considered (n = 57), a wide variety of fuel woods was reported with mesquite (n = 7), saltbush (n = 6), and juniper or pine (n = 5) the most common. Potential food plants were rarely reported, but by frequency of occurrence these include: cheno-ams (n = 4), mesquite beans and corn (n = 2 each), and agave, purslane, and spurge (n = 1 each). This combination suggests that fuel use was more opportunistic than selective and plants with shorter cooking time were processed for consumption rather than preservation and transport.

Small shallow rockless features are much less common (18 dated, 23 total) and more date to the Late Archaic–Early Formative than any other period. None have dates later than the Late Mesilla–El Paso phase. Both the mean depth and diameter are slightly larger than the small shallow with rock features (0.79 diameter and 0.19 m deep) and they tend to get larger and deeper through time. Again, saltbush (n = 9) and mesquite (n = 8) are the most common fuel woods. The only other wood reported is single instances of juniper or pine and woody legume (which include mesquite and acacia; McBride, personal communication, February 2013). Reported food plants are limited to mesquite beans (n = 2) and single reports of corn and spurge. While the number of features and number with reported plant remains are small, the fuel and plant taxa are similar to those with rocks.

Large shallow with rock features comprise the second largest feature group (n = 33 dated and 41 overall). These average 1.61 m in diameter and 0.19 m deep with largest example of this type dating to the Protohistoric–Spanish Colonial period. The Late Archaic period accounts for well over half of the

Table 24.6. Measurements of roasting pit types by time period.

Time Period		Early–Middle Archaic		Late Archaic		Late Archaic/Early Formative		Late Mesilla–El Paso		Protohistoric–Spanish Colonial		Historic		**Total (Diam./Depth in m)**	
Feature Type		Diam.	Depth	Diam.	Depth	Diam.	Depth	Diam.	Depth	Diam.	Depth	Diam.	Depth	Diam.	Depth
Small shallow with rock	N	4	4	23	23	7	7	7	7	2	2	–	–	43	43
	Minimum	0.64	0.00	0.65	0.06	0.63	0.10	0.65	0.08	0.57	0.17	–	–	0.57	0.00
	Maximum	0.80	0.19	0.97	0.29	0.92	0.28	0.93	0.20	0.69	0.18	–	–	0.97	0.29
	Mean	0.71	0.13	0.81	0.17	0.79	0.17	0.79	0.12	0.63	0.18	–	–	0.78	0.16
	Std. Deviation	0.07	0.09	0.10	0.06	0.14	0.07	0.09	0.04	0.08	0.01	–	–	0.11	0.06
Small shallow rockless	N	1	1	5	5	9	9	3	3	–	–	–	–	18	18
	Minimum	0.60	0.06	0.66	0.20	0.63	0.11	0.72	0.20	–	–	–	–	0.60	0.06
	Maximum	0.60	0.06	0.96	0.27	0.99	0.26	0.98	0.28	–	–	–	–	0.99	0.28
	Mean	0.60	0.06	0.82	0.23	0.79	0.16	0.82	0.25	–	–	–	–	0.79	0.19
	Std. Deviation	–	–	0.14	0.03	0.14	0.04	0.14	0.05	–	–	–	–	0.13	0.06
Large shallow with rock	N	3	3	20	20	5	5	4	4	1	1	–	–	33	33
	Minimum	1.50	0.10	1.11	0.11	1.15	0.10	1.05	0.08	2.18	0.22	–	–	1.05	0.08
	Maximum	1.98	0.24	3.43	0.29	3.45	0.25	1.82	0.20	2.18	0.22	–	–	3.45	0.29
	Mean	1.67	0.18	1.59	0.22	1.75	0.14	1.34	0.14	2.18	0.22	–	–	1.61	0.19
	Std. Deviation	0.26	0.07	0.55	0.05	0.97	0.07	0.33	0.06	–	–	–	–	0.58	0.06
Large shallow rockless	N	–	–	3	3	3	3	3	3	1	1	1	1	11	11
	Minimum	–	–	1.20	0.15	1.12	0.10	1.01	0.11	1.25	0.10	1.09	0.10	1.01	0.10
	Maximum	–	–	2.55	0.16	1.84	0.27	1.27	0.21	1.25	0.10	1.09	0.10	2.55	0.27
	Mean	–	–	1.68	0.15	1.36	0.18	1.11	0.17	1.25	0.10	1.09	0.10	1.35	0.15
	Std. Deviation	–	–	0.75	0.01	0.41	0.09	0.14	0.05	–	–	–	–	0.46	0.05
Small deep with rock	N	–	–	6	6	1	1	–	–	–	–	–	–	7	7
	Minimum	–	–	0.65	0.30	0.64	0.37	–	–	–	–	–	–	0.64	0.30
	Maximum	–	–	0.97	0.49	0.64	0.37	–	–	–	–	–	–	0.97	0.49
	Mean	–	–	0.82	0.37	0.64	0.37	–	–	–	–	–	–	0.79	0.37
	Std. Deviation	–	–	0.12	0.07	–	–	–	–	–	–	–	–	0.13	0.06
Small deep rockless	N	–	–	2	2	1	1	3	3	–	–	–	–	6	6
	Minimum	–	–	0.57	0.34	0.70	0.35	0.67	0.32	–	–	–	–	0.57	0.32
	Maximum	–	–	0.98	0.53	0.70	0.35	0.83	0.37	–	–	–	–	0.98	0.53
	Mean	–	–	0.77	0.44	0.70	0.35	0.72	0.34	–	–	–	–	0.74	0.37
	Std. Deviation	–	–	0.29	0.13	–	–	0.09	0.03	–	–	–	–	0.14	0.08
Large deep with rock	N	2	2	5	5	–	–	2	2	3	3	1	1	13	13
	Minimum	1.06	0.35	1.24	0.32	–	–	3.20	0.45	1.15	0.30	2.80	0.46	1.06	0.30
	Maximum	2.70	0.46	2.35	0.60	–	–	3.53	0.63	2.20	0.70	2.80	0.46	3.53	0.70
	Mean	1.88	0.41	1.77	0.44	–	–	3.36	0.54	1.69	0.54	2.80	0.46	2.09	0.48
	Std. Deviation	1.16	0.08	0.48	0.11	–	–	0.23	0.13	0.53	0.21	–	–	0.80	0.13

(Table 24.6, continued)

Time Period		Early–Middle Archaic		Late Archaic		Late Archaic/Early Formative		Late Mesilla–El Paso		Protohistoric–Spanish Colonial		Historic		**Total (Diam./Depth in m)**	
Feature Type		Diam.	Depth	Diam.	Depth	Diam.	Depth	Diam.	Depth	Diam.	Depth	Diam.	Depth	Diam.	Depth
Large deep rockless	N	3	3	–	–	2	2	3	3	–	–	–	–	8	8
	Minimum	1.14	0.30	–	–	1.10	0.39	1.14	0.36	–	–	–	–	1.10	0.30
	Maximum	2.00	0.46	–	–	1.80	0.52	1.55	0.56	–	–	–	–	2.00	0.56
	Mean	1.47	0.38	–	–	1.45	0.46	1.36	0.45	–	–	–	–	1.42	0.43
	Std. Deviation	0.47	0.08	–	–	0.49	0.09	0.21	0.10	7.00	7.00	–	–	0.34	0.09
Total	N	13	13	64	64	28	28	25	25	0.57	0.1	2	2	139	139
	Minimum	0.60	0.00	0.57	0.06	0.63	0.10	0.65	0.08	2.20	0.70	1.09	0.10	0.57	0.00
	Maximum	2.70	0.46	3.43	0.60	3.45	0.52	3.53	0.63	1.40	0.33	2.80	0.46	3.53	0.70
	Mean	1.28	0.23	1.17	0.24	1.06	0.19	1.19	0.24	0.66	0.24	1.94	0.28	1.18	0.23
	Std. Deviation	0.64	0.15	0.55	0.11	0.58	0.11	0.72	0.15	–	–	1.21	0.25	0.61	0.13

dated features and they are particularly common in southeastern New Mexico (Table 24.5). Fuel woods tend to be larger or longer burning (mesquite: n = 5; juniper or pine: n = 7; "hard wood": n = 3; oak: n = 1; mountain mahogany: n = 1; woody legume: n = 8) rather than smaller brush (saltbush: n = 1; tarbush: n = 1; creosote: n = 2; buckhorn: n = 2). Potential food plants associated with this feature type include agave (n = 3, 1 a ring-midden), cheno-ams (n = 2), mesquite beans (n = 2), corn (n = 1), juniper seeds (n = 1), and walnut (n = 1). Larger fuel-wood appears to have been favored for these larger pits and at least the agave would require the longer cooking time. However, the range of other fuels and associated food plants suggest a variety of purposes for this feature type.

Large shallow rockless features are less common (11 dated, 17 total) than those with rocks, but small numbers are found in all but the Early to Middle Archaic sample. These tend to be smaller (1.35 m diameter, 0.15 m deep) than those with rocks, and the mean diameter decreased with time (Table 24.6). Like the rock-filled features, the larger fuel woods are more common (mesquite n = 6, juniper or pine n = 1, hardwood n = 1, woody legume n = 1) than the brushy woods (saltbush n = 1). The only potential food plant found is a single feature with cheno-ams. This may suggest that any food plants processed in these shallow features did not leave any remains behind.

Small deep with rock and rockless features are relatively rare. Of those with rock, 6 of 7 are dated; of those without rock, 8 of 9 were dated. All but one of those with rocks date to the Late Archaic while those without rocks range from the Late Archaic to the Late Mesilla–El Paso periods with the latest group contributing half of the sample (Table 24.5). Those with rock are slightly larger, averaging 0.79 m compared to 0.73 m but with the same average depth (0.37 m). Fuel wood found in those with rocks includes: juniper or pine (n = 2); woody legume (n = 2); and single reports of hardwood and mountain mahogany. Rockless pits had mesquite, saltbush, and juniper (n = 2 each). Potential food remains are similar for the rock and rockless features, and consist mainly of small seeds. Both feature types had cheno-ams (n = 1 and 2), purslane (n = 1 and 2), and corn (n = 1 and 2) while the rockless pits also had single reports of mesquite beans and mustard. A greater variety and number of taxa in the rockless pits could suggest these were used more for plants that required less cooking or processing time. Those with rocks could have been used for both smaller seeds and for plants that require more time to process.

Examples of large deep with rock features (13 with dates, 16 total) occur in all but the Late Archaic/Early Formative sample (Table 24.5). Slightly more are found in the Late Archaic (n = 5) sample. These are by far the largest features, with a mean diameter of 2.09 m and depth of 0.48 m. The largest examples date to the Late Mesilla–El Paso and Historic periods (Table 24.6). Larger fuel woods (mesquite: n = 9; juniper or pine: n = 4) are more common than brush (saltbush: n = 6; tarbush: n = 1; creosote: n = 2). Foods that require longer processing times and could be processed in bulk for storage or transport (agave: n = 2; yucca: n = 2; prickly pear: n = 2) are reported as are other food plants (mesquite beans: n = 2; corn: n = 2; and 1 each of spurge, walnut, and juniper berries).

Large deep rockless pits (8 with dates, 12 total) have dates in three periods and three of the dated features are at the Spaceport (Table 24.5). They are considerably smaller than those with rock averaging 1.42 m in diameter and slightly less in depth (0.43 m), and the size varied little from period to period. Unlike the large deep with rock features, fuel woods are more often brush (saltbush: n = 6; tarbush: n = 1) than substantial woods (mesquite: n = 4; hardwood: n = 1; woody legume: n = 1), perhaps because these features tend to be earlier and mesquite may not have been available in all areas. Evidence for what was cooked in these features is even more ambiguous with single finds of yucca, prickly pear, cheno-ams, purslane, and spurge, suggesting that the processed foods left little or nothing behind.

Summary of Regional Roasting Pits by Time Period

[See Tables 24.5–24.7 and Appendix 5: Table App5.1]

Early–Middle Archaic

Thirteen of the features date to the Early to Middle Archaic period and are slightly more common in the southeastern New Mexico and Fort Bliss/El Paso areas. None are at the Spaceport. These tend to be large (61.5 percent), shallow (61.5 percent), and rock-filled (69.2 percent). Probably because of their age, features from this period are more likely to have fill with only flecks of charcoal (1 each: small shallow with rock, large shallow with rock, large deep with rock) and one had rock only (small shallow with rock). Three were considered ring-middens, one as rock-lined, one as having rock edges, and three as rock-filled. Again, probably because many (8 of 13) are from southeastern New Mexico and Fort Bliss/El Paso, mesquite is the most commonly reported fuel wood (n = 5), with saltbush (n = 2), juniper or pine (n = 1), woody legume (n = 2), and creosote (n = 1) occurring less frequently. While mesquite was reported for all but the small shallow with rock pits, the other wood types were all from large deep pits with or without rock, with the exception of one of the woody legumes from a small shallow with rock feature. The only potential food plant reported is dropseed in a small shallow rockless pit. These results indicate that subsistence during this period included roasting succulents and processing grass and is consistent with Miller and Kenmotsu's observation that processed cacti and desert succulents had become a staple during this period (2004:224), with the addition of parching grass in smaller features.

Late Archaic

Large roasting features attributed to the Late Archaic are mainly in the southeastern and southwestern New Mexico areas and include a wide range of environmental settings. Fewer come from the inter-basin area (Tularosa Basin) but many of those in the more generic New Mexico areas and Fort Bliss/El Paso have similar settings. Overall, the Late Archaic large roasting features tend to be small (56.7 percent), shallow (80.6 percent), and rock-filled (82.1 percent). Notably absent are large deep rockless features, which accounted for 23.1 percent of those from the Early to Middle Archaic period. Most of the Late Archaic features (86.1 percent) retained their charcoal-stained fill, the exceptions are generally the small shallow with rock features, which had single reports of charcoal flecks, rock only, and post-occupational fill. Two of the large shallow features with rock also had charcoal flecks only. These tend to be rock-filled (n = 8), with two described as ring-middens, two as with rock bases, and one each as rock-lined or rock-edged.

Reported fuel woods are diverse with juniper or pine the most common (n = 14) and found most often in the large shallow with rock (n = 6) and small shallow with rock (n = 3) and single reports for the other pits. Mesquite was found in fewer features (n = 9), including all of the shallow feature types and the large deep with rock (n = 2). Saltbush (n = 6) was mainly in the small shallow pits without rock (n = 4) but also in small shallow with rock and large deep with rock. Other fuel woods were reported for the small shallow with rock (n = 7) and large shallow with rock (n = 10), and included woody legume (n = 8), hardwood (n = 6), mountain mahogany (n = 5), and buckhorn (n = 2).

Evidence of food plants reported for 37 features is also diverse, although none had yucca, cacti, or composite remains. Small seeds occurred mostly in the small shallow with rock features (three with cheno-ams and one each with purslane and spurge). Two large shallow with rock and one small deep rockless also had cheno-ams. Unspecified grass types and parts were found in the small shallow rockless (n = 1) and large deep with rock (n = 2) features where it may have served as insulation or a barrier rather than representing a food item. Corn makes an appearance in features of this time period with single finds in a small deep rockless, a large shallow with rock, and a large deep with rock. Phytoliths or lipids were found in a small shallow with rock and a large deep with rock. The only other foods reported are mussel shell in a large shallow with rock and a small deep with rock, juniper berries in a large shallow with rock, and walnuts in a large shallow with rock and a large deep with rock.

Comparing the small sample of features that have both fuel woods and burned plant material provides little evidence of deliberate wood choice for processing particular plants. In the two features where agave co-occurs with identified woods (n = 37), it was found with juniper or pine once and with a woody legume once. Cheno-ams occur in small shallow with rock features that have juniper or pine, oak, and mountain mahogany fuel wood, in large shallow with rock features with juniper or pine and mountain mahogany fuel, and in a small deep rockless feature with juniper or pine fuel, suggesting an expedient gathering of fuel in a wooded setting, given that all are from southwestern New Mexico settings. Corn (n = 2), corn lipids or phytoliths (n = 1), mussel shell (n = 1), and walnut (n = 1) were reported from features that also contained juniper or pine fuel.

While there is ample evidence that corn was used by Late Archaic groups and the number of plant foods found in features from this time period might suggest increased or maintained use of a diversity of plant foods, the length of the time period and the large number of samples compared to the other periods makes this far from certain.

Late Archaic–Early Formative Transition

The sample of large roasting features dating to the Late Archaic–Early Formative is much smaller than for the Late Archaic group. Most are found in the Tularosa Basin and southwestern New Mexico. Features attributed to this period tend to be small (63.6 percent), shallow (84.8 percent), and rockless (53.6 percent).

Nearly all retained their charcoal-stained fill (91.3 percent) with two exceptions that had charcoal flecks (a small shallow with rock and a large shallow with rock). Only one small shallow feature was described as having rock fill and one small deep had rock at the base.

Pits without rock were far more likely to have fuel wood reported. Mesquite was found in eight, all rockless (five small shallow, two large shallow, and one small deep). Saltbush was also found in eight, all but one rockless (a small shallow with rock) (n = 4 small shallow, n = 1 small deep, n = 2 large deep). Also reported were juniper, mountain mahogany, and oak (1 each) in small shallow pits with rock, cholla in a small shallow rockless feature, yucca caudex in two large deep rockless pits, and single reports of woody legumes in a large shallow with rock, a large shallow rockless, and a small deep with rock.

Although fewer features from this period reported flotation results (n = 19), three taxa not found in the Late Archaic were reported (prickly pear and hedgehog cactus in one large deep rockless pit each and dropseed in a large shallow rockless feature). Cheno-ams were recovered from two (a large shallow rockless and a large deep rockless), purslane in a large deep rockless, and mesquite beans in a small shallow with rock and two small shallow rockless. Corn was found in a single small shallow rockless pit.

Thus, the sample of roasting pits from this time period tend to be small and shallow, the wood selection fairly expedient, and the foods are those that require less time to process rather than those that we would expect to be prepared in large quantities.

Late Mesilla–El Paso

Features dating to the Late Mesilla–El Paso phases (n = 25) are primarily reported for the Fort Bliss/El Paso (n = 10) and Tularosa Basin (n = 7) areas. They tend to be shallow (70.4 percent), and somewhat evenly split for size (55.6 percent small, 44.4 percent large) and rock content (52 percent with, 48 percent without). All 18 of the roasting pit with fill descriptions had charcoal-stained fill and 3 were described as rock-filled.

Mesquite was the most commonly reported fuel wood (small shallow rockless: n = 4; large shallow with rock, large deep with rock, and large deep rockless: n = 2 each; and small deep rockless: n = 1). Saltbush was nearly as common with a similar distribution (small shallow with rock: n = 3; large deep with rock and large deep rockless: n = 2 each; and small shallow rockless, large shallow with rock, and small deep rockless: n = 1 each). Creosote was found in five pits (small shallow with rock: n = 3; large shallow with rock and large deep with rock: n = 1 each). Juniper or pine was reported for two (small shallow with rock and small deep rockless) and the large deep rockless pits had single reports of cholla, yucca caudex, tarbush, and hardwood, while a small shallow with rock feature had woody legume.

The large variety of fuel wood in so few features (small shallow with rock: n = 7; large deep rockless: n = 3), again suggests a fairly expedient approach to gathering fuel wood. Nor is there any consistency in the plant foods reported. Succulents were found in four (yucca parts in a large deep with rock and a large deep rockless, agave in a small shallow with rock, and prickly pear in a large deep with rocks). Cheno-ams were present in a small shallow with rock and a small deep without rock, mesquite beans in a large shallow with rock, and juniper in a large deep with rock. Corn was found in four (two small shallow with rock, one small deep rockless, one large deep with rock) and lipids or phytoliths in one (large shallow with rock). Burned rabbit bones, while not necessarily monitored for all of the cases examined, was present in a small shallow rockless and a small deep rockless feature.

As in the previous period, the large roasting features continued to be relatively small and shallow and fuel-use expedient. Even though these groups were more dependent on agriculture, and were mobile and more socially integrated (e.g., Miller and Kenmotsu 2004:238), they continued to exploit succulents and other native resources.

Protohistoric–Spanish Colonial

Only seven large roasting features date to the Protohistoric–Spanish Colonial period and these are spread throughout the area, with only the Tularosa area not reporting large roasting features from this period. The majority are large (71.4 percent) with rock (85.7 percent), but they vary in depth (57.1 percent shallow, 42.9 percent deep). Fuel wood was diverse and fully reported in only five of the features. A small shallow with rock had only woody legume, while a large shallow with rock had woody legume, oak, and buckhorn. The large shallow with rock feature had mesquite wood but it was not clear whether any other wood was found or analyzed. Mesquite was also reported for all three of the large deep with rock features. One also had juniper while the other two had saltbush along with either creosote or cholla and yucca. Food items reported for features dating to this period are largely succulents. The small shallow with rock feature had yucca parts along with mesquite beans and spurge. The three large deep with rock pits had prickly pear, grass, and either spurge, agave, or yucca and agave. Although the sample is small, there does appear to be a consistent association between large deep rock-filled features and succulents that could be processed in mass.

The archaeological record of sites dating to this period is relatively sparse. Miller attributes this to a settlement and subsistence pattern of low-intensity use, generally at multicomponent sites, and the features found lack associated historic artifacts. Features are often small isolated thermal types, of which about 63 percent have rock; they are generally found in interior basins (2001:122). As this study shows, the sample of Protohistoric–Spanish Colonial features has increased and these add considerably to our understanding of this time period.

Historic

The two roasting pits with historic dates include a large deep with rock feature at the Spaceport and a large shallow rockless feature from the Fort Bliss/El Paso area. The large shallow rockless feature had mesquite and woody legume fuel but no food remains were found. The Spaceport feature had a wide range of fuels (mesquite, saltbush, cholla, yucca caudex, and tarbush) and potential food plants (prickly-pear cactus, cheno-ams, grass, and aster) suggesting it was used to process large succulents.

Another large deep rock-filled feature—from the Fort Bliss/El Paso area, but from an earlier time period (it was coded as Protohistoric–Spanish Colonial)—is remarkably similar to the Historic-period one at the Spaceport. It too had a number of large thick slabs at the base; it also contained pieces of stool-leaf bases or root fragments and a small piece of metal. Fuel wood was creosote, mesquite/acadia, broomweed, and saltbush (Quigg et al. 2002:209–213).

Period Summary

Several trends are evident in the feature samples. First, large deep roasting pits comprise 38.5 percent of the earlier Archaic sample, only 7.8 percent of the Late Archaic, 7.1 percent of the Late Archaic/Early Formative sample, 20.0 percent of the Late Mesilla–El Paso sample, 42.9 percent of the Protohistoric–Spanish Colonial sample, and half of that from the Historic period. If the presence of ring-middens can be seen as a proxy for large-scaled processing of succulents, particularly agave, then this was done from at least the Early to Middle Archaic period. However, if pit size is any indication of the scale of this processing, it declined from the Late Archaic to the Late Mesilla–El Paso periods, when corn was more likely to be found and the roasting pits are more likely to be the smaller varieties.

A return to a greater proportion of large deep features in the Protohistoric–Spanish Colonial and absence of corn in this admittedly small sample of features might be interpreted as resulting from differences in subsistence behavior and a return to larger-scale processing of succulents. Plants like agave and yucca are best harvested during a relatively narrow time frame (several weeks in March or April) before they spoil. Pit roasting may be a response to this narrow window of opportunity (Wandsnider 1997:23). Groups that grew corn may not have had as much of a reason to process large succulents for storage, but instead utilized a wide range of seasonally available plants when foraging in the inter-basin areas.

Deliberate as opposed to expedient choices of fuel wood may be more characteristic of some time periods. Mesquite wood, which is long-burning with high heat, and easily split and ignited (Church and Sale 2003:132) should be the obvious choice for roasting plants that have long cooking times. Indeed, large roasting pits (1.0 m or greater in diameter) that have fuel wood reported (n = 45) usually had mesquite. Except for the Late Archaic and Late Archaic/Early Formative samples, mesquite was found in 75.0 to 100.0 percent of the large features, while those two periods have only 21.1 and 25.0 percent respectively. Fewer large features had saltbush, which is difficult to ignite and is low energy as well, but is usually abundant (Church and Sale 2003:133) (earliest to latest: 50.0, 5.3, 25.0, 62.5, 50.0, and 50.0 percent). Late Archaic features have the fewest of both of the main fuel species. Small roasting pits (n = 43) with fuel wood reported are less likely to have mesquite (25.0 to 55.6 percent; 39.5 percent for all periods) than are the large pits. Saltbush has essentially the same range of percentages but the mean is slightly lower at 37.2 percent.

Results are similar when feature depth is considered. Deep features (n = 25) are more likely to have mesquite (60.0 percent compared to 40.0 percent for shallow pits) and to have saltbush (56.0 percent compared to 28.4 percent of the 67 shallow pits). Again, it is the Late Archaic (n = 8) and Late Archiac/Early Formative (n = 4) samples from deep features that have far less mesquite than the other time periods (25.0 percent compared to 83.3 to 100 percent for the other time periods), while saltbush is relatively common (66.7 to 100.0 percent) in all but the Late Archaic samples (12.5 percent). Results are similar for the shallow pits where the Late Archaic samples (n = 33) have the least mesquite (27.3 percent compared to between 52.9 and 100.0 percent), while saltbush is relatively rare in all (ranging for 0 to 45.5 percent).

Again, it is the Late Archaic and Early Formative periods that stand out as somewhat different in fuel wood selection and again this could well be a result of a diversified diet that included corn, the use of ceramic vessels for cooking, and less processing of storable amounts of succulents.

Intra-Regional Trends in Roasting Pit Types

A brief look at the distribution of dated feature pit types within regions (Table 24.7) shows that while none of the Spaceport features are completely unique and the sample size is small (3.9 percent of the features in the dated sample), the Spaceport has

Table 24.7. Summary of large roasting pit feature type by area

	Small Shallow with Rock		Small Shallow Rockless		Large Shallow with Rock		Large Shallow Rockless		Small Deep with Rock		Small Deep Rockless		Large Deep with Rock		Large Deep Rockless		**Total**	
	Count	Row %	Count	Row %	Count	Row %	Count	Row %	Count	Row %	Count	Row %	Count	Row %	Count	Row %	Count	Row %
Spaceport																		
Late Archaic/Early	1	33.3	–	–	–	–	–	–	–	–	–	–	–	–	2	66.7	3	100.0
Late Mesilla - El Paso	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	100.0	1	100.0
Protohistoric - Spanish	–	–	–	–	–	–	–	–	–	–	–	–	1	100.0	–	–	1	100.0
Historic	–	–	–	–	–	–	–	–	–	–	–	–	1	100.0	–	–	1	100.0
Total	1	16.7	–	–	–	–	–	–	–	–	–	–	2	33.3	3	50.0	6	100.0
Tularosa Basin																		
Early to Middle Archaic	1	33.3	–	–	–	–	–	–	–	–	–	–	1	33.3	1	33.3	3	100.0
Late Archaic	2	28.6	1	14.3	1	14.3	–	–	2	28.6	–	–	1	14.3	–	–	7	100.0
Late Archaic/Early	3	42.9	4	57.1	–	–	–	–	–	–	–	–	–	–	–	–	7	100.0
Late Mesilla - El Paso	1	14.3	1	14.3	–	–	3	42.9	–	–	2	28.6	–	–	–	–	7	100.0
Total	7	29.2	6	25.0	1	4.2	3	12.5	2	8.3	2	8.3	2	8.3	1	4.2	24	100.0
SW New Mexico																		
Early to Middle Archaic	–	–	–	–	–	–	–	–	–	–	–	–	–	–	2	100.0	2	100.0
Late Archaic	15	51.7	1	3.4	6	20.7	–	–	3	10.3	2	6.9	2	6.9	–	–	29	100.0
Late Archaic/Early	1	10.0	5	50.0	1	10.0	2	20.0	–	–	1	10.0	–	–	–	–	10	100.0
Late Mesilla - El Paso	–	–	2	50.0	–	–	–	–	–	–	1	25.0	–	–	1	25.0	4	100.0
Protohistoric - Spanish	–	–	–	–	–	–	–	–	–	–	–	–	1	100.0	–	–	1	100.0
Total	16	34.8	8	17.4	7	15.2	2	4.3	3	6.5	4	8.7	3	6.5	3	6.5	46	100.0
SE New Mexico																		
Early to Middle Archaic	2	50.0	–	–	1	25.0	–	–	–	–	–	–	1	25.0	–	–	4	100.0
Late Archaic	5	23.8	2	9.5	10	47.6	2	9.5	1	4.8	–	–	1	4.8	–	–	21	100.0
Late Archaic/Early	2	50.0	–	–	1	25.0	–	–	1	25.0	–	–	–	–	–	–	4	100.0
Late Mesilla - El Paso	1	33.3	–	–	2	66.7	–	–	–	–	–	–	–	–	–	–	3	100.0
Protohistoric - Spanish	2	66.7	–	–	1	33.3	–	–	–	–	–	–	–	–	–	–	3	100.0
Total	12	34.3	2	5.7	15	42.9	2	5.7	2	5.7	–	–	2	5.7	–	–	35	100.0
Fort Bliss/El Paso																		
Early to Middle Archaic	1	25.0	1	25.0	2	50.0	–	–	–	–	–	–	–	–	–	–	4	100.0
Late Archaic	1	14.3	1	14.3	3	42.9	1	14.3	–	–	–	–	1	14.3	–	–	7	100.0
Late Archaic/Early	–	–	–	–	3	75.0	1	25.0	–	–	–	–	–	–	–	–	4	100.0
Late Mesilla - El Paso	5	50.0	–	–	2	20.0	–	–	–	–	–	–	2	20.0	1	10.0	10	100.0
Protohistoric - Spanish	–	–	–	–	–	–	1	50.0	–	–	–	–	1	50.0	–	–	2	100.0
Historic	–	–	–	–	–	–	1	100.0	–	–	–	–	–	–	–	–	1	100.0
Total	7	25.0	2	7.1	10	35.7	4	14.3	–	–	–	–	4	14.3	1	3.6	28	100.0

(Table 24.7, continued)

	Small Shallow with Rock		Small Shallow Rockless		Large Shallow with Rock		Large Shallow Rockless		Small Deep with Rock		Small Deep Rockless		Large Deep with Rock		Large Deep Rockless		Total	
	Count	Row %	Count	Row %	Count	Row %	Count	Row %	Count	Row %	Count	Row %	Count	Row %	Count	Row %	Count	Row %
Total Sample																		
Early to Middle Archaic	4	30.8	1	7.7	3	23.1	–	–	–	–	–	–	2	15.4	3	23.1	17	100.0
Late Archaic	23	35.9	5	7.8	20	31.3	3	4.7	6	9.4	2	3.1	5	7.8	–	–	67	100.0
Late Archaic/Early	7	25.0	9	32.1	5	17.9	3	10.7	1	3.6	1	3.6	–	–	2	7.1	33	100.0
Late Mesilla - El Paso	7	28.0	3	12.0	4	16.0	3	12.0	–	–	3	12.0	2	8.0	3	12.0	27	100.0
Protohistoric - Spanish	2	28.6	–	–	1	14.3	1	14.3	–	–	–	–	3	42.9	–	–	7	100.0
Historic	–	–	–	–	–	–	1	50.0	–	–	–	–	1	50.0	–	–	2	100.0
Total	43	30.9	18	12.9	33	23.7	11	7.9	7	5.0	6	4.3	13	9.4	8	5.8	153	100.0

2 of the 13 (15.4 percent) large deep with rock features and 3 of the 8 (37.5 percent) large deep rockless pits reported for the regional sample. It also has one of the two Historic large roasting pits, one of the three Protohistoric–Spanish Colonial large deep roasting pits, the only two Late Archaic/Early Formative large deep rockless features, and one of the three from the Late Mesilla–El Paso sample.

None of the Tularosa Basin sample of large roasting features dates to the Protohistoric or Historic eras and they tend to be small and shallow with similar numbers of rock and rockless roasting features in all time periods where they are represented. The same pattern is seen in the southwestern New Mexico sample, which has no Historic period samples but does have one from the Protohistoric–Spanish Colonial era, and has considerably more (nearly twice as many) features with rock, especially in the Late Archaic.

Southeastern New Mexico and the Fort Bliss/El Paso areas have more features that are large, more that are shallow, and more that are rock-filled. Regardless of time period, southeastern New Mexico has less variety in features, with most being either small shallow with rock or large shallow with rock. No deep rockless pits are found in that sample. The Fort Bliss/El Paso sample lacks small deep features and again favors the small and large features with rock, at least during the prehistoric periods. Later features tend to be large.

Roasting Pit Discussion

Other researchers have noted the definite absence of food plant remains and addressed the function of large roasting features. Describing features in the El Paso area, O'Laughlin suggests that the presence of small burned seeds in his "small fire-cracked rock features" (which ranged from 0.65 to 1.8 m diameter and 10 to 20 cm deep) was mainly unintentional, rather than indicating these large features were used for parching the seeds. Instead, he felt these features are special-purpose facilities that are consistent with ethnographic examples of features used to bake leaf succulents. He and others have noted a tendency for sites with these features to be located near playas that could contain water seasonally. They tend to occur in areas that now have soap-tree yucca, but are also more widely scattered in mesquite dune and grassland areas. Thus, he concludes that in areas away from the Rio Grande, soap-tree yucca hearts and leaf bases would have been baked or roasted in fire-cracked rock or caliche-filled features, probably in spring when yucca is in its best condition, but also throughout the year. Furthermore, the larger fire-cracked rock features near mountains would have been used for bulk processing of other leaf succulents, such as agave and sotol (1980:120–125).

Since these early observations, most contemporary analyses have relied on LuAnn Wandsnider's observations on food composition with respect to pit-hearth cooking (1997:1–48) for insight into how large roasting pits were used (e.g., Church and Sales 2003; Railey et al. 2002). Some of her most pertinent points are summarized here. Prolonged heating, as in pit-roasting, not only helps to preserve foods by eliminating the water that can work with enzymes to cause spoilage, it increases the amount of digestible material in some plants. The kinds of foods that are generally pit roasted are fatty meats and inulin-bearing plant foods (e.g., agave and yucca stems). Inulin is a form of fructan, or sweet carbohydrate, that cannot be fully digested without modification such as roasting. In general, cooking plant material is less likely to use rock than cooking animal foods. However, rocks serve as heat reservoirs that can achieve a moderate to high temperature for an extended period. Thus, pit-hearth processing of plants is predominately associated with mass processing of storable resources for storage in areas with few other intensifiable resources. For plant foods, pit roasting is almost always employed to process mass quantities for storage. Foods that are generally not pit-roasted include plants that are high in sugars and fast-release starches and lean meats—except for some rabbits and squirrels that might be seasonally fatty. Acorns, small mammals, and birds all take relatively little time to cook (up to two hours), while plants like yucca can take 15 to 30 hours and cactus buds 12 to 18 hours (Wandsnider 1997:Fig. 6). The Mescalero Apaches describe agave, stool, and yucca as "foods that had to be baked" and were relied on during droughts (Basehart 1974:60). Yucca crowns were gathered from the middle of March until the end of summer. The lower stem and leaves were peeled and baked overnight in a pit-oven (Church and Sales 2003:124).

Railey and colleagues (2002:748–753) considered thermal features excavated along U.S. 54 in Otero County as large when the diameter was 70 cm or greater; they did not consider depth because they felt that erosion and surface stripping at these sites could have removed upper portions of pits. Larger pits were considered earth ovens in their study, which would be expected to see repeated use due to the initial energy invested in digging the pits. Their roasting pits were divided into four types: without rock, lined with rock, filled with rock, or only surface concentrations of rock. They propose that the rockless pits were used to cook meat or that the rock had been removed from the pit. Rock-lined pits were what remained after some rock and the food was removed. Those with rock fill were thought to be filled with redeposited rocks that were originally stratified between food layers. Finally, Railey et al. viewed surface-rock varieties as either deflated roasting pits or rock discarded from roasting pits. They propose that changes in cooking technologies resulting from the introduction of ceramics around AD 200 would diminish the use of fire-cracked rock for stone boiling and result in fewer hearths relative to roasting pits. Finally, based on Wandsnider's 1997 findings Railey et al. propose that large rock-filled roasting pits were used for roasting plants like mescal or for roasting fatty meats, such as artiodactyl heads. They also indicate that rabbits may have been roasted when their fat content was high, but probably in smaller pits.

By incorporating a larger sample of features from diverse areas, this initial study suggests that the rock-filled and rockless features do have different functions. These co-occur at nine of the 34 sites in this sample that reported more than one large roasting feature. Furthermore, thermal properties suggest that the larger deeper pits were used to cook plants that required a longer roasting time. Nor is there good evidence that roasting features with rock decline after corn was introduced to the diet. The period with the largest proportion of rock-filled features is the Late Archaic (84.6 percent), when corn first appears, followed by the Late Mesilla–El Paso period group (52.0 percent), which was even more dependent on corn. Given the greater visibility and greater likelihood of excavation for the rock-filled features and evidence that even the latest groups continued to utilize the large succulents, it is unlikely that the introduction and use of corn is the only determining factor. It is also unlikely that these features were used to roast large numbers of artiodactyl heads. Artiodactyl bones are absent to scarce in most of these assemblages and this type of use cannot account for the presence of the large rock-filled features found in most southern New Mexico environments. Increasing the sample size for these interesting features, along with including more refined environmental variables could greatly improve our ability to understand the subsistence behavior represented by these features.

Brush Shelters (Structures or Huts)

A large shallow stain dating to the Late Mesilla phase was partially excavated at LA 111435 (Chapter 8, this report). The size (1.6 by 1.5 m) and depth (0.10 cm), along with the charcoal-stained fill containing burned grass stems and yucca parts, suggest it is the remains of an ephemeral brush structure or hut. It was placed in a dune so that the walls and floor were extremely fragile, marked mainly by burned sand and the charcoal-stained fill. While this was the only such feature excavated during this project, this same site has apparent use areas that could also be the floors of brush structures. These areas (Features 11 and 12) are in a wind-scoured area where charcoal, small pieces of fire-cracked rock, and cultural material is "trampled" into a hardened surface. Additional evidence of these ephemeral structures may still exist at this site and at LA 155963, where there is extensive evidence of use during this time period.

Similar shallow dish-shaped structures lacking prepared floors and walls have been reported throughout the southern part of the state and are generally interpreted as ephemeral brush huts or wickiups built by mobile groups. These are fairly common in Mesilla-phase sites but were used from at least the Middle Archaic, where they were small and shallow, averaging less than 2.0 m in diameter and 15 to 20 cm in depth, rarely had subfloor features, and occasionally produced daub (Miller and Kenmotsu 2004:224, 239). A brief review of many of the same reports that were used for the roasting feature section, above, along with additional reports, resulted in a sample of 40 features generally referred to as brush shelters or huts, or even small pit structures (Table 24.8). All tend to be at least slightly larger than the Spaceport feature (diameters ranged from about 1.4 to 5.6 m with a mean of 2.8 m) and ranged in depth from 0.04 to 1.0 m with a mean of 0.26 m. Fill generally was charcoal-stained with only one reported as recent sand and three that claim only charcoal flecks. Nearly half (43.6 percent) reported no features. Many are not dated (n = 14) and of those that are, most date to the Late Mesilla phase (46.2 percent of the dated structures). The others included a single from the Middle Archaic, two each from the Late Archaic/Early Formative and Early Mesilla, three were early Doña Ana, and four Doña Ana. In this small sample, those dating to the Doña Ana phase are the largest and deepest followed by those from the Late Mesilla phase, while the Late Archaic/Formative and Early Mesilla tend to be the smallest (Table 24.9).

Wood was not consistently reported but mesquite was the most common species (n = 7) followed by saltbush (n = 4) and creosote (n = 3). Unlike the large roasting features, the most common possible food item reported for these structures is burned bone (rabbit or small mammal, n = 10) followed by corn (n = 5), grass (n = 4, plus 3 dropseed), purslane (n = 4), hedgehog cactus (n = 3), prickly-pear cactus (n = 2), and yucca (n = 2).

These types of structures have long been recognized as short-term shelters, occupied for days or weeks (Carmichael 1985c:182). While the older view was that there may have been two types of groups in the area, one highly mobile and the other sedentary (e.g., Carmichael 1985c:368), many researchers now accept that the same group can build and occupy different kinds of structures. Most reports devote attention to defining the characteristics of temporary shelters occupied in the warm and cold seasons. Winter structures are expected to be occupied for longer and to contain thermal features. Structures would be larger and sites should have refuse, storage pits, and a diversity of artifact types. Those occupied during the warm season would be more ephemeral, smaller, have few or no internal thermal features, little storage, and a less diverse artifact assemblage (Church and Sale 2003:193). By that criterion, the LA 111435 structure would represent a short-term residence that was occupied during the warm season. At the same time, investigations in Area B at LA 155963 found accumulation of sherds and burned bone without any indication of structures. The amount of cultural material suggests lengthy or repeated use of this area and that residential structures are or were present.

Table 24.8. Sample of regional brush structures.

Area	Site	Feature or Structure	Dimensions (m)	Depth (m)	Fill	Features	Dates	Subsistence Plants/ Wood	Reference	Comment
Spaceport	LA 111435	8	1.5 x 1.6	0.10	charcoal-stained soil	none	AD 807–976	saltbush, yucca, purslane, hedgehog cactus, grass stems, burned small mammal bone	Chapter 8	–
Cambray Dunes	LA 135343	1	2.1 x 2.2	.10–.25	charcoal-stained soil	none	BC 60– AD 90 (mesquite)	burned rabbit bone	Jones et al. 2010: 1015-1016	–
	LA 9563	4	1.9 x .9	.02–.09	charcoal-stained soil	small pit	site: Late Archaic early formative	disturbed no samples analyzed	Jones et al. 2010: 1464-1469	–
	–	8	3.6 x 2.5+	0.04	charcoal-stained sand	none	–	disturbed; 3 small mammal - 2 burned		–
Fort Bliss	LA 97944	7A	3.0 x 2.5	0.37	charcoal-stained soil	none	AD 700–1000	–	Condon et al. 2008:149-150	–
	–	4A	4.75 x 3.75	0.54	charcoal-stained soil	none	AD 750–1000	prickly pear seed	Condon et al. 2008: 156-157	–
	–	8A	2.7 x 2.2	0.25	charcoal-stained soil	none	AD 700–1000	–	Condon et al. 2008: 158-159	–
	–	10A	2.7 x 2.2	0.10	charcoal-stained soil	2 postholes, 3 hearths	AD 770–900	–	Condon et al. 2008: 162-163	–
	–	32A	5.7 x 5.6	0.40	charcoal-stained soil	6 postholes, hearth	AD 600–850	roof fall	Condon et al. 2008: 167-169	–
	LA 97943	6	4.0 x 4.5	0.78	mottled, lightly stained	4 hearths	AD 750–1000	not burned; sunflower, mormon tea, yucca	Condon et al. 2008: 188-196	–
	–	24	4.0 x 4.5	1.00	charcoal-stained soil	1 hearth?	AD 1000–1200	prickly pear and yucca seeds	Condon et al. 2008: 198-202	–
	LA 126397	1-2	2.2 x 3.0	0.30	mottled, stained soil	none	–	tarbush, mesquite, ocotillo	Church and Sale 2003:82, 121	–
	–	3-1	3.0	0.15	mottled, stained soil	1 post	AD 570 ± 100	burned grass stems and wood; yucca residue	Church and Sale 2003:82–84, 118	–
	–	4	2.0	0.15	mottled, stained soil	ashy stain	–	burned grass stems	Church and Sale 2003:84	–
	–	6	3.0	0.30	mottled, stained soil	area of dark staining	–	saltbush, creosote, mesquite	Church and Sale 2003:84, 91, 118	–

(Table 24.8, continued)

Area	Site	Feature or Structure	Dimensions (m)	Depth (m)	Fill	Features	Dates	Subsistence Plants/ Wood	Reference	Comment
	LA 126698	1-4	3.5	0.10	mottled, stained soil	ashy deposit	AD 650 ±100	burned grass stems, burned bone, ocotilla, creosote, residue: prickly pear, chenopod, yucca, rabbit, deer	Church and Sale 2003:93 119–123	–
	–	12	3.0	0.10?	mottled, stained soil	unknown	–	–	Church and Sale 2003:101	–
	–	13	3.0	0.30	mottled, stained soil	none	–	–	Church and Sale 2003:102	–
	–	23	2.8	0.10	charcoal-stained soil	none	–	tarbush, dropseed	Church and Sale 2003:105, 122	–
US 54 Tularosa Basin	LA 6829	5	5 x 2.8	0.40	ashy midden	5 postholes, 5 pits	AD 1030–1280	burned rabbit, rodent, artiodactyl	Railey et al. 2002:141	flot remains for this site were not given by feature
	–	6	3.3 x 2.54	–	charcoal-stained soil	none	AD 900–1260	burned small mammal	Railey et al. 2002	–
	–	7	2.55 x 1.95	0.33	ashy midden	none	–	–	Railey et al. 2002	–
	–	8	2.75 x 2.5	0.06	charcoal-stained soil	none	–	–	Railey et al. 2002	–
	–	9	1.9-1.65	0.10	charcoal-stained soil	hearth, posthole	–	corn cob	Railey et al. 2002	–
	–	10	2.3 x 1.42	0.26	charcoal-stained soil	hearth	–	burned rabbit; corn cob & kernel	Railey et al. 2002	–
	–	13	2.26 x 2.5	0.29	ashy midden	none	AD 1200–1400	burned rabbit	Railey et al. 2002	–
	–	14	2.5 x 2.4	0.12	ashy midden	none	–	burned rabbit; corn cobs	Railey et al. 2002	–
	–	16	2.55x2.0	0.37	ashy midden	none	–	burned rabbit	Railey et al. 2002	–
	–	17	3.0 x 1.6	0.36	charcoal-stained soil	none	AD 1160–1300	burned rabbit	Railey et al. 2002	–
	LA 115262	1	2.1 x 1.9	0.17	charcoal-stained soil	hearth	AD 230–550	mesquite wood	Railey et al. 2002	–

(Table 24.8, continued)

Area	Site	Feature or Structure	Dimen-sions (m)	Depth (m)	Fill	Features	Dates	Subsistence Plants/ Wood	Reference	Comment
	–	2	inferred 2.75 x 2.06	unknown	recent sand	hearth?, 3 postholes, 4 pits	ceramics post AD 1060	–	Railey et al. 2002	–
	LA 128699	1	2.8+ x 2.9	0.31	ash stained	2 hearths	AD 610–880	–	Railey et al. 2002	–
	–	2	3.22 x 2.64	0.37	ash stained	1 hearth, 2 other	AD 620–880	–	Railey et al. 2002	–
	–	3	2.9 x 2.15	0.22	dark sandy loam with	hearth	2140–1920 BC and 1910–1 BC	–	Railey et al. 2002	–
Santa Teresa	LA 86774	1	3.2 x 2.95	0.30	charcoal-stained soil	rock-filled heating pit	AD 615–790	sunflower seeds, purslane, dropseed/mesquite wood	Moore 1996:148–156	–
Alamo-gordo	LA 119530	1	4.0 x 3.0	0.40	sandy loam with charcoal flecks	none; external posthole	unknown	mustard, pigweed, purslane, grouncherry, 4 wing saltbush, hedgehog cactus, globemallow, monocot stems/pinon, desert willow, mesquite, saltbush	Turnbow and Kuroto 2008	–
	–	2	3.2 x 2.4	0.23	post-abandonment with ash and charcoal flecks	hearth	unknown	–	Turnbow and Kuroto 2008	–
	–	3	4.2 x 3.5	0.24	ashy silt	hearth, small pit	early Dona Ana; AD 990–1160	mustard, purslane, yucca, corn, mesquite/creosote,	Turnbow and Kuroto 2008	–
	–	8	3.04 x 2.68	0.26	trash-filled	hearth	early Dona Ana	saltbush	Turnbow and Kuroto 2008	–
	–	6	1.8 x 2.15	0.25	loam with charcoal	hearth;, 2 postholes	early Dona Ana; AD 910–920 and 960–1180	corn, dropseed, purslane, globe mallow, hedgehog/charred brush	Turnbow and Kuroto 2008	–

Table 24.9. Brush shelter mean depth and diameter by time period.

Time Period		Depth (m)	Mean Diameter (Length x Width ÷ 2) (m)
Middle Archaic	Mean	0.22	2.52
	N	1	1
	Minimum	0.22	2.52
	Maximum	0.22	2.52
	Std. Deviation	–	–
Late Archaic/Early Formative	Mean	0.065	2.5
	N	2	2
	Minimum	0.04	1.4
	Maximum	0.09	3.6
	Std. Deviation	0.04	1.56
Early Mesilla	Mean	0.16	2.5
	N	2	2
	Minimum	0.15	2
	Maximum	0.17	3
	Std. Deviation	0.01	0.71
Late Mesilla	Mean	0.32	3.16
	N	12	12
	Minimum	0.1	1.55
	Maximum	0.78	5.65
	Std. Deviation	0.20	1.11
Early Dona Ana	Mean	0.25	2.88
	N	3	3
	Minimum	0.24	1.98
	Maximum	0.26	3.8
	Std. Deviation	0.01	0.91
Dona Ana	Mean	0.7	3.36
	N	2	4
	Minimum	0.4	2.38
	Maximum	1	4.25
	Std. Deviation	0.42	0.86
Late Dona Ana	Mean	0.24	2.34
	N	2	2
	Minimum	0.12	2.3
	Maximum	0.36	2.38
	Std. Deviation	0.17	0.06
Unknown	Mean	0.22	2.57
	N	14	14
	Minimum	0.06	1.78
	Maximum	0.4	3.5
	Std. Deviation	0.11	0.50
Total	Mean	0.27	2.83
	N	38	40
	Minimum	0.04	1.4
	Maximum	1	5.65
	Std. Deviation	0.19	0.85

25 | Addressing the Research Orientation

James L. Moore and Robert Dello-Russo

Introduction: The Theoretical Perspective

The theoretical perspective used to guide this study was presented in Chapter 4, and was described as an Ecological Landscape approach. The primary interest of this approach, as used by OAS, is developing an understanding of how human groups used different strategies and tactics to adapt to changes in landscape parameters, both environmental and human in nature. The people using the sites investigated by this study can be divided into two basic subdivisions: foragers and forager-farmers. "Foragers" covers components that exhibited use by hunter-gatherers in the Paleoindian, Archaic, and Historic periods. "Forager-farmers" includes the people known as the Jornada Mogollon, and primarily consists of Mesilla-phase components, though some evidence of use during the later Doña Ana and El Paso phases was also recovered.

Climatic variation, both long- and short-term, is a critical factor in assessing how a population could and did use a particular landscape. Another critical factor is population size and distribution on the landscape. Both of these factors must be addressed when examining changes in human adaptations and settlement systems through time, because both directly affect how people used a landscape. The interior basins of the bolsons of south-central New Mexico, including the Jornada del Muerto, are a good case in point. Permanent water sources are rare or nonexistent in the basin interiors, and water availability is therefore dependent on localized precipitation. Because of this, the basin interiors were never good locations for sedentary villages, because reliable supplies of water for drinking and growing crops were lacking. As models developed by Hard (1983) and Whalen (1994a, 1994b) suggest, villages were sited on alluvial fans along mountain peripheries at the basin edges or in river valleys (see Chapter 3, this report). Several critical resources were available in those locations, including firewood, dependable water sources, and arable land.

As populations grow, access to foraging areas can be limited by territorial constraints. However, this may not have been an important factor in access to the interior basins of south-central New Mexico, because they were not permanently occupied by anyone until the Historic period, when ranchers moved into the region. Since the basins were not available for exploitation on a yearly basis, and in fact might not have been productive for several years at a stretch, hard and fast territorial boundaries may never have been established within them. In other words, any groups with access to adjacent basin interiors may have been able to exploit them without risking conflict over their resources with others. Unfortunately, this possibility cannot be proven or disproven with data available from the current study, so we simply assume that access was unconstrained by territorial claims. We also assume that the main factor limiting access to the resources of the interior basins was climatic variation. Only when precipitation levels were sufficient to provide both drinking water and exploitable floral resources were those areas open to use. Both of these types of resources had to be juxtaposed for foraging use to occur, and both were dependent on precipitation patterns. Thus, detailed climatic data are critical to any understanding of the human use of the interior basins.

Climatic variation can also be a factor in applying optimal foraging models, at both fine- and coarse-grained scales. Fine-grained scales cover comparatively short periods of time, during the course of which variation in precipitation levels directly affected year-to-year decisions concerning where to forage and when to go there. For example, while foraging resources may be available in basin interiors in good years, they are generally not in bad years. Decisions must be based on assessment of precipitation levels and how they might have affected plant and animal growth. Coarse-grained scales take long-term climatic variation into account. Changes in plant and animal communities can occur over long periods of time in response to changes in climate, but would not have been as obvious to the human groups occupying the region because they occurred at multi-generational scales. Thus, the plants and animals available for consumption during the Folsom period were not the same as those that were available during the Mesilla phase, and this difference in availability affected the degrees of reliance on faunal versus floral resources, and what specific animals and plants were exploited for subsistence needs under different climatic regimes. As discussed in Chapter 4, Hogan (1986:57) proposed that Archaic hunter-gatherers followed a serial foraging strategy, targeting a "relatively small number of seasonally abundant resources," with their locations and productivity in a specific year constraining seasonal movement and settlement. While a number of potential foods are available in the interior basin of the Jornada del Muerto, some were more heavily exploited than others. For much of the Prehistoric period and into the Historic period, succulents appear to have filled this role in the study area, as Chapter 24 proposes, building on earlier studies by O'Laughlin (1980) and by Miller and Kenmotsu (2004). While other resources were undoubtedly also collected while foraging in the basin interior, succulents appear to have been one of the main focal points of exploitation, and excursions would have been planned around their availability.

Climate, and precipitation patterns in particular, constrained human use of the interior basin of the Jornada del Muerto in two ways. The lack of dependable, permanent water sources created one constraint on settlement, and the effects of variation in annual precipitation rates was another. In the first case, as discussed earlier, the lack of permanent water sources meant that sedentary settlements could not be established in the interior basin until the technology to excavate deep wells became available and ranchers moved into the region. In the second case, the growth and general availability of plants were dependent on the amount of soil moisture, which, in turn, was determined by annual precipitation rates. Both of these constraints had to be factored into the decision-making process by foragers, and only when sufficient supplies of drinking water and certain plant foods were available would they have been able to effectively use the study area. Thus, precipitation was the most critical factor in deciding where and when to forage in an area.

Discussion of the Precipitation Record

Climatic regimes can be discussed at several levels of detail. At the broadest level, long periods of time can be characterized by a summary of the dominant climatic characteristics for the period. At the most specific level, climatic data can be examined by year or sometimes by even shorter subdivisions. This discussion examines climate for the occupational periods represented in our study area at three levels. The climate during the Paleoindian through most of the Archaic period (prior to 0 AD/BC) is characterized at a very broad level, using data presented in Chapter 2 to summarize the climatic regimes for subdivisions of these periods. The climate for the remainder of the Archaic period through the Historic period (post-0 AD/BC) is examined at levels that are much more fine-grained. Lacking a tree-ring based precipitation record for the project area, a reconstruction of precipitation patterns for the latter period was developed using speleothem layer thicknesses from a stalagmite collected in Carlsbad Caverns as a proxy. While some variation in the actual patterning of precipitation is expected between the Carlsbad Caverns record and our study area in the Jornada del Muerto, the level of significant variation is not expected to be as high as it might be were a dendroclimatic reconstruction from more northerly locations used instead. Precipitation patterns in the study area are expected to have been similar to those exhibited by the Carlsbad Caverns record, though variation in specifics is likely. Nonetheless, this record is considered suitable for the purpose of this discussion.

The reconstruction for the period predating 0 AD/BC is shown in Table 25.1. In that table, site components are matched to climatic periods using radiocarbon dates (dated occupation) or temporally diagnostic artifacts (inferred occupation). The single Clovis component, inferred by the recovery

Table 25.1. Broad reconstruction of climatic patterns based on data presented in Chapter 2.

Date	Geologic Period	Cultural Period	Climate	Details	Dated Occupation	Inferred Occupation
10,900 BC 9,200 BC	Immediately post-glacial	Clovis to early Folsom	cooler but drier	Punctuated by 900-year period of climatic vacillations at Clovis/Folsom boundary		LA 111429
9,200 BC 8,200 BC	Younger Dryas Interval	Folsom	cooler and wetter	Lubbock Subpluvial-increased rainfall and slightly cooler temperatures around 8,900 BC	LA 111429, LA 155963, LA 155968	
8,200 BC 6,000 BC		Late Paleoindian	warming trend	cooler than average temperatures continue		LA 111429, LA 111432, LA 155963
6,000 BC 1,300 BC	Altithermal	Early to Late Archaic	warmer and dryer	punctuated by the middle Holocene Pluvial from ca 5,00–-2,600 BC	LA 111435 (F 10)	
1,300 BC 1,100 BC		Late Archaic	pluvial conditions		LA 111435 (F 3)	
1,100 BC 800 BC		Late Archaic	more arid conditions			
800 BC 340 BC		Late Archaic	pluvial conditions		LA 111435 (F 7)	
340 BC 10 BC		Late Archaic	arid conditions			

of a Clovis point from LA 111429 during initial recording (HSR 1997), reflects a period when immediately post-glacial conditions prevailed, including cooler temperatures and drier conditions, creating a savannah-like environment. Higher elevation ecotones were also elevationally depressed during this period, with forests and woodlands occurring at much lower altitudes than is the case for the region today. The Folsom components on LA 111429, LA 155963, and LA 155968 were occupied during a period that was cooler and wetter than the Clovis period, and also cooler and wetter than the modern climate. Unfortunately, since we lack radiocarbon dates for these components, they cannot be more precisely placed in a temporal-climatic framework. Nonetheless, these occupations occurred during a period when the climate was considerably more equable than its modern counterpart. A long-term warming trend began during the Late Paleoindian period, although temperatures probably remained cooler than average. Use of the study area during this period was indicated by a Late Paleoindian component at LA 111432 and the recovery of isolated projectile points from LA 111429 and LA 155963.

The Altithermal extended from the Early Archaic period to the early part of the Late Archaic period. This was a time when temperatures were elevated worldwide, and arid conditions—interspersed by short pluvial episodes—tended to prevail. Two of the three dated Archaic components reflect occupations during periods dominated by pluvial conditions, while only one reflects an occupation that occurred during a period dominated by more arid conditions.

Examining the Speleothem Record

The speleothem record from Carlsbad Caverns is based on analysis of calcite layer thicknesses for a single stalagmite (Rasmussen et al. 2006, 2008). There is a gap in this record for the years between ca. 1454 and 1592, which probably represents a long period of intense drought, so there are no thicknesses available for these years. A similar gap also occurs in the speleothem record from a stalagmite collected from Hidden Cave, also in the Guadalupe Mountains, which is missing speleothems between ca. 1389 and 1697 (Rasmussen et al. 2006, 2008). The speleothem records from Carlsbad Caverns and Hidden Cave broadly correspond in patterning, but a direct year-to-year correlation is relatively weak (Rasmussen et al. 2006:2). Since there are fewer gaps in the Carlsbad stalagmite record, only those data are used in this discussion. Comparisons made by Rasmussen et al. (2008) with Historic precipitation records and tree-ring data from the Guadalupe Mountains demonstrated that speleothem thicknesses were an accurate proxy for precipitation levels, and they are used for that purpose in the current discussion.

While layers dating between 714 BC and AD 1909 were measured for the Carlsbad stalagmite, only measurements for the years between 0AD/BC and 1909 are used in most of this analysis, the exceptions being presented later in a discussion of two Late Archaic features. Precipitation patterns were constructed at two scales. Decadal values were calculated for the years between AD 1 and 1908 to smooth the curve and allow examination of long-term trends. The decadal mean speleothem thickness was 0.0921 (standard deviation = 0.0128), with decades during which there was no speleothem growth eliminated from consideration to prevent the lowering of mean precipitation levels. Yearly values were used when examining the most precise 2-sigma date ranges for individual features. The yearly mean was calculated between AD 1 and 1909, again eliminating years when there was no speleothem growth, providing a figure of 0.0924 (standard deviation = 0.0309). For the period between 714 BC and 0 AD/BC, the mean layer thickness was 0.1124, with a standard deviation of 0.03698. Thus, in general, the years before AD 1 were somewhat wetter than were those after that date. For the entire record, the mean speleothem thickness was 0.0981 and the standard deviation was 0.03398. This is only slightly higher than the means used in analyzing the years after AD 1.

Examining Long-Term Trends in the Decadal Speleothem Record

Figure 25.1 shows the decadal curve for the post-AD 1 period. During the initial 410 years of this period, generally above-average decadal precipitation levels prevailed (ca. AD 0–410). This was followed by about 600 years of mostly lower than average precipitation (ca. AD 411–1020). Next came about 330 years of mostly above-average decadal precipitation (ca. AD 1021–1350), with drought conditions prevailing during the next 260 years (ca. AD

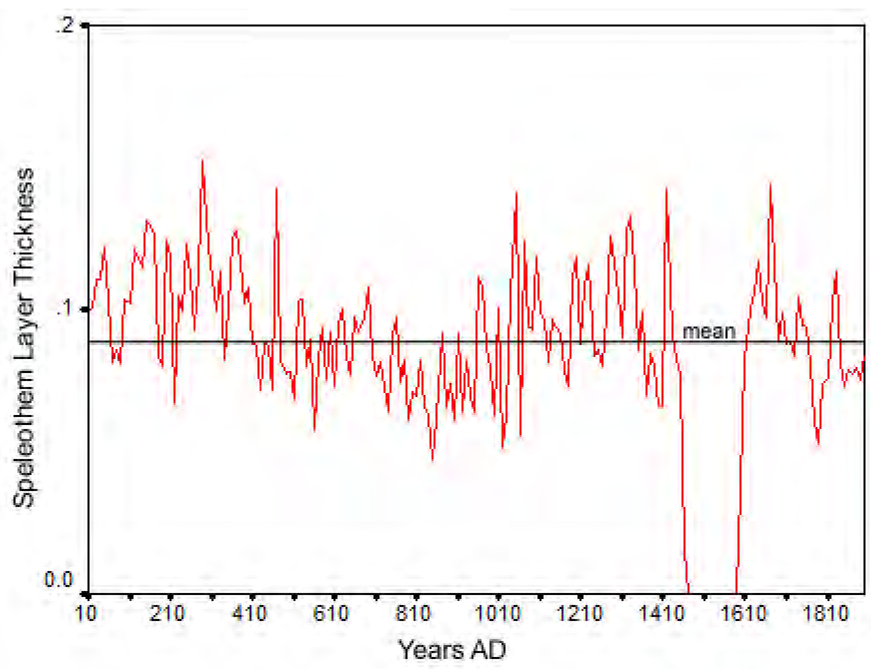

Figure 25.1. Decadal speleothem layer thickness curve for AD 1–1909.

1351–1610). This was followed by about 100 years of above-average precipitation (ca. AD 1611–1710), while the last 200 years of the curve were dominated by below-average decadal precipitation (ca. AD 1711–1908). This pattern of alternating wetter and drier conditions replicates patterning in Table 25.1 for the pre-0 AD/BC period, suggesting the continuation of long-term climatic trends. However, the variation seen within each of the periods defined for the precipitation curve in Figure 25.1 suggests that a similar level of variation probably also prevailed during the period summarized in Table 25.1.

In general, we would expect to see occupations in the study area occurring mostly during the long periods of predominantly above-average decadal precipitation. However, when examining the date ranges for the 14 features shown in Table 19.7 that date to the Mesilla phase or later, only four fall within any of those periods (Features 3 and 11 from LA 111429, and Features 8 and 9 from LA 155963), while 10 were used during periods when decadal precipitation was mostly below the mean. Thus, at this level of climatic resolution, the pattern exhibited by our data does not match the expected pattern. Decadal variation throughout the period represented in the curve tended to be high, and even within long periods of below-average precipitation there are short periods when precipitation was above the mean. The reverse also applies to periods of mostly above-average decadal precipitation where there were short intervals of below-average decadal precipitation. Thus, for our data, broad precipitation patterns are not particularly good indicators of human behavior. Our assumption is that hunter-gatherer or forager-farmer groups would have opportunistically used the study area when moisture levels were high enough to provide enough food and water to sustain them, and perhaps provide a surplus of food for long-term storage. Long-term precipitation trends do not appear to have been the motivation for exploitation of the area.

Examining the Decadal Data for Shorter Time Periods

Figures 25.2–25.5 present shorter sections of the decadal curve, with time spans representing the most precise 2-sigma date ranges for features whose dates fall within those sections of the curve also being shown. Figure 25.2 shows the decadal curve between AD 130 and 700, with the date ranges for five features falling into this period. The date range for Feature 3 from LA 111429 falls mostly within a period of above-average precipitation, while the other four features were used during periods when decadal precipitation levels were predominantly below average. In Figure 25.3, the date ranges for four features occur between AD 600 and 1000, slightly overlapping the curve shown in Figure 25.2. The date ranges for these features all occur within periods of lower than average decadal precipitation. Figure 25.4 shows the curve for the years between AD 1010 and 1460. Though decadal precipitation generally tended to be above average during this period, the date range for Feature 8 from LA 155963 falls mostly within a period of below-average precipitation. The first half of the range for Paleosol A from LA 111429 is within a period of above-average precipitation, while the second half falls within a period of below-average precipitation. The last of these plots, Figure 25.5, shows the period from AD 1600 to 1900, with Feature 11 from LA 111429 and Feature 9 from LA 155963 both falling within periods of above-average precipitation, and Feature 1 from LA 155964 and Feature 6 from LA 155963 both occurring during periods of mostly below-average precipitation. The only feature not shown in these figures—Feature 1 from LA 155963—has a date range that falls entirely within a period with no evidence of speleothem growth that is interpreted to indicate a long-term extreme drought.

These sections of the decadal precipitation curve generally tend to replicate the pattern seen by comparing date ranges for features to the broad climatic periods defined for the AD 1–1900 decadal curve as a whole: the date ranges for three features (rather than four as in the original analysis) fall during periods dominated by higher than average decadal precipitation levels, while the remainder fall into periods when precipitation was predominantly below average. While the use of decadal values smoothes precipitation curves and makes it easier to spot long-term trends, it also removes a great deal of variation that may be significant when viewed at higher resolution. Thus, a period of several decades during which precipitation levels are below average can also contain several years when conditions were better and there was more rainfall. This type of variation can be seen when yearly speleothem thickness values are examined.

Examining Precipitation Level Variation for Individual Features

Individual curves for each radiocarbon-dated feature are shown in Figures 25.6–25.18. Yearly speleothem layer thicknesses are used in each of these plots as proxies for precipitation levels, and the most precise 2-sigma date range as determined in Chapter 19 is shown as a bar at the bottom of the plot, with the midpoint marked. In instances where the midpoint is not the exact middle of the range, there were not enough speleothem data available to fully plot the 2-sigma range, so only that part of the range for which data are available is presented. The features shown in Figures 25.6–25.9 are early Mesilla phase in date; those in Figures 25.10–25.13 date to the later part of the Mesilla phase; Figures 25.14–25.15 show a feature and a paleosol that date to the Doña Ana and El Paso phases; and Figures 25.16–25.18 show features from the Historic period.

The sections of the speleothem thickness curve shown in Figures 25.6–25.18 all contain periods of variable length that reflect higher than average precipitation, even when most of the curve is dominated by years with below-average precipitation levels. The three features with date ranges that fell into periods dominated by above-average precipitation are Feature 3 from LA 111429 (Fig. 25.7), Feature 11 from LA 111429 (Fig. 25.15), and Feature 9 from LA 155963 (Fig. 25.17). The individual yearly curves for these features also reflect this, with more of these curves occurring above the mean. However, when these curves are more closely examined, Feature 9 from LA 155963 also appears to have been used during a period dominated by above-average precipitation. The individual yearly curves for the features previously categorized as occurring within periods of lower than average precipitation also reflect this classification when the yearly precipitation curves are examined, though in many cases the number of years below the mean appear to only

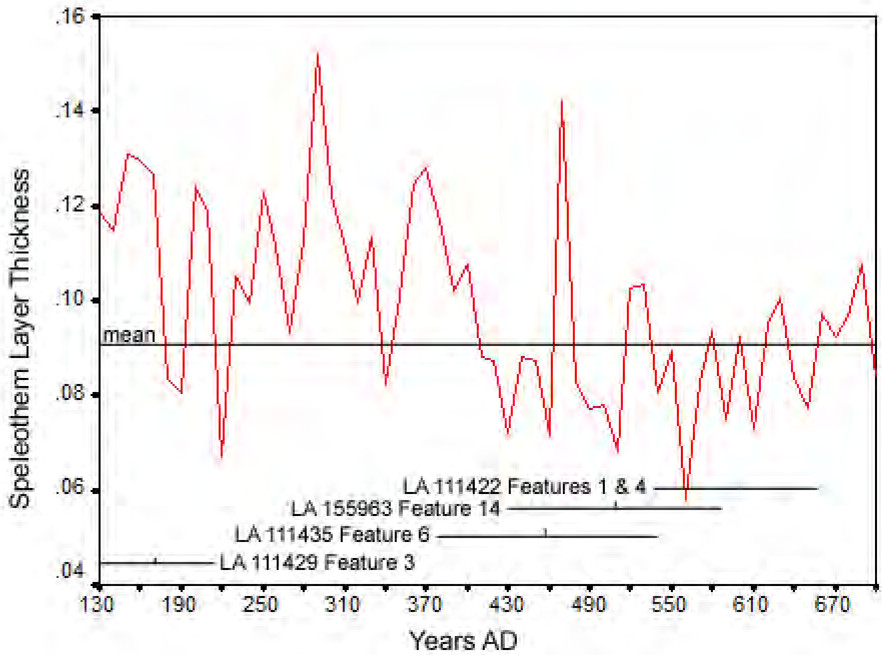

Figure 25.2. LA 111422, Features 1 and 4; LA 111429, Feature 3; LA 111435, Feature 6; and LA 155963, Feature 14: decadal speleothem layer thickness curve for AD 130–700, showing the most precise 2-sigma date ranges.

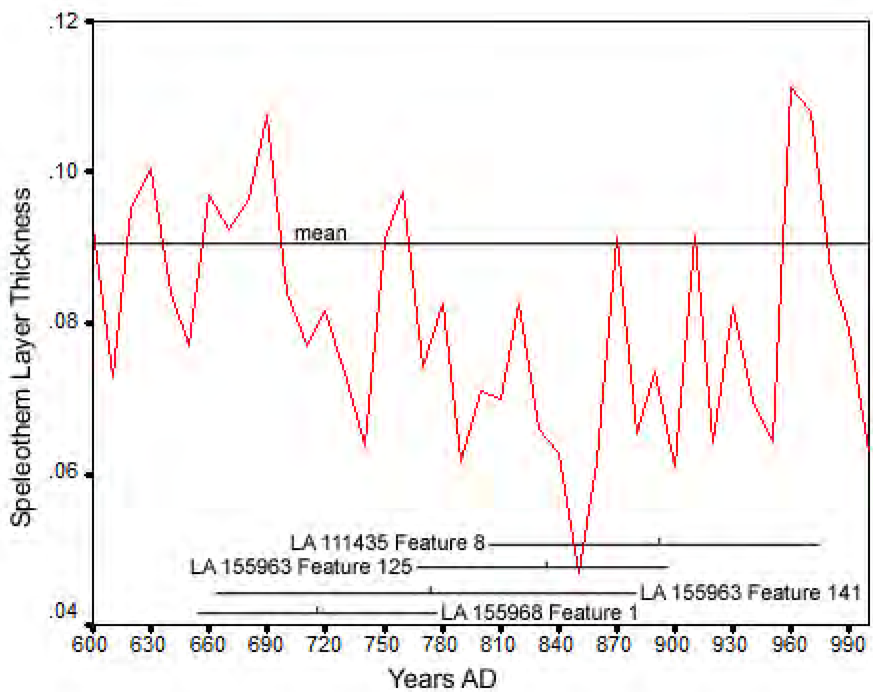

Figure 25.3. LA 111435, Feature 8; LA 155963, Features 125 and 141; and Feature 1 from LA 155968: decadal speleothem layer thickness curve for AD 600–1000, showing the most precise 2-sigma date ranges.

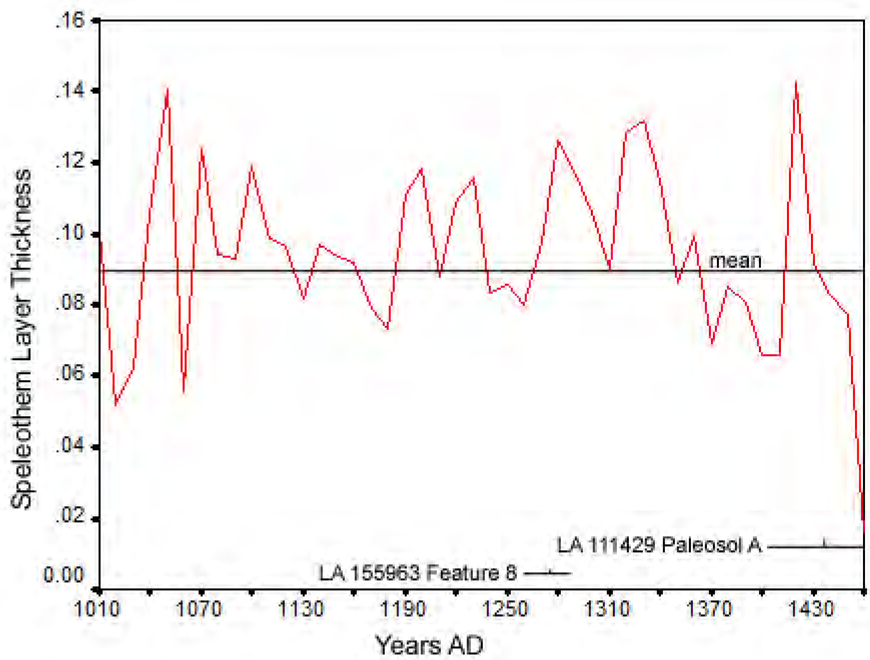

Figure 25.4. LA 111429, Paleosol A and LA 155963, Feature 8: decadal speleothem layer thickness curve for AD 1010–1460, showing the most precise 2-sigma date ranges.

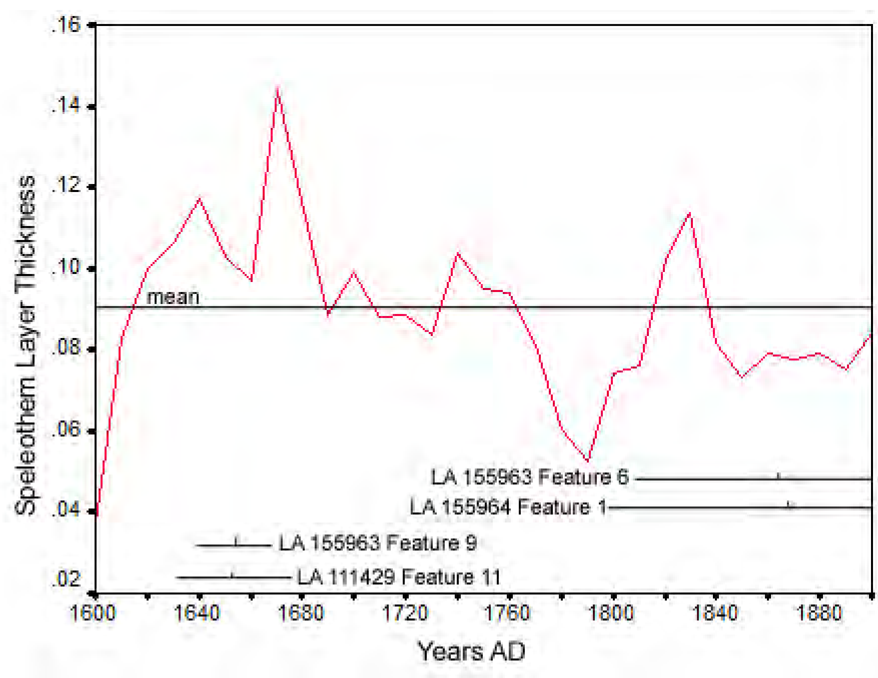

Figure 25.5 . LA 111429, Feature 11; LA 155963, Features 6 and 9; and LA 155964, Feature 1: decadal speleothem layer thickness curve for AD 1600–1900, showing the most precise 2-sigma date ranges.

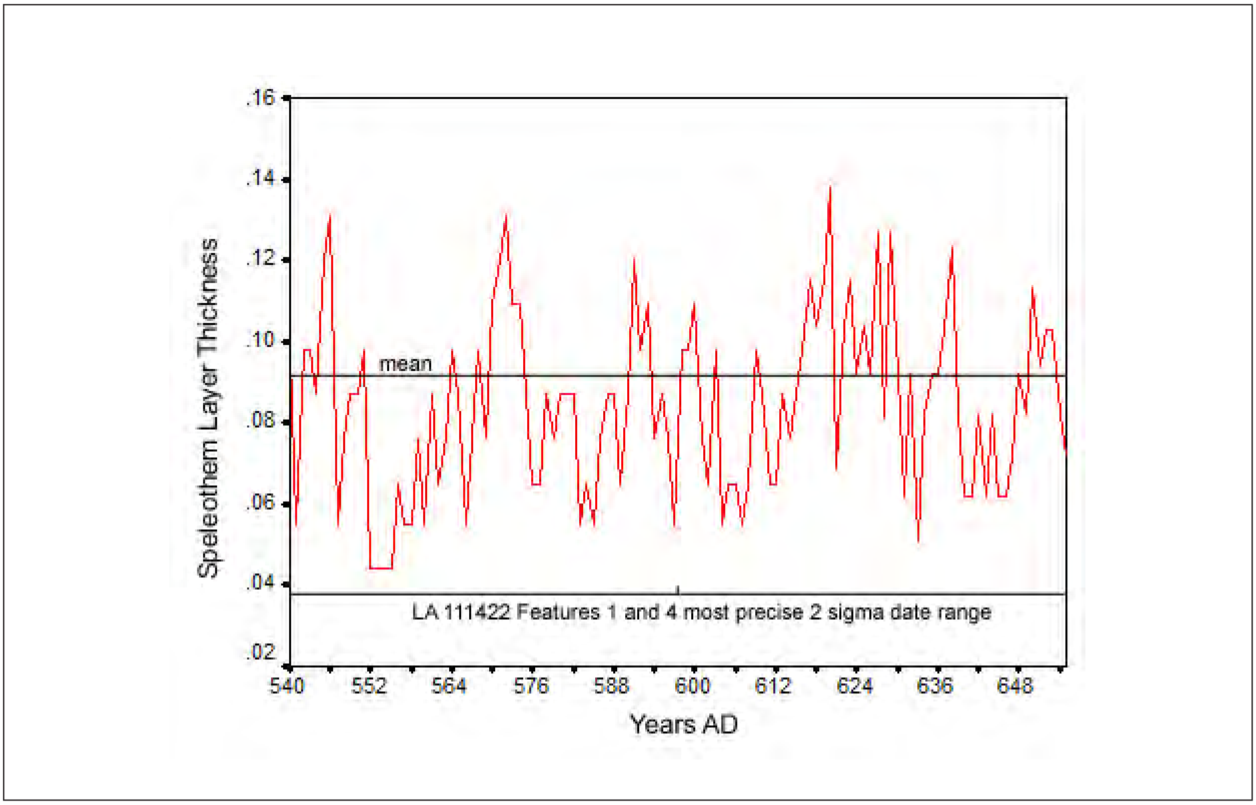

Figure 25.6. LA 111422, Features 1 and 4, yearly speleothem layer thickness curve for the most precise 2-sigma date range.

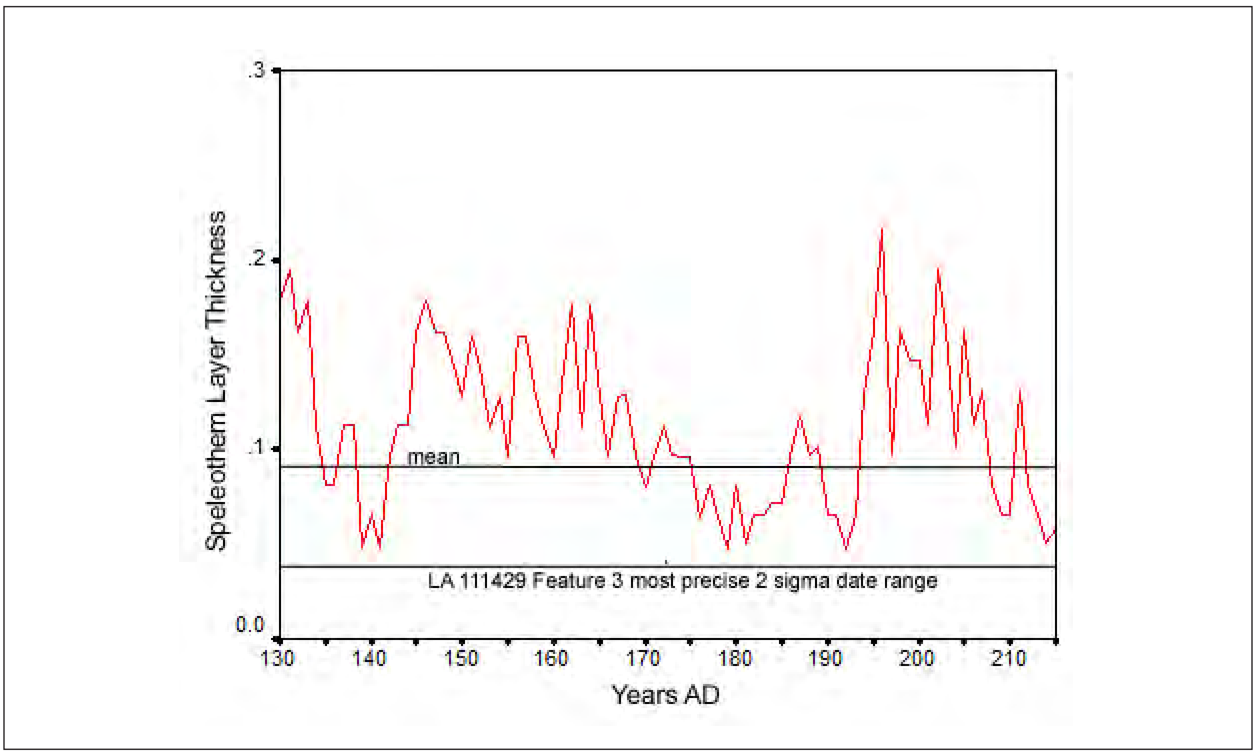

Figure 25.7. LA 111429, Feature 3, yearly speleothem layer thickness curve for the most precise 2-sigma date range.

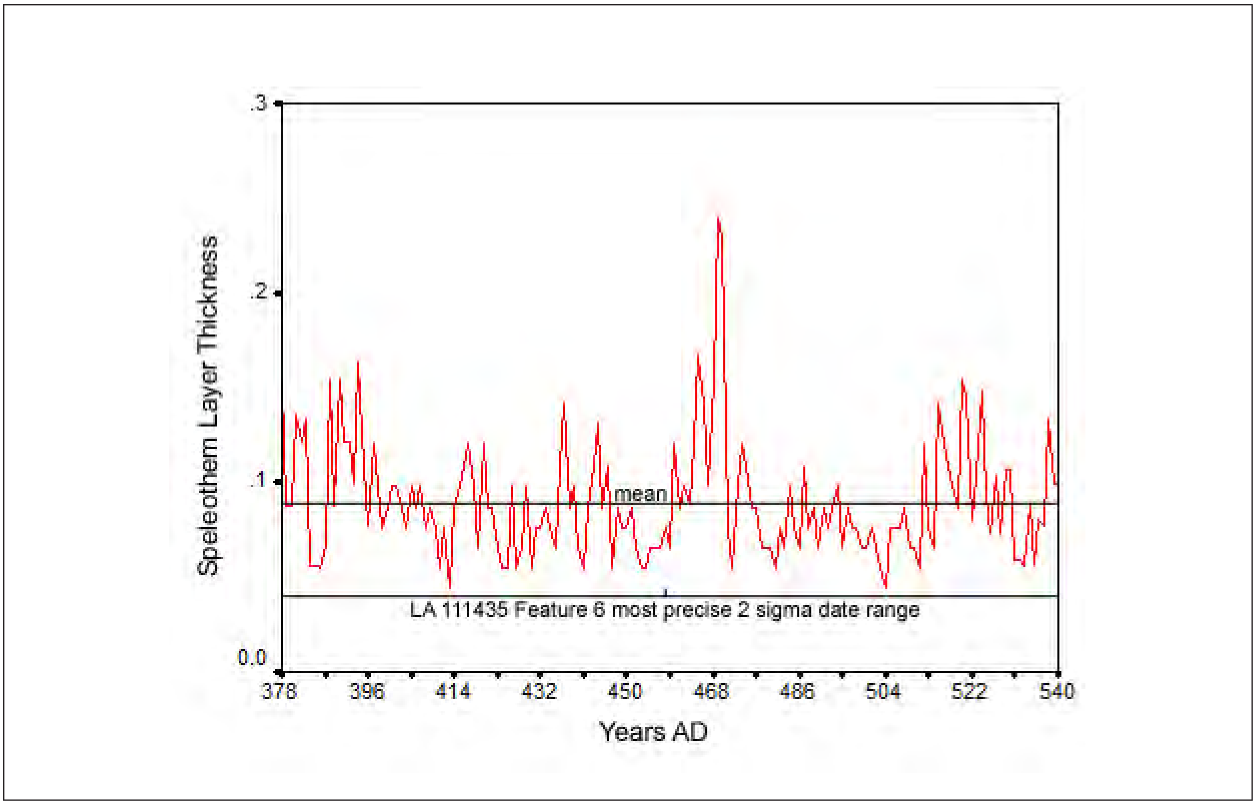

Figure 25.8. LA 111435, Feature 6, yearly speleothem layer thickness curve for the most precise 2-sigma date range.

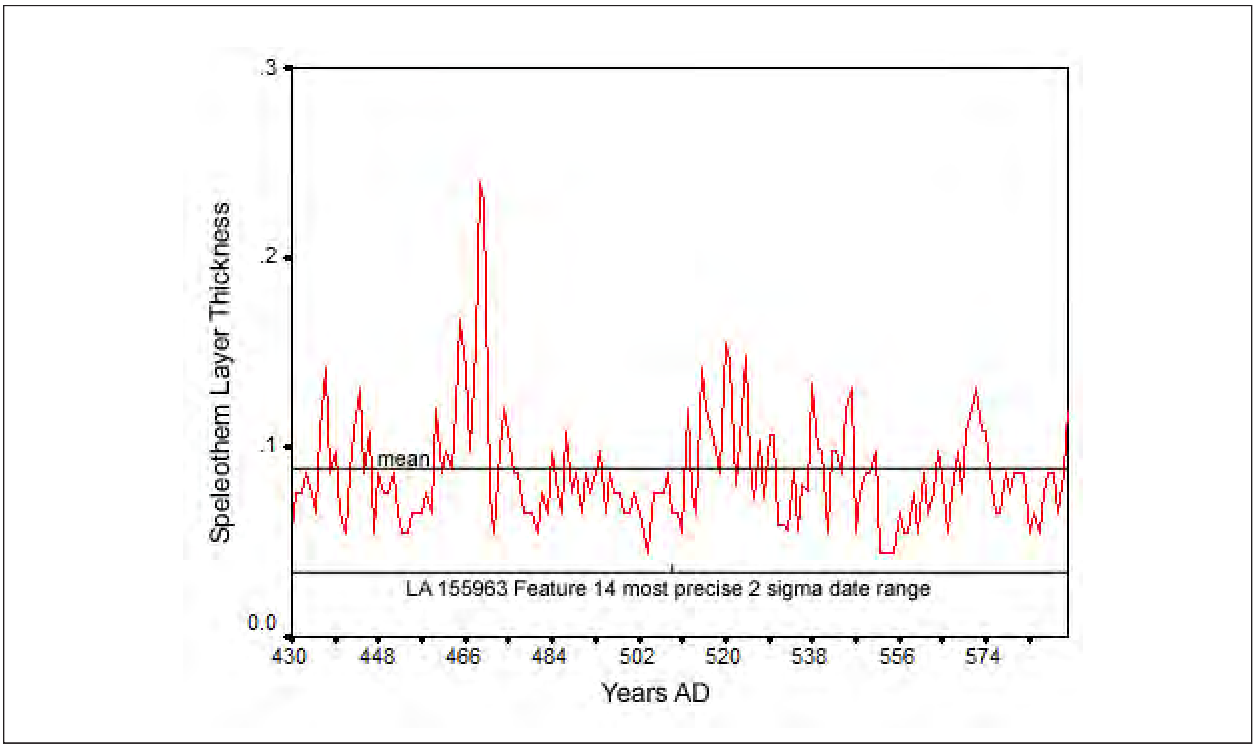

Figure 25.9. LA 155963, Feature 14, yearly speleothem layer thickness curve for the most precise 2-sigma date range.

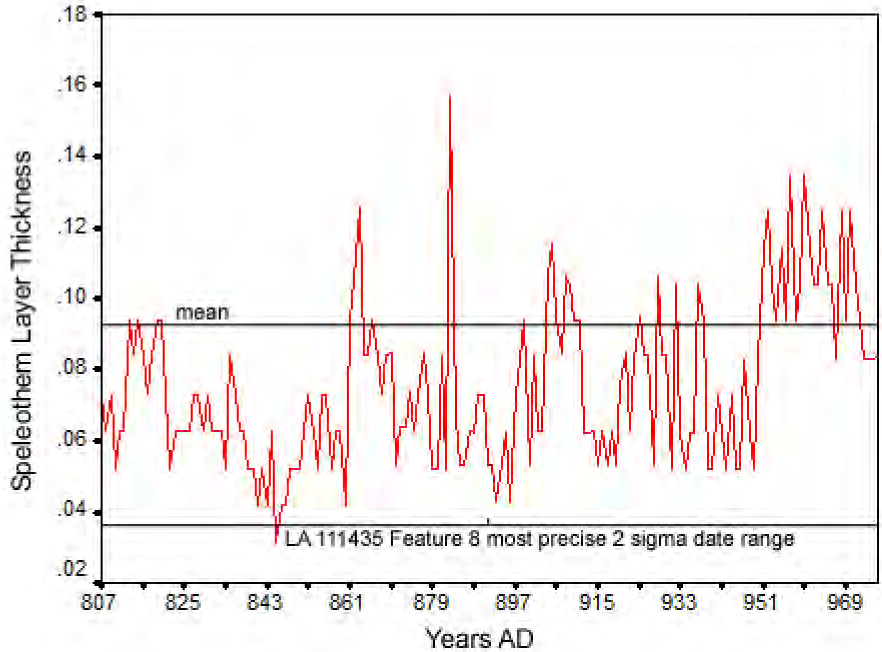

Figure 25.10. LA 111435, Feature 8, yearly speleothem layer thickness curve for the most precise 2-sigma date range.

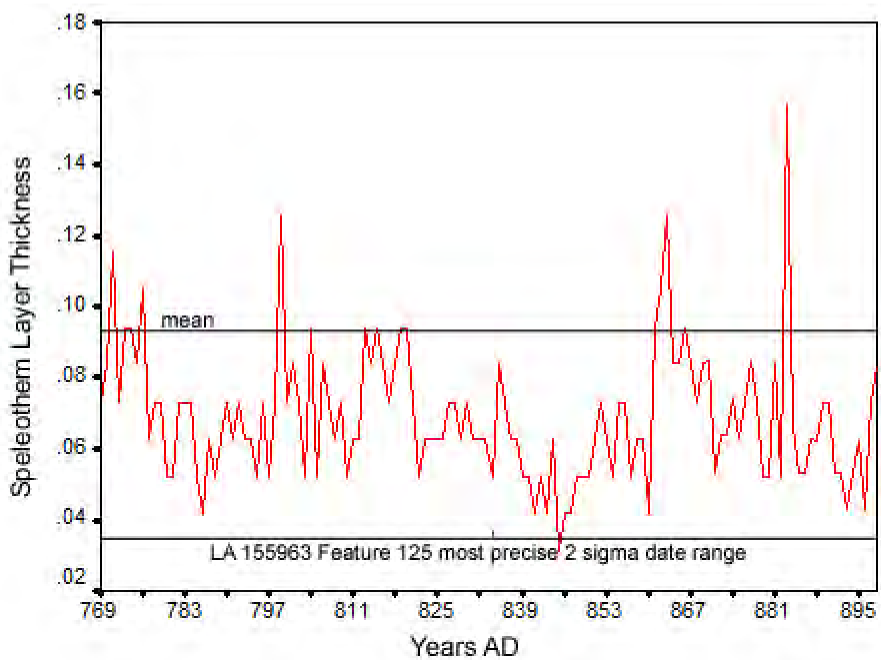

Figure 25.11. LA 155963, Feature 125, yearly speleothem layer thickness curve for the most precise 2-sigma date range.

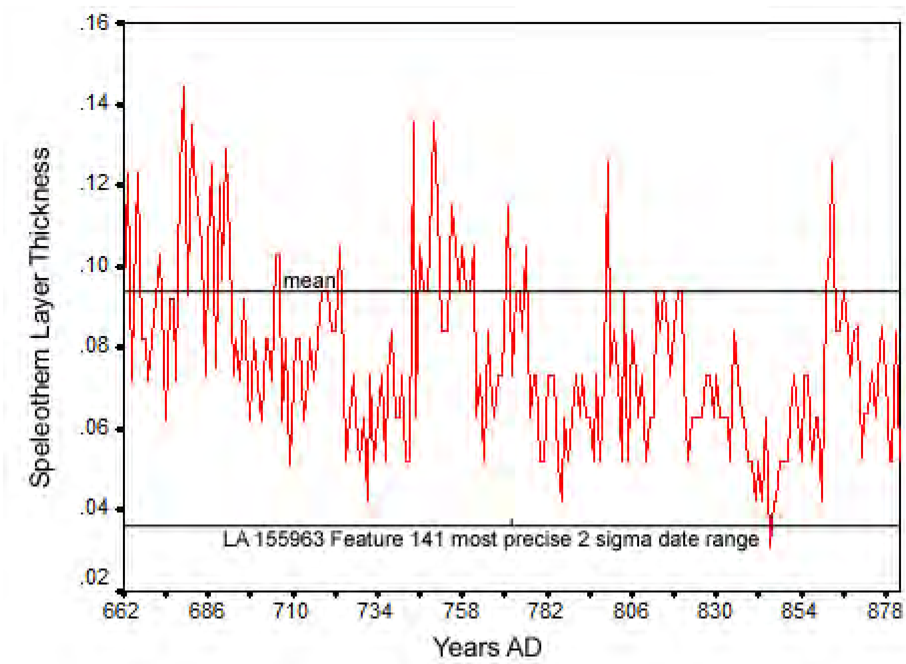

Figure 25.12. LA 155963, Feature 141, yearly speleothem layer thickness curve for the most precise 2-sigma date range.
25.12. LA 155963, Feature 141, yearly speleothem layer thickness curve for the most precise 2-sigma date range.

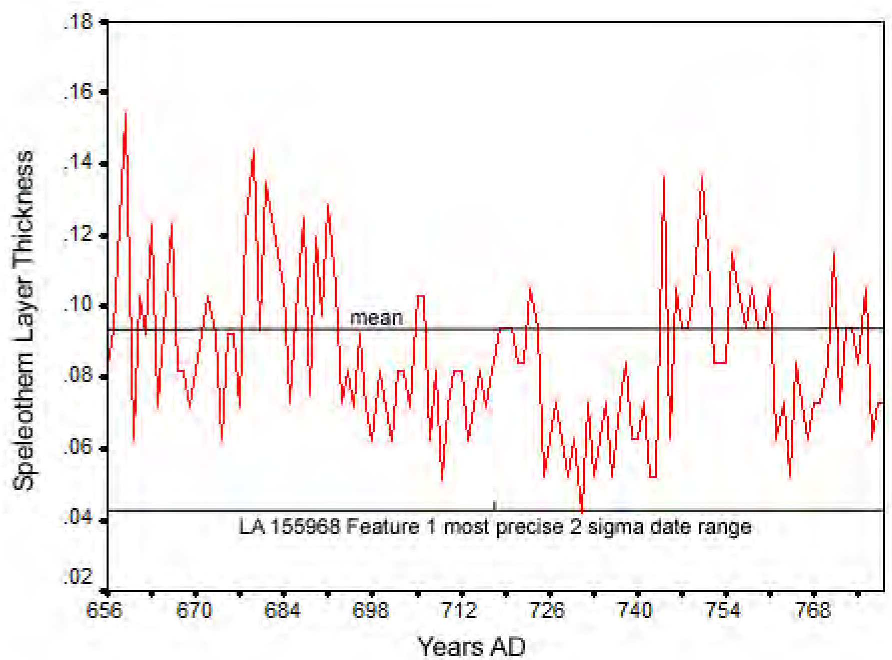

Figure 25.13. LA 155968, Feature 1, yearly speleothem layer thickness curve for the most precise 2-sigma date range.

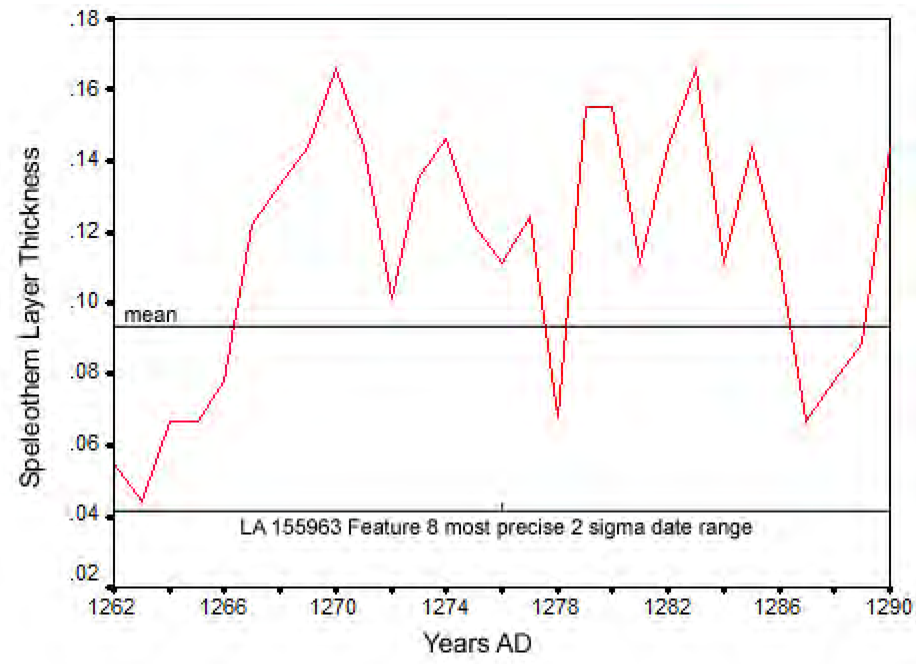

Figure 25.14. LA 155963, Feature 8, yearly speleothem layer thickness curve for the most precise 2-sigma date range.

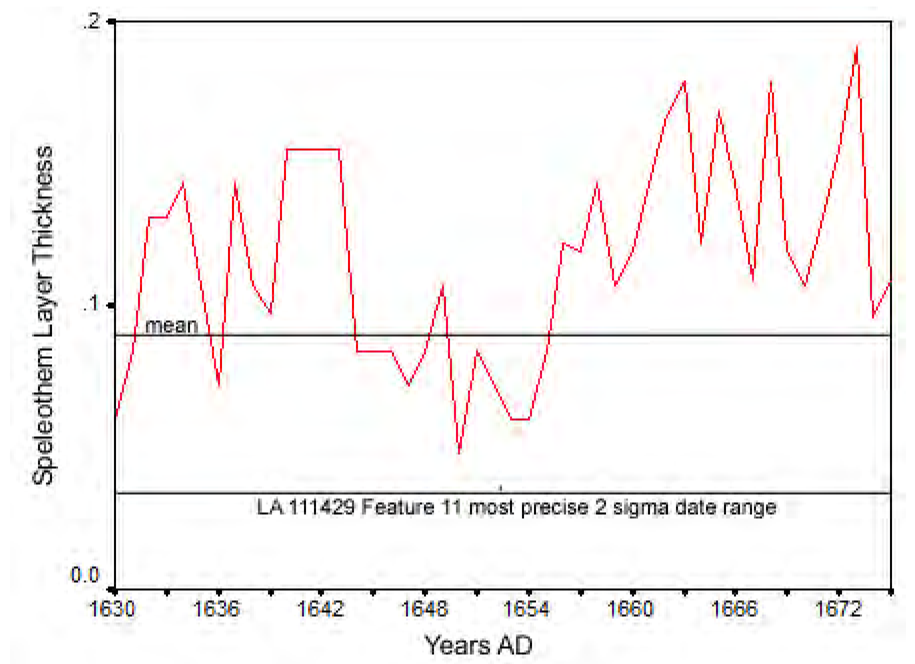

Figure 25.15. LA 111429, Feature 11, yearly speleothem layer thickness curve for the most precise 2-sigma date range.

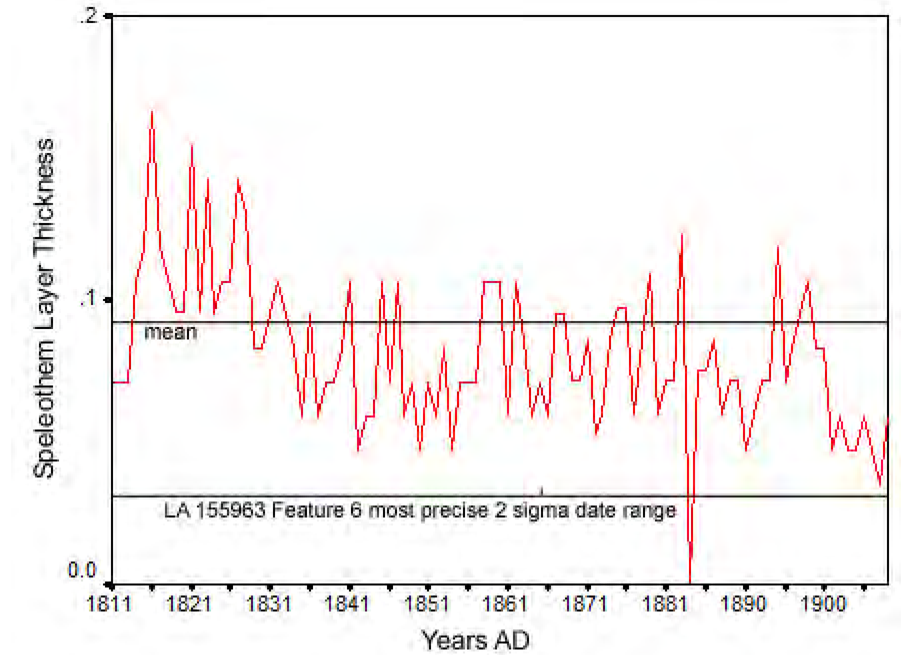

Figure 25.16. LA 155963, Feature 6, yearly speleothem layer thickness curve for the most precise 2-sigma date range.

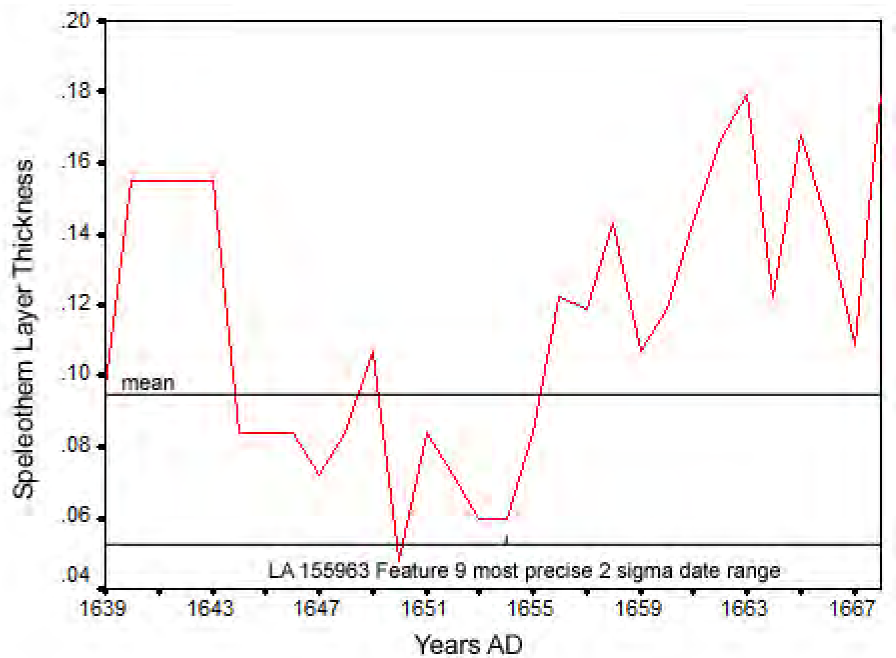

Figure 25.17. LA 155963, Feature 9, yearly speleothem layer thickness curve for the most precise 2-sigma date range.

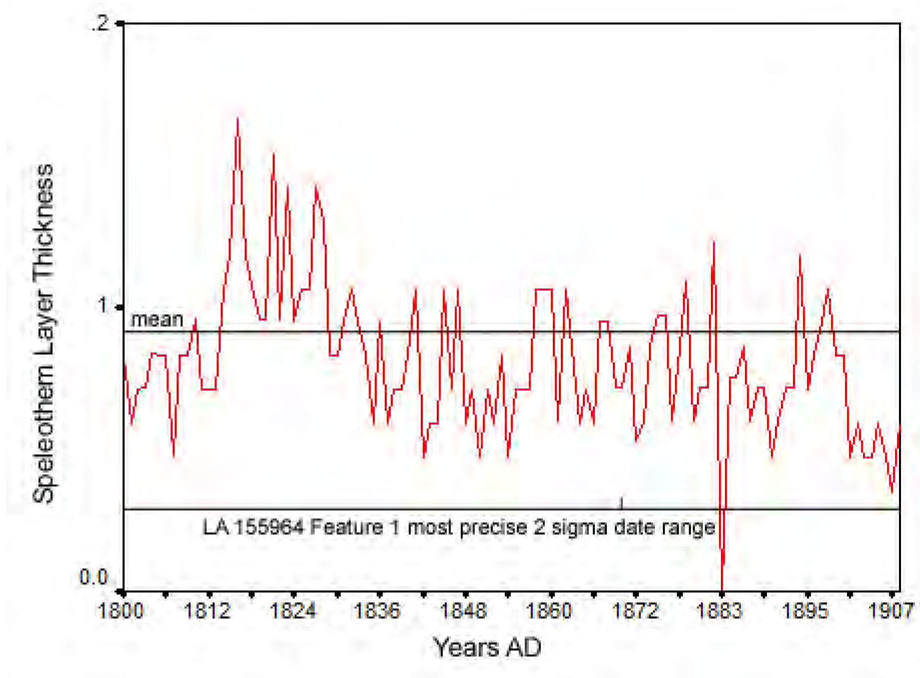

Figure 25.18. LA 155964, Feature 1, yearly speleothem layer thickness curve for the most precise 2-sigma date range.

slightly outnumber those above the mean. The most extreme cases are Feature 8 from LA 111435 and Feature 125 from LA 155963, where spikes above the mean occurred very infrequently in the sections of the curve represented.

Table 25.2 presents information on all of these features, including the number and percentage of years that fell either above or below the mean. While only slightly more than half of the years between 0 AD/BC and AD 1909 exhibited lower than average precipitation levels, nearly all of the 2-sigma date ranges for these features were dominated by years with below-average precipitation. Four features—Features 3 and 11 from LA 111429, and Features 8 and 9 from LA 155963—have ranges dominated by years of above-average precipitation. Each of these features correctly matched our assumptions during the examination of broad climatic periods at the beginning of this section, and three of the four correctly matched our assumptions during the examination of decadal precipitation trends. Since these features represent use of the study area during periods of generally good climatic conditions, little more explanation for their presence is needed. It is the other features, those whose uses appear to have occurred during periods of generally bad climatic conditions, that bear further discussion.

Examining Trends in Yearly Precipitation Levels

Decisions about whether or not to exploit an area during seasonal hunting and gathering rounds were undoubtedly opportunistic and based upon the amount of precipitation as a predictor of the availability of food and drinking water. As Hard's (1983b) model of Mesilla-phase residential patterns suggests, most foraging excursions into basin interiors probably occurred during the rainy season when drinking water was available in intermittent streams, ephemeral ponds, and natural tanks. Plant growth would also have been stimulated by the availability of moisture, which, in turn increased the availability of potential foods, but water availability was probably the limiting factor because without fresh water, basin interiors would have been unsuitable for foraging use. A single year of above-average precipitation could make the basin interiors both accessible and useable, and multiple successive years of above-average precipitation would have resulted in an even higher level of suitability for foraging.

Table 25.3 presents information on multiple successive years of above-average precipitation occurring within the most precise 2-sigma date ranges for each of the dated features. In all cases, there were multiple stretches of successive years of above-average precipitation for each feature, ranging from a low of two to a high of 13. Table 25.3 also lists the number of years in the longest stretch of above-average precipitation for the most precise 2-sigma date range for each feature. These stretches range from a low of three years to a high of 28, with the date ranges for all but two features containing a stretch of seven or more successive years of above-average precipitation. The average number of years in these stretches is at least three in all but one case, and ranges as high as 10. Once again, the four features classified as occurring during regimes of predominantly higher than average moisture levels in the examination of long-term climatic patterns using decadal speleothem layer data have the highest proportions of their date ranges made up of successive years of above-average precipitation. They also tend to have the longest stretches of successive years of above-average precipitation, and both of these factors account for their initial classification.

This analysis shows that even when climatic trends were generally bad, stretches containing successive years of above-average precipitation occurred during the date ranges defined for each of the features used during and after the Mesilla phase. These are the most likely times when the study area was targeted by foraging expeditions, because the productivity of both the plant and animal communities would have increased in response to successive years when growing conditions were better than average. These were also most likely the times when sufficient supplies of fresh drinking water were available. Overall, the date range for Feature 125 from LA 155963 contains the lowest percentage of years with above-average precipitation (11.50 percent), its longest stretch of successive years above the mean is the shortest (three years), the average number of years in stretches above the mean is the lowest (2.33), and the percentage of the date range occupied by successive years of above-average precipitation is the lowest (12.64 percent). Even so, there was one period containing three successive years of above-average precipitation within this date range. Thus, even under generally very arid conditions, brief periods occurred in which increased levels of precipitation made it possible to use the basin interiors for foraging.

Returning to the Long-Term Trends

The broad climatic periods defined in Table 25.1 were times when either pluvial or arid conditions prevailed, but where each dominant trend would have been interrupted by periods when the opposite climatic condition prevailed. Thus, as discussed above, even during the driest times there may have been short periods in which above-average precipitation prevailed. While this possibility cannot be examined with detailed data for most of the climatic periods shown in Table 25.1, data from the Carlsbad speleothem record can be used to further assess two of the broadly defined climatic intervals that occurred during the Late Archaic period (800–340 BC and 340–10 BC) when, respectively, pluvial and arid conditions prevailed. One of the Late Archaic features investigated during this study—Feature 7 from LA 111435—falls within the first of these broadly defined climatic periods and can be examined using the same methods as those applied to the features dating to the post-0 AD/BC period.

Figure 25.19 shows the decadal speleothem width curve for the years between 710 and 10 BC. Unfortunately, the period between 800 and 711 BC is not covered by the Carlsbad Caverns speleothem record. While this curve generally replicates the broad climatic periods defined in Table 25.1, there are important differences. Most of the pluvial period between 710 and 340 BC in Table 25.1 is also visible in Figure 25.19, though precipitation levels between 460 and 380 BC were mostly below average, with higher precipitation levels again prevailing between 380 and 330 BC. Arid conditions dominated the rest of the period shown in Figure 25.19, interrupted by brief periods of above-average precipitation levels. Thus, while the pluvial and arid periods defined in Table 25.1 that occurred between 800 and 10 BC are

Table 25.2. *Years above and below mean-precipitation levels for all features dating after AD 100.*

Period	Site/Feature	2 Sigma Date Range	Years Above Mean	Years Below Mean
Early Mesilla Phase	LA 111429 Feature 3	AD 130–215	59 (68.6%)	27 (31.4%)
	LA 111435 Feature 6	AD 378–540	61 (37.4%)	102 (62.6%)
	LA 155963 Feature 14	AD 430–591	50 (30.9%)	112 (69.1%)
	LA 111422 Features 1 & 4	AD 540–655	37 (31.9%)	79 (68.1%)
Late Mesilla Phase	LA 155968 Feature 1	AD 656–779	46 (37.1%)	78 (62.9%)
	LA 155963 Feature 141	AD 662–882	52 (23.9%)	169 (76.5%)
	LA 155963 Feature 125	AD 769–898	15 (11.5%)	115 (88.5%)
	LA 111435 Feature 8	AD 807–976	43 (25.3%)	127 (74.7%)
Doña Ana-El Paso Phase	LA 155963 Feature 8	AD 1262–1290	20 (69.0%)	9 (31.0%)
	LA 111429 Paleosol A	AD 1405–1470	20 (29.0%)	49 (71.0%)
Historic Period	LA 111429 Feature 11	AD 1630–1675	32 (69.6%)	14 (30.4%)
	LA 155963 Feature 9	AD 1639–1668	19 (63.3%)	11 (36.7%)
	LA 155964 Feature 1	AD 1800–1940	36 (32.7%)	74 (67.3%)
	LA 155968 Feature 6	AD 1811–1920	35 (35.4%)	64 (64.6%)
Overall pattern		**AD 0–1908**	**801 (45.3%)**	**969 (54.7%)**

Table 25.3. *Periods of multiple years above the mean for precipitation values for each dated feature.*

Site/Feature	2 Sigma Date Range	No.of 2+ Years Above Mean	Longest Stretch Above Mean	Average No. of Years in Stretches Above the Mean	% of Range in Multiple Years Above Mean
LA 111429, Feature 3	AD 130–215	6	28	9.67	68.26%
LA 111435, Feature 6	AD 378–540	13	7	3.31	26.56%
LA 155963, Feature 14	AD 430–591	12	7	3.08	22.96%
LA 111422, Features 1 & 4	AD 540–655	9	5	3.11	24.34%
LA 155968, Feature 1	AD 656–779	11	7	3.64	32.55%
LA 155963, Feature 141	AD 662–882	9	7	3.44	14.07%
LA 155963, Feature 125	AD 769–898	7	3	2.33	12.64%
LA 111435, Feature 8	AD 807–976	7	16	5.00	20.71%
LA 155963, Feature 8	AD 1262–1290	2	11	9.50	67.86%
LA 111429, Paleosol A	AD 1405–1470	4	12	4.75	29.23%
LA 111429, Feature 11	AD 1630–1675	3	20	10.00	66.67%
LA 155963, Feature 9	AD 1639–1668	2	18	9.00	62.07%
LA 155964, Feature 1	AD 1800–1940	6	15	4.50	24.77%
LA 155968, Feature 6	AD 1811–1920	6	15	4.50	27.55%

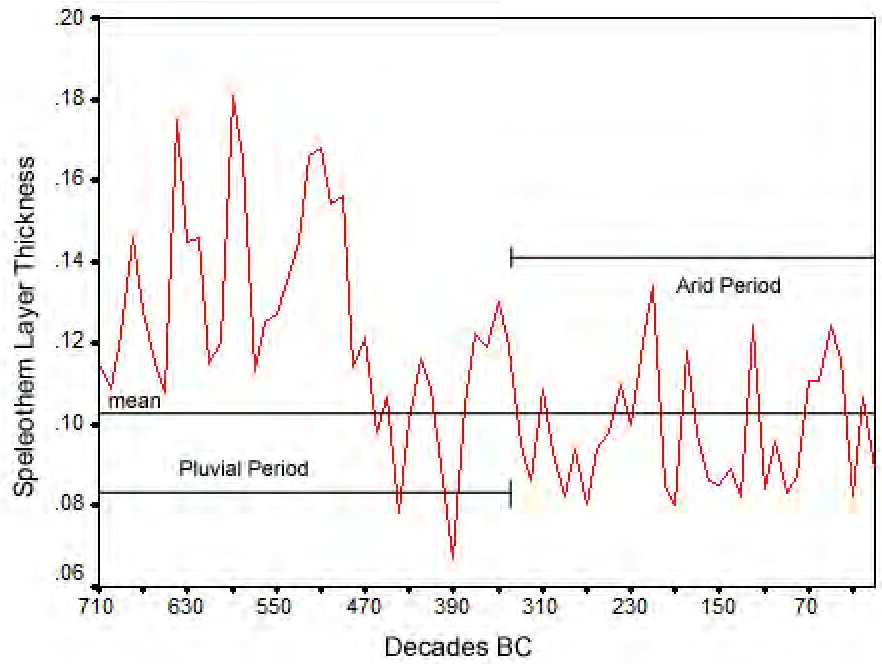

Figure 25.19. Decadal speleothem layer thickness curve for 710–10 BC, showing the broad climatic periods defined for the Late Archaic in Table 25.1.

mostly replicated in the speleothem data, there are important variations within each that disappeared when they were described in very broad terms.

These differences are evident when yearly precipitation rates for those periods are examined more closely. For example, though the climate between 800 and 340 BC is classified as pluvial in Table 25.1, precipitation rates were above the mean in only 56.1 percent of the years between 710 and 340 BC. While there were two stretches that each contained 29 consecutive years of above-average precipitation, there were also two long stretches of 18 and 19 consecutive years of below-average precipitation. Thus, while precipitation levels were generally above average during this period, arid conditions were also fairly common. In contrast, the arid period defined between 340 and 10 BC appears to have been predominantly dry, with only 26.2 percent of those years exhibiting above-average precipitation. Within this period there were 10 stretches containing 10 or more consecutive years of below-average precipitation, with a high of 27 consecutive dry years, and three stretches of 20 or more years of below-average precipitation. The longest stretch with above-average precipitation was 13 consecutive years, and there were only three stretches with six or more consecutive years of above-average precipitation. Thus, while these periods were described as pluvial and arid in Table 25.1, arid years were common in the pluvial period. While the arid period was in general bad, there were also a few stretches of comparatively good climatic conditions.

The most precise 2-sigma date range for Feature 7 from LA 111435 falls within the pluvial period defined between 800 and 340 BC. The yearly speleothem width curve for the Feature 7 date range is shown in Figure 25.20. Yearly values are generally above average through most of this period, though there are also significant periods of below-average precipitation. Indeed, 60.00 percent of the years within the most precise 2-sigma date range for this feature had above-average precipitation levels (n = 114), while below-average conditions prevailed during 40.00 percent (n = 76). There were 18

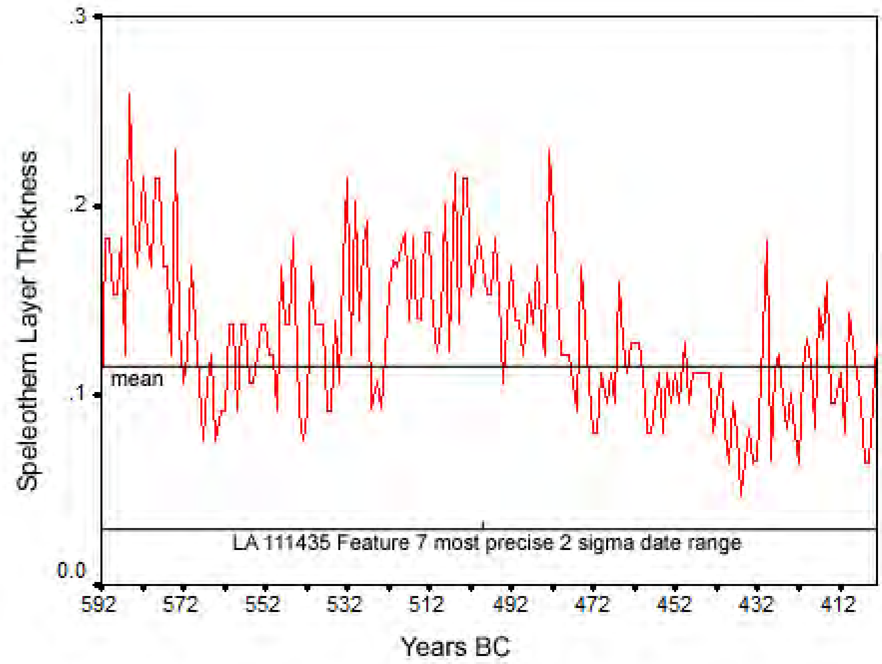

Figure 25.20. LA 111435, Feature 7, yearly speleothem layer thickness curve for the most precise 2-sigma date range.

stretches containing two or more consecutive years of above-average precipitation, the longest of which was 29 years. The average length of periods containing consecutive years of above-average precipitation was 6.00, and these periods made up 54.14 percent of the date range.

Summary

The most important conclusion that can be drawn from this discussion is that the resolutions of climatic and radiocarbon data can be quite different and attempts must be made, when evaluating past human behavior, to examine trends in both datasets at the same or similar scales. As emphasized earlier, even within periods dominated by above- or below-average precipitation there are stretches, sometimes rather lengthy, during which the opposite condition prevailed. Thus, while most human occupations in basin interiors would be expected to occur during pluvial periods, intervals during which there were several consecutive years of above-average precipitation—even in the most arid of times—could also have allowed effective use of basin interiors. Thus, when attempting to model past human occupation in basins like the Jornada del Muerto, long-term climatic patterns are not necessarily the best predictive variable. While likely that most occupations occurred during periods of above-average precipitation, those periods could have been as short as just a few years, and could have fallen within a long period of generally arid conditions.

Applying the Climatic Data to the Theoretical Orientation

Most rain in New Mexico falls in localized patterns, especially during the monsoon season. While one area could receive in excess of an inch of rain in a short period of time, another place a few kilometers away might receive none at all. Thus, yearly precipitation rates from the Guadalupe Mountains (where Carlsbad Caverns is located) are probably not directly applicable to our study area in the Jornada del Muerto. However, broad patterns in the level of precipitation as well as the type of yearly patterning seen in the record from Carlsbad Caverns undoubtedly can be applied to our study area. While the sections of the speleothem thickness curve shown in Figures 25.6–25.18 obviously do not accurately reflect the yearly precipitation pattern for those years in our project area, they do provide a good idea of what the general precipitation regime was like.

What is most striking about the patterning of annual precipitation shown by the record of speleothem layer thicknesses is its periodicity. In general, short periods of above-average precipitation alternated with short periods of below-average precipitation, and for the most part those good or bad periods tended to last for only one to a few years. Longer good or bad climatic regimes were uncommon and only occurred sporadically. Except for a 162-year-long period between 1454 and 1592, for which speleothem layers were missing from the analyzed stalagmite and which is interpreted as a long-term and extreme drought, most periods of above and below-average precipitation tended to last only a few years before cycling into the opposite regime.

As an example of this periodicity, the speleothem record for the years between AD 399 and 1001 was examined. These years were selected because they begin and end with sequences of above or below-average precipitation, and cover most of the Mesilla phase. Within this period, there were 421 years of below-average precipitation and only 183 years when precipitation was above average. The longest stretch of above-average precipitation lasted 16 years, and this was the only interval of above-average precipitation that lasted more than seven years in this 603-year-long period. In contrast, the longest stretch of below-average precipitation lasted 40 years, and there were 14 periods that contained more than 10 consecutive years of below-average precipitation. Table 25.4 shows the sequence of intervals of above and below-average precipitation for this period. For the most part, these intervals lasted between one and three years. Precipitation patterns like these suggest that there would have been little consistent use of the interior basin of the Jornada del Muerto for foraging during the Mesilla phase, and that precipitation levels were probably not sufficient for such use as much as 70 percent of the time. Sequences of short alternating intervals end in long intervals of below-average precipitation, and the longest period of above-average precipitation followed a long period when it was consistently below average.

Thus, foragers who exploited the inner basins when sufficient water and food was available had to have been keyed into their environments, with continual observation of both local and distant weather patterns. Such information could come from direct observation, interaction with other groups, or through scouting forays to see how resources looked in a certain area. All three of these strategies were probably needed in order to efficiently use areas that were unproductive or otherwise unusable most years. Knowledge of specific locations where water was available in springs or pooled when there was enough rainfall would have created sites that were repeatedly used over a long period of time. This appears to have been the case for LA 155963, which is located near La Cruz de Aleman, a "paraje," or commonly used camping location, on the Camino Real. Marshall (2013:17) indicates that there is an intermittent spring in the floor of Aleman Draw that furnished water for the nearby paraje, and it was one of the most dependable water sources in the Jornada del Muerto, despite sometimes being dry (Marshall 2013:7). This spring appears to be dependent on seasonal rainfall and runoff in the Caballo Mountains, and during favorable periods may provide water throughout the year (Marshall 2013:16) .A similar spring appears to occur near the Spaceport area in Yost Draw (Elizabeth Oster, personal communication, July 15, 2013). These intermittent water sources probably existed as early as Paleoindian times, leading to repeated occupation through time of the nearby ridge that contains LA 155963. A similar situation may have existed along Jornada Draw in the area where LA 111420, LA 111421, LA 111429, LA 111432, and LA 111435 are located, though whether that potential source was another spring or an area where water pooled is unknown. The clustering of these sites, and the multicomponent nature of several of them (LA 111429 in particular) suggests the presence of predictable water in that area as well.

While sources like the springs in Aleman and Yost Draws and the probable water source in Jornada Draw represent predictable water sources, they were still intermittent. Though these were good locations for camps, the water sources were

Table 25.4. Example of patterning in precipitation levels for the years between AD 399 and 1001.

4		**1**		**5**		**1**
1		2		1		2
7		**1**		**2**		**3**
2		1		3		1
3		**9**		**4**		**1**
1		7		3		2
1		**3**		**16**		**6**
2		6		5		1
1		**1**		**1**		**2**
1		1		1		1
1		**19**		**3**		**5**
1		2		1		1
4		**2**		**12**		**1**
5		3		1		4
1		**11**		**4**		**7**
16		2		2		1
12		**12**		**1**		**1**
2		4		2		1
4		**1**		**1**		**2**
1		2		3		2
3		**1**		**7**		**2**
1		7		2		
3		**5**		**1**		
1		1		1		
12		**5**		**1**		
4		2		3		
1		**1**		**1**		
3		1		2		
4		**1**		**1**		
1		1		4		
15		**1**		**2**		
1		3		1		
16		**3**		**17**		
1		4		1		
2		**11**		**6**		
3		2		1		
40		**7**		**2**		
2		1		1		
3		**1**		**8**		
1		1		3		
1		**1**		**2**		
1		1		7		
8		**1**		**1**		
1		2		1		
4		**1**		**1**		
1		5		1		
23		**6**		**13**		
1		1		1		

Sequence begins in lower right corner of table . **Bold**, shaded numbers denote length of intervals of below-average precipitation; unshaded numbers denote intervals of above-average precipitation.

apparently not dependable enough to sustain permanent villages or sufficient for cultivating fields. Since the Aleman and Yost springs were charged by groundwater that probably originated in the Caballo Mountains, their outflow levels would have responded to fluctuations in overall precipitation patterns, though probably not immediately. During periods of drought when regional rainfall levels were depressed, the amount of water available in the springs would have decreased and they may have even dried up during long periods of intense drought. Indeed, as Marshall (2013:316) notes, some observers found the Aleman spring to be dry when they visited it. The dates for those visits were 1726 and 1766, and both visits occurred during a long generally arid period, as shown in Figure 25.5. Thus, there is some historical evidence that indicates that the outflow of these springs probably responded to the general precipitation pattern.

For the purpose of this analysis, human exploitation of the basin interior was assumed to have been most feasible during years with above-average precipitation, and exploitation was not feasible during years with below-average precipitation. Multiple consecutive years of above-average precipitation may have been necessary to ensure that there were sufficient resources available for foraging use in many cases. This is a simplification of the actual situation, of course, but it is sufficient for this discussion. Currently, more than half of annual precipitation comes in the form of intense monsoonal storms, occurring from July through September. This precipitation regime has probably been in effect since the Early Archaic and certainly by at least the establishment of the modern climate about 4,000 years ago (see Chapter 2, this report). As discussed in Chapter 24, succulents were one of the main food resources available in the Jornada del Muerto, and were exploited from the Archaic period into the Historic period. In the case of the study area, this mainly comprised yucca, with the flowers, pods, stems, and crowns constituting the edible parts. Processing by baking in rock-filled pits allowed succulents to be consumed or stored for later use. Yucca is best for processing and eating in the spring, but can be collected and processed throughout the summer. Other plant foods like mesquite and grass seeds were probably also collected for storage, and were possibly processed in the field by parching for storage and later consumption.

Collecting yucca from an area would have exhausted the potential of that area for several years following the harvesting. *Yucca elata* stalks generally grow at a rate of about an inch a year, with growth rate dependent on the amount of rainfall (Campbell and Keller 1932). The maximum height of the plant, which includes the flower stalk, is about 2 m at 20 years, with a maximum height at maturity of 6 m (http://plants.usda.gov/java/charProfile?sumbol=YUEL).

Harvested yuccas can regenerate from the taproot and rhizome, even if the top of the plant has been removed (Young et al. 2011). In general, yucca is considered to have a slow growth rate. By removing only the tops of mature yuccas and leaving their rhizomes in place, a location could probably have been harvested every 15 to 20 years, as an estimate. Longer periods might have been required for recovery if the rhizomes were also collected, leaving only immature plants to continue growing. Thus, while the periodicity of rainfall controlled the growth rate of plants, succulents exploited in the study area, such as yucca, were probably only able to slowly re-establish themselves in harvested zones. This means that knowledge of the current state of plants suitable for exploitation was also a necessary component of the decision-making process.

Deciding whether or not to forage in an area required information on the state of local precipitation as well as that of the vegetative community. Despite their proximity to intermittent water sources, even locations that were often favored for use, like LA 111429 and LA 155963, could only have been exploited over widely spaced intervals dictated by both precipitation patterns and plant growth rates. These requirements would have led to sporadic occupations by comparatively small foraging groups residing in camps for short periods of time—perhaps at the level of a few days to a few weeks depending on the availability of both drinking water and collectible food within a reasonable distance. Locations where occupations seem to have been more intense, such as Area B on LA 155963, could indicate a different type of gathering behavior, such as repeated and more frequent uses of the location for collecting mesquite seeds rather than, or in addition to, succulents. It could also reflect longer residential duration, with logistical forays transporting food back to the main camp for processing and eventual transport to cold season villages at the edge of the basin. Both patterns could result in more intense occupation, evidenced by the relatively high artifact densities in Area BBesides the general long-term patterning of alternating pluvial and arid periods, the periodicity of much shorter intervals of above- and below-average precipitation in those general periods is critical to understanding the types of occupations reflected in our data as well as the types of yearly decisions that needed to be made about where to forage. Specific locations were only useable when precipitation levels were high enough to provide sufficient plant foods for collecting and storage, as well as water for drinking. In a desert, drinking water is a critical limiting factor. The lack of reliable permanent sources for drinking water in the interior of the Jornada del Muerto made that area uninhabitable except on a sporadic basis until modern technology permitted the drilling of deep wells. Though springs occur in certain areas, like those in Aleman and Yost Draws, they may not always flow year-round and can dry up during periods of drought, rendering them unreliable as locations for more permanent residences. An understanding of these factors together with the irregular nature of rainfall patterns in the region helps account for the short-term, sporadic, and often overlapping occupations seen in our data.

This situation has changed through time, along with the climatic regime and the types of resources being targeted for exploitation. The climate was milder at the end of the Pleistocene during the Folsom period, with cooler temperatures and higher precipitation rates. The Folsom period was well-represented in our sample of site components, with extensive occupation areas at LA 111429 and somewhat smaller components at LA 155963 and LA 155968. While we were not able to collect any subsistence-related data from the Folsom components, that population is generally considered to have been specialized hunters that mainly exploited bison herds for their subsistence needs. Such was probably the case in our study area as well. Bison bones associated with Folsom and Late Paleoindian occupations have been found in areas to the west, east, and north of the study area, including Blackwater Draw Locality 1 near Clovis (Sebastian and Larralde 1989:31), the AKE site in the Plains of San Augustine (Beckett 1980), and Water Canyon near Socorro (Dello-Russo et al. 2010). This suggests that bison also ranged through the Jornada del Muerto, at least in Paleoindian times.

Though a Late Paleoindian occupation of the study area was indicated by the recovery of several isolated projectile point fragments, the only actual component from this period was at LA 111432, and that association remains tenuous. However, the presence of isolated point fragments demonstrates that use of the project area continued into the Late Paleoindian period, a time when temperatures were warming but were still cooler than they are today. Late Paleoindians are also generally considered to have primarily subsisted by big-game hunting, and this may indicate the continued presence of bison in the region, though there is currently no good evidence for this.

Foraging decisions made during the Paleoindian period would have been based, to a large extent, on the location and abundance of large game animals. The movement of large game animals would have been dictated by the seasonal abundance of forage and water in a particular area. Considering that most of the Paleoindian remains in our sample occurred in two general areas centered on LA 111429 and LA 155963, it follows that those locations would have contained the necessary requirements for camp sites. This is particularly true for LA 111429, as suggested by evidence for repeated occupations at that site. The necessary requirements for campsites were similar to those in later time periods, including nearby water, firewood, and materials for crafting shelters and stone tools. Nevertheless, Paleoindian hunters in the Jornada del Muerto were nomadic by necessity, since they had to be prepared to respond to the movement of game that was, in turn, predicated on the availability of sufficient forage in different seasons.

The beginning of the long Archaic period saw great changes in both the climate and the associated human subsistence system. Conditions throughout the Archaic period were warmer and drier than they had been during the Paleoindian period. The large mammals that roamed through the Jornada del Muerto during the Paleoindian period were gone by this time, and the climate was probably much closer to the modern regime, as shown by the alternating intervals of above and below-average precipitation in the Carlsbad Caverns speleothem record. The beginning of the Archaic probably saw the initiation of the pattern of sporadic foraging use of the project area that was discussed above. Rather than having movement patterns conditioned by the availability of large prey animals, as was the case during the Paleoindian period, movement during the Archaic period may have been affected by the availability of plant foods which was, in turn, affected by both rainfall patterns and by what locations had been used for foraging in the recent past. Water, of course, was the primary limiting factor, both for drinking and for plant growth and availability.

Settlement in the study area remained temporary in subsequent periods due to the nature of the local environment. As discussed in Chapter 24, large roasting pits were only rarely used during the Early and Middle Archaic, but came into relatively common use during the Late Archaic, and the level of use remained about the same through the transition into the early Formative period. However, when the size of roasting pits was examined in Chapter 24, the scale of this type of processing declined from the Late Archaic into the late Mesilla/El Paso phase, picking up again during the Protohistoric and Historic periods.

These apparent decreases in the use of wild plant foods could reflect the use of corn during the Mesilla to El Paso phases, with a concomitant decline in succulent processing. The use of corn may have caused a change in the types of resources collected in the interior basins, perhaps with less attention paid to succulents and more attention to such resources as mesquite beans. However, this variation could also indicate a change in the locus of succulent processing. At Turquoise Ridge, a cold season village in the Hueco Bolson, Whalen (1994a:129) noted a difference in roasting pits between the early and late parts of the Mesilla phase. Early Mesilla-phase succulent processing appears to have been done in small roasting pits, while large roasting pits were used in the late Mesilla phase. Whalen (1994a:129) interprets this as indicating an intensification of succulent processing during the late Mesilla phase, a period when the data presented in Chapter 24 that primarily come from basin interiors suggest the reverse. This disparity could instead indicate a change in the primary processing locale from foraging camps to villages. In any case, deciding when and where to forage in the basin interior from the Archaic through the Formative periods remained dependent on the availability of drinking water and the plant foods being targeted. Successive years of above-average precipitation may have been the basis for this choice, because the potential for sufficient water (even in springs) and plant foods in a specific location would have increased with every successive good year.

The changes in roasting pit type during the Protohistoric and Historic periods, as discussed in Chapter 24, suggest a return to a lifestyle similar to that of the Archaic. However, the decision-making process undoubtedly changed during the Historic period because of the introduction of the horse. This innovation would have increased mobility and would, potentially, have permitted more frequent use of basin interiors because of decreased travel times. However, water would have continued to have been a limiting factor.

Throughout the post-Paleoindian use of the study area, the lack of dependable water determined the timing and level of occupation. Permanent villages could not have been established in the interior of the Jornada del Muerto because of this lack, and only short-term occupations were possible when and where drinking water and targeted plant foods were juxtaposed. Even springs, such as the one in Aleman Draw, were not reliable enough water sources for the establishment of villages and their related fields. Since the recharge rate and level of discharge in springs depended on rainfall patterns, they might flow for only part of a year or go completely dry during extended droughts. Thus, they were good locations for camps but poor locations for permanent residence. The decision to forage in the study area would have been based on traditional knowledge of where water would occur during good years—either in temporary pools or springs—in combination with observations of contemporary precipitation patterns, perhaps augmented by scouting expeditions to assess on-the-ground conditions. Changes in the types of plants being targeted during the Formative period may have resulted in an increased duration of camps, but foraging decisions continued to be dependent, in large part, on water availability.

By necessity, the prehistoric and historic occupants of south-central New Mexico needed to study a vast landscape, and to have a detailed knowledge of both local and regional conditions in order to make good foraging decisions because the spatial and temporal variability in precipitation patterns meant that optimal foraging locations could have changed accordingly. Information acquired through both observation and tradition played significant roles in the decision-making process. Observation entailed the study of visible weather patterns and the use of scouting forays to check the availability of both potential water supplies and potential plant foods. Tradition played a role by providing knowledge of optimal camping locations where necessary resources were juxtaposed. Tradition also served to provide memories of where and when foraging had previously occurred and where recovering succulent plant populations might again be ready for harvesting.

26 | Addressing the Research Questions

A series of research questions to be addressed was presented in the research design for this study (Chapter 4, this report). These are based on four general themes established during Section 106 consultations to guide future Spaceport undertakings (NMSA 2010). The research themes can be investigated by posing specific research questions and using the results of archaeological investigations in the project area to potentially provide answers to those questions.

Since the research questions presented in Chapter 4 were developed prior to the initiation of this study, data to address all of them may not be available. Some of the research questions have been examined in detail in other chapters, and where such is the case, any answers to these questions are only summarized in this section.

Theme 1: Development of Prehistoric and Historic Chronologies, Culture Histories, and Historic Contexts for All Time Periods of Occupation/Use in the Region

This theme is aimed at understanding how people used and adapted to a region through time. Research questions 1 and 2 were developed to address this theme. The first asks, "What are the chronologies of occupation/use for the various cultural components in the study area?" The second question asks, "Do these chronologies of site occupation fit the current regional culture-historic framework?"

Chronological controls were mainly established using radiocarbon dates for features and are discussed in detail in Chapter 19. The radiocarbon data are supplemented by examinations of temporally diagnostic artifacts, primarily projectile points, which are discussed in Chapter 14, and pottery, which is discussed in Chapter 18. OSL dates are also applied to the sediments in which archaeological remains are found, as discussed in Chapter 22. Components from five chronological periods were identified during this study and include: Paleoindian, Archaic, Formative, Protohistoric, and Historic. The Paleoindian components mainly appear to date to the Folsom period, though Clovis and some later Paleoindian projectile points were found in isolated contexts. The Archaic period is represented by Early, Middle, and Late Archaic components, as well as a component from the Archaic/Formative transition. The Formative period is primarily represented by the Mesilla phase, though additional evidence of occupation during the later Doña Ana and El Paso phases was also found during analysis of the ceramic assemblages (Chapter 18). As discussed in Chapter 9, a single Doña Ana-phase feature was also investigated at LA 155963 (Feature 8). Protohistoric and Historic components were much better represented in our study than was initially anticipated.

Paleoindian Period

The earliest evidence for human occupation reflected in our data is from the Folsom period, as indicated by the recovery of diagnostic projectile points by OAS. However, a Clovis point was found at LA 111429 during initial recording by HSR (1997), suggesting that an earlier component could also be present. OSL samples obtained from the lower section of the cover sediment (Qcs) at several sites indicate that cultural materials from that level are Paleoindian in age.

Folsom components were demonstrated for three sites by the presence of diagnostic projectile points, spurred end scrapers, and chipped stone assemblages that differed significantly from those of later occupational periods (Chapter 14). As discussed in Chapter 22, the occurrence of these materials in the lower part of the cover sediment (Qcs) supports the OSL Paleoindian date. The diagnostic projectile points in combination with the OSL dates, which strongly suggest a Folsom association, were documented at Paleoindian Areas 1 and 2 (and possibly 3) on LA 111429, Area A North on LA 155963, and at LA 155968. The most extensive remains from this period appear to occur on LA 111429, and may include much of the material eroding out of the west edge of that site, though there is mixing with materials from later periods in much of that area. The lowest artifact-bearing strata at this site in the Feature Area may also reflect a Folsom occupation related to the materials in Paleoindian Area 1, though this has not been demonstrated. A probable late Paleoindian occupation appears to be reflected at LA 111432, as indicated by an Eden-like projectile point fragment recovered during initial recording by HSR (1997). While other late Paleoindian projectile point fragments suggest occupations at other sites, none are associated with excavated areas so they provide little additional information.

All of the Folsom components and the late Paleoindian component on LA 111432 represent camps rather than kill or processing locations. This is suggested both by the amount of debitage in each location and the range of tool types, especially scrapers. In contrast, excavations at the Folsom type-site recovered very few pieces of debitage and the tools mainly consisted of projectile points rather than those used for processing (Meltzer 2006).

Miller and Kenmotsu (2004) indicate that evidence of Folsom occupations in the region tends to be more common than is the case for the earlier Clovis period, and this is certainly the case for our study area. Though HSR (1995) recorded a Clovis point base on LA 111429 during the initial recording of that site, the current study recovered no evidence for materials earlier than the Folsom period. Though Miller and Kenmotsu (2004:216) note that Folsom assemblages in the region typically contain large percentages of exotic high-quality materials, Elyea (2004) feels that most of the materials used for Folsom chipped-stone reduction in the Jornada del Muerto originated in the Rio Grande Valley, followed by more locally outcropping materials. While materials from the Folsom assemblages examined by the current study were not sourced well enough to make a similar discrimination, very few exotics were found in those assemblages. The presence of a few pieces of both Pedernal chert and obsidian suggest ties with the Rio Grande Valley, where these materials are available in gravel deposits. Our Folsom assemblages exhibit a degree of connection to Rio Grande Valley sources and little use of exotic materials. The heavy dependence on cherts for the manufacture of relatively large bifacial tools suggests acquisition of these materials in the Rio Grande Valley where nodule size is presumably larger than those seen in the local gravels, but this is by no means certain. Thus, the pattern noted by Elyea (2004) is more likely similar to the pattern in the Folsom components examined by our study, but to a degree that currently cannot be determined. However, the pattern noted by Miller and Kenmotsu (2004) is certainly not exhibited by our Folsom components.

Amick (1994, 1996) suggests that Folsom occupations in the Hueco and Tularosa basins used residential sites as bases from which to exploit game animals other than bison. The only potential information on game generated by our study was derived from blood-residue analysis (Appendix 1). Since the only protein identified by blood-residue analysis came from rabbit, including samples taken from a Folsom point and spurred end scraper from LA 111429, and a spurred end scraper from LA 155963, rabbit could have been one of the types of animals hunted at the Folsom sites in our study as well. However, because rabbit protein also occurred in one of the soil samples submitted as a control, and because all the aforementioned Paleoindian artifacts were recovered from the surface, the results of our residue analysis might suggest some degree of contamination for surface artifacts and may not, therefore, be indicative of Folsom hunting activities. Since no faunal materials were recovered that would either support or refute these results, we view them with suspicion and do not suggest that darts or spears tipped with Folsom points were used to hunt rabbits.

In our overview of the Paleoindian period in Chapter 3, we noted that most recorded Paleoindian sites are part of multicomponent locales or occur in badly eroded areas, suggesting that many Paleoindian components may have been exposed by erosion or are mixed with the remains left by later peoples who either mined the earlier sites for useable lithic materials or chose to occupy the same locations. These characteristics are certainly true for the Folsom components in our study. LA 111429 is on the east side of Jornada Draw in an area that appears to have been highly favored by people from the Folsom to the early Historic period. While LA 11429 was recorded as a single site it actually represents numerous occupation areas spanning these time periods. The west side of Jornada Draw is literally lined with sites occupied during the Archaic and Formative periods, matching many of the components at LA 111429 on the east side of the drainage. The Folsom remains at LA 111429 are primarily eroding from beneath a ridge topped with recent coppice dunes, and extend for an uncertain distance beneath that ridge.

LA 155963 also represents a collection of components from most time periods. The Folsom component at this site occupies the north end of the large low ridge, in an area overlooking Aleman Draw. Raw materials for chipped stone reduction are available in gravel beds along the edge of the ridge in the vicinity of the Folsom component, as well as along Aleman Draw. An extensive view of the area is provided from the crest of the ridge, where the Folsom component sits. While cultural materials are less dense in the vicinity of the Folsom component, evidence suggests that this part of the site was also used by Archaic, Formative, and Historic groups.

The Folsom component at LA 155968 is partly overlain by a Formative-period occupation. Since most of the Folsom materials at this site lie upon or just above the Pleistocene B substrate, this component appears to have been exposed by erosion and, as with other Folsom components, these materials appear to have been moved vertically by erosional and depositional processes. The single late Paleoindian site—LA 111432—is also in a highly eroded area. Indeed, most of the artifacts noted at this site were lying atop the pre-occupational Pleistocene B soil horizon, though a few were recovered from eolian sediments that were lying atop the Pleistocene B soil horizon and were semi-stabilized by grass hummocks.

Thus, despite the lack of intact deposits and hard dates for the Folsom components, they appear to fit the general pattern seen in the Jornada del Muerto. All four or five Folsom components on these three sites are felt to represent camps of varying intensity of use rather than resource extraction or kill locales. While there is some evidence of use during the Clovis and late Paleoindian period, that evidence is currently limited to isolated projectile point fragments that currently cannot be linked with more extensive artifact assemblages.

Archaic Period

While the long Archaic period is well represented in south-central New Mexico, it is not as well represented in our data from Spaceport America. This is because many of the dated Archaic components represent isolated features on multicomponent sites, or they were investigated during the testing phase, and the amount of data available was, thus, limited. The only sites that appear to comprise purely Archaic remains are LA 111420 and LA 111421, both of which were investigated during the testing phase. Components dating to the Early and Middle Archaic occur at LA 111420, while LA 111421 can only be assigned to the general Archaic period because of the presence of a dart point preform, as discussed in Chapter 14. While it is likely that LA 112370, LA 112371, and LA 112374 are all pre-Formative in age, this cannot be established with certainty. Similarly, aspects of the chipped stone assemblage suggest that LA 155963 Area A South represents an Archaic component, but it contained no temporally diagnostic materials so this assignment is uncertain.

Otherwise, the presence of an Early Archaic projectile point on LA 111435 could be indicative of a component dating to that period, but it could as easily have been a salvaged tool. None of the excavated features on LA 111435 date to this period. Components dating to the Middle and Late Archaic are represented at LA 111435 by Features 3 and 10 (both Middle Archaic) and Feature 7 (Late Archaic). Only Feature 3, the base of a rock-lined and filled fire pit, was an intact feature. The other two were stains, associated with fire-cracked rock (Feature 10) or in a rodent burrow (Feature 7). All three had saltbush as fuel wood and flotation samples from Feature 10 found burned goosefoot, dropseed grass, aster, and prickly-pear cactus. However, even though the main component at LA 111435 dates to the Formative period, materials from all occupations are potentially mixed because of deflation, as discussed in Chapter 22.

The Late Archaic- to Formative-period transition is represented by features on two sites including a large roasting pit (Feature 3) on LA 111429 and a stain or small fire pit (Feature 15) on LA 155963. Neither produced subsistence remains but both had saltbush and yucca caudex fuel wood. Unfortunately, in neither case were large artifact assemblages associated with these features. LA 111429 also yielded Late Archaic projectile points, and Early, Middle, and Late Archaic points were recovered from LA 155963, though none of the Archaic points from these sites were associated with these closely examined proveniences.

Though only LA 111420 contains a substantial Early Archaic component, it appears to be consistent with the pattern defined by Miller and Kenmotsu (2004) for the region. The Early Archaic date assigned during the current study is based on the recovery of a Bajada point fragment during testing. During an earlier recording phase, a Jay point and two Bajada points were found (Quaranta and Gibbs 2008), strengthening this temporal association. Miller and Kenmotsu (2004) note that Early Archaic sites differ from those of the Paleoindian period in that they exhibit the first evidence for the use of ground stone tools and rock elements in thermal features. Early Archaic projectile points also tend to be manufactured from coarser-grained materials than are Paleoindian points. LA 111420 exhibits these characteristics. Two one-hand mano fragments were noted on this site, as were fragments of fire-cracked rock (though the latter were not separately plotted and analyzed). The collected Bajada point is made from fine-grained metaquartzite, rather than a fine-grained chert as is common in Paleoindian assemblages and, in fact, the entire chipped stone assemblage from this site is dominated by metaquartzite rather than chert. An Early Archaic Bajada point was also found at LA 155963, suggesting that a component dating to this period could also occur there.

The Middle Archaic is also potentially represented by a component on LA 111420, as well as by excavated features with a few associated artifacts on LA 111435. Middle Archaic San José and Sudden Side-Notched points were found on LA 155963 in areas that were not closely examined, suggesting that Middle Archaic components may occur on this site as well. Miller and Kenmotsu (2004:223) suggest that there was a general continuity of Early Archaic settlement, subsistence, and technology into the Middle Archaic, perhaps intensifying in the latter part of the Middle Archaic. Since the Middle Archaic is not well represented in our data we can neither verify nor refute this possibility. Our results indicate that there was a Middle Archaic presence in the study area, but this observation adds little to the overall knowledge base.

The Late Archaic is much better represented in south-central New Mexico than the earlier phases of the Archaic period, and Late Archaic sites are much more common, possibly reflecting population increase (Miller and Kenmotsu 2004). However, this trend could also indicate population stability with a decreased territorial range caused by extra-regional population factors that limited the amount of territory available for exploitation, leading to more intensive use of the landscape (Miller and Kenmotsu 2004:230–236). Cultigens were first introduced during this period, but appear to have acted as a supplement to the subsistence system rather than a focus (MacNeish and Marino 1993; Miller and Kenmotsu 2004:227). Burned-rock features are more common on sites of this period, and ring middens occur in areas outside the Hueco Bolson (Miller and Kenmotsu 2004).

While there is generally a much better representation of Late Archaic sites in the surrounding region, this is not the case in the current study. The only Late Archaic date was obtained from stained rodent burrow fill rather than an actual feature on LA 111435. However, the lack of Late Archaic dates is probably due to our sampling rather than cultural processes, because artifacts diagnostic of the Late Archaic are certainly more common on some sites than these results suggest. A possible Late Archaic or early Formative point was found on LA 111429 during initial recording (HSR 1995), and at least three dart-point fragments found during research investigations probably also date to this phase. Two Late Archaic San Pedro points and an Armijo point were found at LA 155963 during research investigations, and another San Pedro point was found during initial recording (Quaranta and Gibbs 2008). In addition, several corner and side-notched dart point fragments were found on LA 155963 and probably represent other Late Archaic uses. Numerous deflated thermal features occur in Area B and the east section of Area C, most of which are aceramic and could be of Archaic origin. Unfortunately, because of heavy deflation and the consequent lack of potential for chronometric and subsistence remains, these parts of the site were not a focus of research investigations. Late Archaic projectile points were found in all major site divisions (Sections A, B, and C), suggesting heavy use of this locale during that period.

Judging from the number of Late Archaic projectile points recovered from various sites, as compared to those of the Early and Middle Archaic, there does indeed seem to have been an increase in the amount of use of the Spaceport area during the Late Archaic period. If most of the deflated thermal features mentioned above for LA 155963 were used during the Late Archaic period, there may also be evidence for an increased intensity of landscape use during both this period and, perhaps, in the Late Archaic/Formative-period transition (see below). Large roasting pits that were probably used for the bulk processing of succulents for storage occur in most regions during the Early to Middle Archaic but do not make an appearance at the Spaceport until the transition period (Chapter 24). In general, the Archaic occupation of the Spaceport area seems to mirror that seen in the region as a whole, though there are enough gaps in our data that this conclusion remains somewhat uncertain.

Radiocarbon dates suggestive of the Archaic to Formative transition were recovered from LA 111429 (Feature 3) and LA 155963 (Feature 15). The lack of pottery associated with these features could be more indicative of Archaic occupations, though the absence of pottery is not surprising given the small size of the assemblages associated with these features. However, considering the early dates it might be safer to consider these features indicative of very late Archaic use of the region

Formative Period

The Jornada Mogollon occupation of south-central New Mexico is collectively known as the Formative period. The Formative period is divided into three phases: Mesilla (AD 200/400–1000), Doña Ana (AD 1000–1250/1300), and El Paso (AD 1250/1300–1450). The Doña Ana phase is essentially a transition between the Mesilla and El Paso phases, in which small villages of semi-subterranean houses transitioned into larger above-ground pueblo-like villages, and the evolving use of agricultural products ranged from their incorporation as basic supplements to components of a diet heavy with hunted and gathered foods, to the mainstay of a lifestyle dependent on farming. Hard (1983) and Whalen (1994a, 1994b) have modeled the Mesilla-phase settlement system, indicating that cold-season villages should occur near permanent water sources and arable land. Warm-season camps, in contrast, should be found in basin interiors.

More specifically, Hard (1983) proposes that cold-season villages should have been in the mountain periphery and riverine zones, where both water and firewood would have been available. Warm-season camps should have been in basin interiors, where gathered subsistence resources were available. Exploitation of resources in the inner basins should have occurred during the rainy season, when water would have been available, and such camps are expected to have been moved whenever local resources were exhausted, perhaps on the order of every few days or weeks. When the rainy season ended in October the population is expected to have returned to the cold-season villages. The entire population is not expected to have moved to the basin interiors during the warm season, because someone would have had to remain behind to tend fields located nearby, probably the older and very young members of the village. Fields were situated near the cold-season camps because more moisture was available for plants, and because people would be available to tend the crops.

Whalen's (1994a, 1994b) model of the Mesilla-phase settlement system is less detailed, but agrees with Hard's (1983) ideas. Whalen divides the Mesilla phase into early and late parts, and suggests that the early Mesilla-phase people basically maintained an Archaic-like settlement and subsistence system, differing from the Archaic in a more intensive use of winter camps for horticulture. A major difference between the settlement and subsistence systems used during these periods is in the scale of food storage in winter camps. While Archaic winter camps exhibit some evidence of food storage, early Mesilla-phase winter villages exhibit large scale storage. Many of the foods stored at the winter camps include those collected in summer camps as well as cultigens grown there. Thus, a focus of the summer occupation of basin interiors would have been to collect surplus foods for transport to and storage in the winter village.

Whalen (1994a, 1994b) feels that this pattern persisted into the late Mesilla phase, though with some changes. Food storage at winter villages seems to have further intensified during the late Mesilla phase, as there is some evidence of a greater dependence on cultigens. There is also evidence for a reorganization of society into larger groups using the cold-season villages, and for the construction of communal structures.

Miller and Kenmotsu (2004:245) indicate that Doña Ana- and El Paso-phase sites tend to cluster on alluvial fans outside the basin interiors and nearer the surrounding mountains, with El Paso-phase sites occurring at somewhat lower elevations. Use of the interior basins declined markedly after AD 1000, though did not halt altogether. However, alluvial fans outside basin interiors and river valleys appear to have become the focus of settlement as well as subsistence activities (farming) during these phases. Since Spaceport America is located in the interior of the Jornada del Muerto basin, Mesilla-phase use of the area should have included warm-season camps occupied for comparatively short periods of time. Favored locations may exhibit dense collections of cultural materials, but should not contain structures suitable for cold season or year-round use. While use of this area may have occurred during the Doña Ana and El Paso phases, considerably less evidence for foraging in the basin interior is expected.

Some of these trends are reflected in data collected by excavations at Spaceport America. Most of the dated Formative-period components are from the Mesilla phase and include components on LA 111422, LA 111435, LA 155963, and LA 155968. Dates from two features at LA 111422, in conjunction with the ceramic assemblage from that site, suggest a Mesilla-phase occupation. Feature 1, a stain, and Feature 4, a deflated fire pit, both had saltbush and yucca caudex fuel; Feature 4 also had burned cheno-ams and cottontail rabbit bone. Two separate Mesilla-phase occupations can be suggested for LA 111435, one dating to the early part of the phase (Feature 6) and a second to the later part (Feature 8). Feature 6 at LA 111435 is a large roasting feature that contained mesquite, saltbush, and yucca caudex fuel along with yucca leaves and fiber. Feature 8, a possible ephemeral structure, was probably constructed of saltbush, yucca, and grass. Purslane and hedgehog cactus seeds were also found in these features. In addition to the dated Archaic components, this site appears to have represented a favored location during multiple occupational periods. The Formative component on LA 155968 can be dated to the middle to late Mesilla phase based on a radiocarbon sample from Feature 1, a large roasting pit. A variety of fuel wood was recovered from the feature including tarbush, saltbush, cholla, and yucca caudex. Also present were yucca stems and leaf fragments.

Similarly, multiple Mesilla-phase occupations in all areas of LA 155963 seem indicated. Feature 14, a large roasting pit in Section A, dates to the early Mesilla phase; Feature 141, a small fire pit in Section B, dates to the middle or late Mesilla phase; and Feature 125, a small fire pit in Section C, also dates to the late Mesilla phase. All three features had fire-cracked rock and mesquite and saltbush fuel. Only Feature 141 had subsistence remains including mesquite and sumac seeds, hedgehog cactus, grass, and burned rabbit bones. The character of the ceramic assemblage in Area B, with its close association with Feature 141, tends to confirm the Mesilla-phase date for this fire pit. However, when sherds from around Feature 125 are considered, the assignment of this feature to the late Mesilla phase becomes problematic. A single sherd was classified as El Paso Polychrome based on the presence of mineral paint, and three other sherds exhibit red slip that could also be indicative of an El Paso Polychrome vessel. These four sherds (of the 14 in proximity to Feature 125) suggest a Doña Ana- or El Paso-phase affiliation that is at odds with the radiocarbon dates. It is also at odds with ceramic data for nearby Surface Investigation Area 1. Since old wood does not appear to be responsible for the early radiocarbon date (fuel wood for Feature 125 is saltbush), this feature is difficult to place, temporally. Is the radiocarbon date or the ceramic date correct? If the radiocarbon date is correct, we have some of the earliest examples of El Paso Polychrome yet found, potentially either suggesting an earlier starting point for the Doña Ana or El Paso phases, or an earlier date for the polychrome type. Neither possibility can be verified using such limited data, so we must consider the dates for this feature to be an anomaly that cannot yet be explained, though the radiocarbon dates for the feature are probably more reliable.

A Doña Ana-phase occupation appears to be represented by Feature 8 on LA 155963, which has a middle to late thirteenth-century date. Other than this, the only potential post-Mesilla phase dates are based on two El Paso Polychrome sherds and two Chupadero Black-on-white sherds, all of which were recovered from LA 155963.

The Formative-period components appear to conform to some of our expectations. Most of these components date to the Mesilla phase, and appear to represent multiple short-term occupations. The smaller thermal features at LA 111422 and LA 155963 have plant remains suggesting warm-season occupations (cheno-ams, mesquite beans, hedgehog cactus seeds). However, the presence of large roasting features at LA 111435, LA 155963, and LA 155968 could indicate use of the area during spring when succulents (yucca crowns and cactus) were best for large-scale processing (see Chapter 24). The only structure found was a small hut on LA 111435 that can be dated to the Mesilla phase, which is consistent with the use of the area for warm-season camps during the Mesilla phase. While there is some evidence for later Formative-period use of the study area, the pattern exhibited appears to be similar to that of the Mesilla phase, and was perhaps even more sporadic and shorter term.

Protohistoric Period

Use of south-central New Mexico during the Protohistoric period is thought to have been similar to those of the Archaic period and the early Mesilla phase (Carmichael 1986; Kenmotsu et al. 2009, Upham 1984, 1988). This may represent a return to an earlier settlement and subsistence pattern by the indigenous population or abandonment of the region by the Jornada Mogollon and movement into the area by other groups. While evidence for the Protohistoric period is documented for the southeastern and southwestern portions of the state and the Fort Bliss/El Paso area (Chapter 24, this report), no such components had been documented for the middle Jornada del Muerto.

Two proveniences at Spaceport America have Protohistoric-period dates. Radiocarbon samples from an A-soil horizon at LA 111429 date to the fifteenth century. While the soil samples are non-cultural, they do indicate that part of the Protohistoric landscape is preserved under coppice dunes at this site. Thus, stripping the coppice dunes away could reveal Protohistoric-period occupation zones, especially since LA 111429 appears to have been a prime location for camping from the Folsom period to the early Historic period.

The second Protohistoric date is from Feature 1 in Area A North at LA 155963. This fire pit dates from the late fifteenth to early seventeenth century, so an early Historic-period affiliation is also possible. Few artifacts and no subsistence remains were directly associated with this feature, so it probably represents a very short-term camp.

The few Protohistoric-period dates recovered during this study provide little information other than to document the preservation of a landform and a single camping episode. Even so, they indicate that there is potential for finding intact Protohistoric-period components beneath later sand deposits at LA 111429 and perhaps elsewhere on the Spaceport property. Feature 1 at LA 155963 also potentially represents the first culturally associated Protohistoric-period date for the middle Jornada del Muerto. Unfortunately, these few data are not sufficient for addressing the models of settlement and subsistence that have been developed for this period, and they answer few questions.

Historic Period

While the Historic period was covered in the cultural resource overview, the main tone of that discussion was Eurocentric. This tone was set by the absence of evidence for any Native American components dating to this period during the various surveys or testing phase. Given this absence, we believed we were unlikely to encounter deposits dating to this period. When several features were dated to the early Historic period it came as a great surprise. These features included Feature 11 at LA 111429 and Feature 9 on LA 111563, both of which were dated to the seventeenth century. In addition, Feature 6 on LA 155963 and Feature 1 on LA 155964 both probably reflect early nineteenth-century use, even though their dates span the nineteenth through the mid-twentieth centuries. This conclusion is based on the lack of associated metal and other Euroamerican artifacts, which should have become more common and more easily obtained after the opening of the Santa Fe Trail in 1821, when trade with the United States began. Feature 6, a disturbed fire pit, and Feature 9, a stain, at LA 155963 are located in Area A North. Fuel wood in Feature 6 was monocot stems while that in Feature 9 was mesquite and saltbush. The only subsistence item was charred goosefoot seeds in Feature 9. The other two features—Feature 1 on LA 155964 and Feature 11 on LA 111429—are large rock-filled roasting pits. The earlier one, Feature 11 at LA 111429, had fuel remains mainly consisting of mesquite wood with some saltbush, cholla, and yucca caudex. Subsistence remains tend to favor a late summer occupation as they include cheno-ams, dropseed, and prickly pear fruit. However, they also include prickly pear pads and yucca stalks and leaves, a possible indication of spring succulent processing. Feature 1 at LA 155964 produced a similar array of plants, including a cactus pad, amaranth, aster, grass, and yucca leaves and stalks, suggesting both spring and late summer occupation. Fuel was mesquite, yucca caudex, and tarbush.

These components probably better fit the Protohistoric template discussed in Chapter 3 for the Apache. Baugh and Sechrist (2001:272–273) note that Protohistoric Apache components often occur on sites that mainly belong to different cultures and time periods, and are often discounted as evidence of occupation during the Protohistoric period. Seymour (2002) feels that the Protohistoric period is under-recorded in the region because it has not been recognized. This may well be the case with the Historic-period feature identified at LA 155964, which contained an abundant chipped stone assemblage that evidenced an expedient reduction trajectory, a characteristic of the Cerro Rojo (Apache) complex defined by Seymour and Church (2002). However, other characteristics of the Cerro Rojo complex were not encountered.

While the Historic-period components could also reflect Apache occupations and a continuation of the settlement and subsistence systems that prevailed during the Protohistoric, there is currently no way to link these components to a specific cultural group. These components do not fit the characteristics expected for the Historic period, since they lack associated Euroamerican artifacts, but they are undisputedly present. Like Protohistoric sites, those belonging to Native American groups dating to the early Historic period are under-represented regionally in the archaeological record (Kenmotsu et al. 2009). This is most likely because, like LA 155964, they closely resemble prehistoric components unless temporally diagnostic artifacts are present. When there are no temporally diagnostic artifacts, these sites tend to be classified as prehistoric by default. Only by dating them chronometrically can they be distinguished from sites of the prehistoric period.

The Historic component on LA 155968 is, on the other hand, a completely different matter. A single chipped stone tool—a strike-a-light flint—was identified at this site, and is the only evidence of a Historic-period use. Whether any of the other chipped stone artifacts from this site are associated with the strike-a-light flint is unknown, but this possibility is considered unlikely. In all probability, the strike-a-light flint represents a tool that was discarded by a Spanish traveler along the Camino Real.

In general, the prehistoric components fit into the temporal and land-use schemes already in use for the region. The finding of several features resembling those used during prehistoric occupations yet indisputably representing Historic-period use of the region were the surprise, and are indeed rare in southern New Mexico. While it is likely that the historic features are more common than previously reported, only one other large roasting feature dating to this period was encountered in reports reviewed for Chapter 24, suggesting they may not, in fact, be that common. A unique set of circumstances, such as the isolation of the central Jornada del Muerto, may have attracted these groups and provides an avenue for future research in the area.

Theme 2: Interaction of Settlement, Land Use, Access to Scarce/Desired Resources, and Subsistence Practices in the Region for All Time Periods and All Cultures

This theme explores the role that critical resources played in settlement patterns and land use. Water is considered the most critical resource and is, thus, thought to have had a major role in conditioning land use patterns. Other major factors in conditioning land use patterns include access to tool stone and, during the Historic period, access to manufactured goods. The presence of abundant desert succulents that could be processed in bulk, fuel wood, and of arable land, could also have factored into the selection of site location.

Research questions 3 through 6 were posed to address this theme. Research Question 3 asked how site locations and types vary according to the availability of water through time. Research Question 4 asks the same question of other critical resources. Research Question 5 asks if there is evidence for either continuity or changes in land-use patterns through time and between regions. Research Question 6 asks what site-structure analysis can tell us about occupational patterns through time.

The first three of these questions can be addressed together. For the most part, site locations appear to have been selected to allow access to multiple types of critical resources at one time. Sites of all periods literally line the sides of Jornada Draw north of Prisor Hill, exhibiting evidence of use during the Paleoindian, Early Archaic, Middle Archaic, Late Archaic, Mesilla, and early Historic periods. The juxtaposition of intermittent water in the draw and raw materials for chipped stone and ground stone tool manufacture on and around Prisor Hill undoubtedly made this a prime location for camps. Occupations primarily appear to have been on the dunes and sand sheets that occur above the floodplain on both sides of Jornada Draw—areas that would have supported growths of native grasses, yucca, mesquite, and other plants that provided foods.

A similar situation pertains at LA 155963, the largest site recorded in the study area that contains evidence of occupation during all periods from the Folsom period on. Several resources are juxtaposed in this location to make it a prime spot for occupation. Water would have been available seasonally in Aleman Draw to the west of the site and possibly in springs just west of the site boundary.

The role of water in a desert environment was addressed by Quaranta and Gibbs (2004:409) in reporting the results of survey at Spaceport America. They note that site density is often greater along streams owing to the scarcity of surface water in the region. The availability of moisture along stream courses helps to support a higher diversity of plants, thereby providing a habitat for small animals and attracting larger game in search of food or water. Since water courses act as a draw for game. Camps tended to be located a distance from water sources to avoid scaring off game, but near enough to allow access to surface or well water. For example, the San of the Kalahari locate their camps within half a km of a watering hole to avoid scaring off game (Yellen 1976). The Ngatatjara of western desert Australia locate their camps about 75 m from a water source for the same reason (Gould 1968). Thus, in most cases we would expect sites to be located within easy walking distance of a water source, but not right at the source.

Significant rainfall tends to occur during the summer monsoon season (July to September at Aleman Ranch) and often falls as intense thunderstorms, causing intermittent watercourses to run and leave puddles and sometimes playas in low spots on the landscape. Summer monsoons also usually stimulate plant growth since this is one of the few times during the year when enough moisture is available to sprout seeds and permit plant reproduction. This suggests that one of the main uses of the study area—at least from the middle Holocene onward—could have been during the summer monsoon season and directly thereafter, when both water and fresh plant growth were available. However, use during the spring to exploit succulents is also likely. The presence of relatively abundant stands of soaptree yucca and scattered prickly-pear cactus could have attracted Holocene era groups needing to process quantities of these desert succulents for storage. These plants are best harvested and processed in large roasting pits during spring (March and April; see Chapter 24). As long as water was available, and this includes underground flow in arroyos that could have been tapped by shallow wells, people would have been able to reside in this area.

Kelly (1995:126–127) notes that water availability is often a more critical factor in camp location in a desert than are foraging conditions. Foragers will at times sacrifice foraging efficiency rather than move away from a reliable water source. Foragers who are tethered to water sources may be willing to forage further from their camp than are those that are not so restricted. This type of tethering can be seen in the archaeological record. In an analysis of Archaic settlement patterning on the CGP lease area in northwestern New Mexico, Moore (1980:364) calculated that 84.6 percent of the Archaic sites were located within one km of a water source and 69 percent were within half a km.

This discussion points out the importance of water to settlement patterning in a desert environment. All of the sites investigated along Jornada Draw—LA 111420, LA 111421, LA 111422, LA 111429, LA 111432, LA 111435, LA 112370, LA 112371, and LA 112374—are situated within about 0.6 km from the aforementioned draw. Most of LA 155963 is within one km of Aleman Draw, as are LA 155964 and LA 156877. LA 155969 is about 2 km from Aleman draw, while LA 155968 is a bit farther than 2 km from Jornada Draw. While the latter two cases seem anomalous, water could have been available in small intermittent drainages or puddles that were closer to these sites. This is also a possibility in the case of LA 155963. At least one fairly large intermittent stream drains the interior of this site, starting near the crest of the escarpment and proceeding to the southeast. The most heavily occupied part of this site, including most of Area B, is adjacent to this interior drainage, suggesting its ancillary importance to site selection. However, a marshy area just to the west of the site could also have been a factor, even though modern modification to enhance that area is likely.

Other critical resources are also available in the areas where sites cluster. As discussed in Chapter 23, raw materials for chipped stone reduction are available in gravel deposits along the northwest edge of LA 155963, at Prisor Hill a kilometer or two from the cluster of sites along Jornada Draw, and in gravel beds along Aleman Draw less than one km west of LA 155963. These areas also contain rock suitable for other purposes as well, such as ground stone manufacture and as thermal elements. Numerous types of igneous rocks are available at Prisor Hill, including vesicular basalt. Caliche is available at the north end of LA 111429, and both caliche and limestone nodules are available at LA 155963. As noted earlier, plant growth tends to be denser along watercourses so, in addition to plant foods, fuel wood can also be collected there. Fuel wood may also have been more common at the north end of LA 155968 where a layer of caliche creates an impermeable barrier to moisture, holding it nearer the surface where it is accessible to plant roots. This is currently the case, with comparatively dense growths of mesquite and creosote occurring at the north end of LA 155963. Retrodicting the prehistoric situation is difficult, because the exact timing for the movement of mesquite and other desert plants into the region is uncertain (by the early Mesilla phase at least), and modern cattle ranching has obscured vegetation patterning. Large-scale vegetation community reorganizations also occurred during the transition from the Late Pleistocene (Paleoindian era) to the early Holocene (early-to-middle Archaic period).

Especially for the Folsom components, visibility (for game observation to facilitate hunting) may have also been an important factor in site location choice. The Folsom component at LA 155963 is located at the crest of the escarpment this site occupies, providing a wide view in all directions. Similarly, the Folsom components at LA 111429 occupy a comparatively high location with a wide view to all but the east. That this parameter was probably important during other occupational periods at these sites as well is suggested by the multicomponent nature of these areas on both sites.

Thus, rather than a single resource, site locations selected for most of the Spaceport America sites reflect the availability of several critical resources in juxtaposition. This accounts for both the density of cultural remains along Jornada Draw and at LA 155963, as well as the multicomponent nature of many sites. The same parameters appear to have been important throughout the history of human use of this section of the Jornada del Muerto, at least for the type of use reflected by the sites examined in this study.

Rather than attempting a site-by-site and feature-by-feature analysis of site structure we argue simply that all visible components on the smaller sites (LA 111422, LA 155964, LA 155969, LA 155969, and LA 156877) and the intensively investigated parts of the larger sites (LA 111429, LA 111435, and LA 155963) represented camps used for varying durations and for varied tasks. Ethnographic examples of task specific locales and camps of very limited duration demonstrate that evidence of these uses are obscured within a few years of their use (Campbell 1968; Gould 1971; Peterson 1971) and that we are unlikely to find this in the archaeological record. Our conclusion that parts of the Spaceport America sites investigated by this study represent the remains of camps is supported by evidence for the performance of a range of activities in which chipped stone tools were either manufactured or used and the presence of thermal features in most cases. In other cases, where thermal features were not preserved, fragments of fire-cracked rock indicate that one or more such features had originally been present. Evidence for the use of thermal features for heating, cooking, or roasting occurred on Spaceport sites dating from the Early Archaic through the Early Historic period, with only the Folsom occupations in doubt for this function. However, this is not because there was no fire-cracked rock associated with the Folsom components but, because of extensive and repeated deflation of sediments in those areas, the fire-cracked rock found there could not be conclusively linked to those earliest occupations.

While we assumed that evidence of task-specific locales and camps of short duration would have been obscured by natural processes within a few years of use, this may not actually be the case. The variety of dates from scattered features on LA 155963 that span the Archaic through Historic period suggests that evidence for task-specific locales and short-term camps may be available from this site, in areas where repeated occupations of variable duration have not created a palimpsest of mixed materials that can obscure the actual patterning of cultural remains. Several of the thermal features excavated by this study appeared to be isolated with few associated artifacts, suggesting very short-term use. While Section B on LA 155963 may also contain evidence for multiple repeated uses of variable duration and purpose, a combination of heavy use through time and deflation has scattered and mixed materials in that area, making it difficult or impossible to decipher their meaning. Similarly, at the level of examination conducted by this study, evidence of task-specific locales and camps of limited duration may also exist at LA 111429 but was not identified. Further excavations at this site may recover more detailed site structural evidence related to individual occupations, but the areas investigated by this study were either extensively eroded or too small to provide the detail needed for this sort of study.

In some cases, our ability to complete a detailed site-structure analysis was limited by the discovery of multiple components in areas initially assumed to represent a single use (the western sections of LA 111435, LA 155964, LA 155968, and LA 156877). In these instances, separating the features and assemblages associated with each occupation was tentatively accomplished, when possible, but that did not provide sufficient reliable data for a detailed structural analysis. Other sites appeared to represent single components (LA 111422 and LA 155969), but patterning was obscured by erosion.

Thus, the absence of detailed site-structure analyses does prevent some definition of site function. Most components appear to represent camps of variable duration. No evidence of long-term or permanent residence was found in any component, despite the often dense deposits of cultural materials. The only structure identified was an ephemeral hut, which is consistent with the pattern of short-term occupation suggested for these sites. While large-scale surface stripping could potentially locate one or more pit structures indicative of longer durations of stay during the Formative period, this is considered highly unlikely in light of the lack of sufficient amounts of available water through most of the year, and the usual presence of winter villages along the periphery of the interior basins rather than in the middle of the basins.

Theme 3: Military History, Encompassing Native American Military Activities as Well as Spanish, Mexican, and American Military Actions and Settlements, Including Historic Forts and Camps

The research design anticipated a lack of data that could be used to address this theme, though a single question was posed. Research Question 7 asked whether there is evidence of an Apache presence in the project area that can be tied to concurrent military activities.

The answer to this research question is that there may be evidence of such activities, but our study did not recover any data that could directly link archaeological deposits to Spanish, Mexican, or American military activities in the region. While components dating to the Historic period were identified, date ranges are too long to permit us to confidently suggest a direct connection to any known military campaign. Indeed, looking at the character of the associated assemblages in addition to the dates, we can suggest that all of the Historic-period components that are dated probably occurred no later than the Mexican period, and probably before. This is based on the negative results of all metal-detector surveys around the features that date to the Historic period, reflecting the rarity of metal. This is a situation that pertained especially during the Spanish Colonial period, but was also prevalent during the Mexican period. Not until the American period was enough metal available that it became a disposable commodity that was not used to the last scrap. Cartridges recovered from surface survey during the testing phase of this project include one that is of a caliber used mainly by the military between 1866 and 1873. Records indicated that the Aleman Ranch was sporadically used by the U.S. Army between 1867 and 1880 (Barber 2011:131; Quaranta and Gibbs 2008:58–64), a period that falls within the radiocarbon date ranges for Feature 6 at LA 155963 and Feature 1 at LA 155964.

While some components, especially the early Historic-period components on LA 111429 and LA 155964, could represent Apache occupations, no artifacts diagnostic of this cultural affiliation were found at these locations and, therefore, any identification of cultural affiliation is tentative and unreliable. Thus, as expected, no data were recovered that can be used to explore this research question.

Theme 4: Dynamics of Trade, Interaction, and Economy Throughout All Time Periods, Including a Focus on El Camino Real as a Transportation Corridor, Evaluation of the Development of Railroads in the Region, and the Development of Aerospace Exploration in New Mexico

Data recovered by this study are applicable to the evaluation of trade networks during the prehistoric occupation of the area, perhaps extending into the early Historic period. Examination of El Camino Real and the development of railroads and the aerospace industry were not a focus of the research phase; data suitable for these examinations were not expected and no data pertaining to these topics were recovered.

Only one question pertaining to this theme was asked. Research Question 8 asks, “With what areas did the occupants of the study area interact during the various periods of occupation?” Miller and Kenmotsu (2004) present a model of exchange patterns in the Jornada region, suggesting that materials mainly moved along a north–south axis during the Archaic period, shifting to an east–west axis during the Mesilla phase, and back to a north–south axis during the Doña Ana and El Paso phases. Data that can be used to address the timing and direction of movement were generated during analysis of the chipped stone and ceramic assemblages.

During the Archaic, Miller and Kenmotsu (2004) suggest that obsidian moved north into the region from Chihuahua and south from the Jemez Mountains. No mention is made of Paleoindian interaction patterns. Three characteristics in the chipped stone assemblage can be used to assess whether evidence of trade or exchange with other regions is available for these periods. The first is the presence of potentially exotic material types; the second is the type of cortex on artifacts; and the third is the source of obsidian.

The problem with using exotic materials to indicate trade or exchange is that the same material can often be obtained from different locations or by different means. Exotic materials can be obtained from the outcrops in which they occur or from secondary gravel deposits. Materials obtained from an outcrop exhibit chemically weathered cortex, but should show little if any evidence of mechanical weathering. This is the difference between non-waterworn (chemical weathering) and waterworn (mechanical weathering) cortex. For example, a piece of Polvadera obsidian (also called El Rechuelos) with non-waterworn cortex would have been procured from its source in the Jemez Mountains. However, a piece of Polvadera obsidian with waterworn cortex could have been obtained anywhere within the stream system that drains the Jemez Mountains, and especially from gravel beds along the Rio Grande as far south as the Mexican border. Thus, cortex type is an excellent clue as to where a material used for chipped stone reduction was obtained.

As alluded to above, cortical information can be critical when considering whether tool stone materials could have been found in gravel deposits closer to the sites or in the original outcrops. The situation is different when materials are from a distant drainage system and could not have been recovered from nearby alluvial deposits. That is the case with materials such as Alibates, Tecovas, and Edwards Plateau cherts. These materials outcrop in Texas in areas that drain away from the Rio Grande system. This means that the presence of any of these materials on our sites cannot be attributed to natural processes so, if any occur, they had to have been moved by cultural mechanisms. The same possibility goes for materials that outcrop to the west of the study area, such as Mule Creek or Gwynn/Ewe Canyon obsidian. Since neither of these materials could have reached the study area through natural processes they would also have come in to the project area through cultural processes.

Two types of cultural processes can be responsible for the occurrence of exotic materials on a site. The most commonly assumed cause for exotic materials to occur on a site is trade or exchange. Materials can either move directly from one group to another or through middlemen in a down-the-line exchange. Either of these processes can be responsible for exotic goods moving long distances from where they originated. The second process is direct acquisition by highly mobile groups during their annual or multi-year movement patterns. Meltzer (2006) assumed the latter when considering why chipped stone artifacts made of materials procured from areas hundreds of kilometers away were found at the Folsom site in northeastern New Mexico. When long-distance movement was virtually unobstructed by the presence of competing groups, such as is often thought to have been the case in the early Paleoindian period, direct procurement may be the best explanation for the presence of exotic goods at sites. However, as the landscape began filling with competing groups, which probably occurred during the late Paleoindian or Early Archaic periods, the direct acquisition of exotic goods while traveling would have become much more difficult and, thus, less likely.

Three obsidian artifacts were recovered from the Paleoindian component on LA 111429 and one was recovered from the Paleoindian component on LA 155963; none was found on LA 155968. Unfortunately, only one obsidian specimen from LA 111429 was large enough to be sourced. That specimen came from the Cerro del Medio source in the Jemez Mountains, which Arakawa et al. (2011) assert does not occur in Rio Grande gravels. If this assertion is correct, then at least one piece of obsidian in the Paleoindian components at the Spaceport was acquired through trade with more northerly groups or by long-distance travel.

Other potential imports found on components of this period include Pedernal chert, Alibates chert, and Tecovas chert. While Pedernal chert outcrops in the Chama Valley of northern New Mexico, this material is also transported down the Rio Chama to the Rio Grande, and is commonly found in gravel deposits in the Rio Grande Valley. Indeed, a sample of this material was recovered during this project from Rio Grande gravels near Truth or Consequences (see Chapter 23). Alibates and Tecovas cherts are mainly available in West Texas, and especially in the Texas Panhandle (Banks 1990). The areas in which these materials occur belong to drainage systems that carry materials east from their sources. Thus, neither Alibates nor Tecovas cherts can occur naturally near the study area and their presence can only be accounted for by trade or long distance travel.

Pedernal chert is the most common of these three chert varieties in the Paleoindian components, with nine specimens recovered from LA 111429 and eleven from LA 155963. Except for a core, all of the Pedernal chert specimens are debitage. Two specimens from LA 111429 and three from LA 155963 retain some cortical surface and, in each case, the cortex is waterworn. This confirms that the source of this material was gravel deposits in the Rio Grande Valley, and suggests that the Folsom-period occupants of these sites probably spent some time in the Rio Grande Valley before traveling to our sites.

A single piece of Alibates chert was identified at LA 111429 and one piece of Tecovas chert was found at LA 155963. Both are formal tools—the Alibates chert artifact is a spurred end scraper and the Tecovas chert specimen is an end scraper. Since Folsom groups often covered very large distances in their travels (Meltzer 2006), the materials from which these tools are made were probably directly obtained in West Texas rather than having been acquired by trade. However, acquisition by exchange with other groups cannot be ruled out. Coupled with the sourcing information for obsidian, there is limited evidence for both east–west and north–south movement or trade contacts during the Paleoindian period.

The only potential exotic materials found in the Archaic components are obsidian and Tecovas chert. Six pieces of probable Archaic-age obsidian were sourced, including one from LA 111429 and five from LA 155963. The only Tecovas chert specimen is a core flake from LA 155963. While it is possible that this artifact was procured through trade, it could also have been scavenged from an earlier Paleoindian component, or its presence could indicate a mixing of Archaic and Paleoindian materials. Since the origin of this artifact is questionable, it must be considered a tentative example of trade material.

The obsidian artifacts are a different matter. While most are unutilized debitage, two specimens from LA 155963 are projectile points: a San José point (Bear Springs Peak obsidian) and an Armijo point (Cerro Toledo obsidian). Since evidence for the manufacture of these tools at the locations where they were found is lacking, these projectile points undoubtedly represent tools that were made elsewhere and lost or discarded at LA 155963. Since both of these types of obsidian are available in Rio Grande gravels (Appendix 3), the materials from which these points were made could have been obtained in the Rio Grande Valley, though procurement at the source and movement by trade cannot be ruled out. The four remaining pieces of obsidian include a core flake from LA 111429 and two core flakes and a biface flake from LA 155963. The specimen from LA 111429 is Mule Creek obsidian, while those from LA 155963 are Cerro Toledo (n = 2) and Cerro del Medio (n = 1) obsidian. The Cerro Toledo obsidian was probably obtained from Rio Grande gravels, since one of the two specimens exhibits waterworn cortex. The Cerro del Medio obsidian, on the other hand, was probably obtained from the Jemez Mountains. Rather than being evidence of trade, most of the obsidian artifacts probably indicate that the Archaic groups that occupied these Spaceport sites were in the Rio Grande Valley at some time prior to moving to the study area. The Cerro del Medio specimen is the only potential example of a material acquired through trade, and it suggests a link with populations to the north of the study area. Thus, these very limited data support the suggestion by Miller and Kenmotsu (2004) of a north–south trade axis during this period.

Most of the Formative-period materials date to the Mesilla phase, with some indications for a much-reduced use of the area during the Doña Ana and El Paso phases. The only potential exotic materials found in Formative-period assemblages are Pedernal chert (n = 6) and obsidian (n = 12). Four pieces of Pedernal chert were found at LA 111435. One other came from LA 155963 and another was from LA 156877. Of the 12 pieces of obsidian from this period that were sourced, one is from LA 111429, and 11 are from LA 155963. The Pedernal chert artifact from LA 155963 exhibits waterworn cortex, as do four of the pieces of obsidian (three Cerro Toledo and one El Rechuelos). The remaining obsidian specimens are non-cortical and include examples from the Mule Creek (one each from LA 1114219 and LA 155963), Mount Taylor (n = 2), Bear Springs Peak (n = 1), and Gwynn/Ewe Canyon (n = 1) sources. All three varieties of Jemez obsidian as well as the Mount Taylor obsidian are available in Rio Grande gravels and, considering that the three pieces of Cerro Toledo obsidian had waterworn cortex, were probably obtained from those deposits. However, Mule Creek and Gwynn/Ewe Canyon obsidian outcrop on the other side of the continental divide and could not have reached the study area or the Rio Grande Valley through natural processes. Thus, these materials were probably traded into the area, and may be indicative of an east–west trade axis, especially during the Mesilla phase.

Patterns seen in the ceramic assemblage both match and differ from those defined by Miller and Kenmotsu (2004). These suggest that an east–west trade axis existed during the Mesilla phase, switching back to a north–south axis during the Doña Ana and El Paso phases, similar to the prevailing axis of trade for the Archaic period. Potential ceramic trade wares from the Spaceport America sites include probable early Cibola white wares (n = 6), Mimbres painted wares (n = 6), and perhaps in some cases, Jornada Brown and South Pecos Brown. Both the Mimbres wares and the Jornada and South Pecos Brown wares are indicative of an east-west trade axis, especially if many sherds of the latter types were traded into the region rather than being indicative of transient use of the study area by groups from the northern Jornada area. As discussed above, limited data from obsidian sourcing also support an east–west trade axis. The occurrence of a few sherds of Chupadero Black-on-white may indicate a shifting of the trade axis to a north–south alignment after the Mesilla phase as Miller and Kenmotsu (2004) suggest, though there is little evidence for this from our sites. However, the presence of the probable Cibola white wares—possibly fragments of Red Mesa Black-on-white vessels—suggests that a north–south trade also existed during the Mesilla phase, though its importance relative to that of the east–west axis is uncertain.

While many of the Jornada Brown and South Pecos Brown sherds recovered from our sites could be evidence of trade with the northern Jornada region centered on the Sierra Blanca area, this may not have always been the case. The ceramic assemblage from one site—LA 111422—is dominated by Jornada Brown ware sherds (216 specimens, of which 10 are El Paso Brown). While the occurrence of Jornada Brown wares often increases in the late part of the Mesilla phase (C. Dean Wilson, personal communication, 2013), radiocarbon dates for LA 111422 suggest an occupation during the early Mesilla phase, in the sixth to seventh century. The dominance of Jornada Brown in this assemblage in conjunction with early dates could indicate that a northern Jornada group occupied this site on a short-term basis. However, a sherd of El Paso Polychrome was also identified in the ceramic assemblage, suggesting the possibility of a multicomponent situation with no radiocarbon dates derived from the later occupation. Jornada Brown sherds also comprise a large percentage of the ceramic assemblage from LA 111435, but the Formative-period date for that site indicates occupations during both the early and late parts of the Mesilla phase. The latter is consistent with a larger proportion of Jornada Brown, but the early date is not, and the sherds cannot be linked to a specific occupation period. Jornada Brown and South Pecos Brown sherds were also recovered from various proveniences at LA 155963, but were far outnumbered by El Paso Brown sherds, suggesting that they could represent trade goods.

No good evidence for trade patterns can be suggested for the Protohistoric or Historic periods due to the paucity of remains from those periods in our database. A piece of obsidian with probable non-waterworn cortex and a piece of Alibates chert, both from LA 155964, could be evidence of long-distance movement or trade during the early Historic period. Conversely, this site appears to represent a multicomponent locale, and the earlier component was not dated. Since neither of these exotic artifacts was directly from the Historic period remains in Feature 1, or directly adjacent to it, they cannot be confidently assigned to that component.

Thus, evidence of trade was sparse in our assemblages and in many cases could have multiple meanings. While partial confirmation was derived for the Formative-period patterns proposed by Miller and Kenmotsu (2004), contrary evidence was also recovered. No good evidence for trade during the Paleoindian or Archaic periods was recovered, though evidence for east–west movement was suggested for the Paleoindian period. Any evidence for trade during the Historic period is of questionable association with deposits from that period, and cannot be used as accurate indicators.

Questions Unrelated to the Research Themes

In addition to the questions posed to address the research themes, Research Question 9 asked about the history of geomorphic changes in the middle Jornada del Muerto, and how these changes relate to the archaeological remains. This question was addressed in detail in Chapters 21 and 22. Chapter 21 presents geomorphological data for the study area and discusses the results for each site. Because geomorphological samples from both the testing and research phases were submitted together, investigations at all 14 sites are reported in that chapter. Chapter 22 discusses the geomorphological data in light of the archaeological results, using the former to explain aspects of the latter. This was especially important in providing more secure dates for the Paleoindian components based on OSL samples. While absolute dates were not possible for these components, the suite of OSL sediment dates provides strong evidence for a Folsom affinity.

The Pleistocene sediment geology (Chapter 21) consists of piedmont alluvial deposits derived from the Caballo and San Andres mountains. Sediments from the Caballos dominate in the west part of the study area, and sediments from the San Andres dominate in the east part, underlying the sites that line both sides of Jornada Draw. Two of the sediments deposited on top of the piedmont alluvium can contain cultural materials. The cover sediment (Qcs) mainly occurs above piedmont alluvium derived from the Caballo Mountains, but can also be found above piedmont alluvium derived from the San Andres Mountains, especially at LA 111429. The cover sediment was deposited over about a 10,000-year period beginning around 14,900 BP and ending around 5,000 BP. This layer can contain materials dating from the early Paleoindian period through the Middle Archaic. The eolian sand sheet (Qes) mantles the piedmont alluvium derived from the San Andres and was deposited between about 10,300 and 1,400 years ago. It can contain late Paleoindian through Mesilla-phase materials. Thus, wherever the cover sediment or eolian sand sheet has not been eroded away there is a potential for buried cultural deposits that might not be expressed on the modern surface. While cultural materials will not always occur in these situations, they are a possibility.

Using the geomorphological and archaeological results, Chapter 22 evaluates the research potential of each site. Eight sites are concluded to have little or no potential for future research because deflation has completely or mostly displaced the cultural materials vertically and probably horizontally. These sites include LA 111421, LA 111432, LA 112370, LA 112371, LA 112374, LA 155964, LA 155969, and LA 156877. The first four sites in this list are completely deflated, and the last four are mostly deflated. However, there are exceptions to this conclusion when archaeological data are factored in. LA 111432 is still considered to have research potential because it was assigned a probable late Paleoindian date based on the presence of an Eden-like projectile point fragment, and because it currently is the only potential component from that period that is well-defined. LA 155964 also retains research potential despite its mostly deflated condition because it contains shallow deposits that are related to a well-preserved Historic thermal feature (Feature 1) that was only partially excavated. A possible earlier component on LA 155964, on the other hand, may have little research potential because those remains are not nearly as well-preserved. A large buried thermal feature was found in a road cut at LA 156877, indicating the potential for fairly intact subsurface remains—mainly features excavated into sterile sediments—despite the deflated nature of this site. Thus, of the eight sites that appear to have little or no research potential based solely on the geomorphological study, when archaeological characteristics are considered, three of the eight still have the ability to provide information on local prehistory and history.

Based on the results of both studies, six remaining sites have the potential to provide further information. LA 111429 and LA 155963 lead this list because they are both very large and contain multiple components dating from the Paleoindian through the Protohistoric and early Historic periods. While parts of these sites are significantly deflated, other parts remain covered with sediments that contain cultural materials and have features that are intact to varying degrees. The other sites that have research potential based on the results of both studies are LA 111420, LA 111422, LA 111435, and LA 155968. In each of these cases, at least some sediment that contains cultural materials has not been completely deflated and, as a consequence, partly intact features are present.

Combining information derived from the cover sediment (QCS) and the eolian sand sheet (Qes), portions of the time period from the late Pleistocene into the late Holocene appear to have been fairly stable, with sediment being deposited between about 15,000 and 1,400 years ago. For example, a paleosol dating to the Protohistoric period was documented at several sites in the vicinity of Jornada Draw. In contrast, we can, by combining the level of deflation estimated for the Early Historic Feature 11 at LA 111429, estimate that erosion has removed up to 50–70 cm of sediment from many areas sometime during the past 600 years. Dates for coppice dunes indicate that eolian sand was deposited above earlier sediments in many areas about 150 years ago. Not all dunes in the region are attributable to recent eolian activity though, because the sand ridges on both sides of Jornada Draw that contain LA 111422, LA 111429, and LA 111435 are up to several thousand years old.

Project Summary and Conclusions

The ultimate goal of this study was to collect data from eight sites that could be used to address a series of research questions linked to themes developed in the mitigation plan for examining archaeological sites at the Spaceport America facility in the central Jornada del Muerto (FAA and NMSA 2010). The data produced by the current study, combined with those from an earlier testing phase (Akins and Moore 2011a), were useful in addressing many of the research questions, though comprehensive answers were not always possible. This study shows that many aspects of the research themes can be examined for the prehistoric period using information derived from archaeological sites at Spaceport America. Since the sites examined by this study were not fully excavated, most retain the ability to provide further information on the cultural use of the Spaceport America area.

LA 111422 is a small Formative-period site that retains the ability to provide further information, particularly for the middle portion of the Mesilla phase. One of the main questions that can be asked for this site is whether the high percentage of sherds from the northern Jornada area, which are more indicative of a late Mesilla-phase occupation, represent a separate temporal component. If not, does the presence of these sherds then indicate a middle Mesilla-phase occupation by a group from the Sierra Blanca area? If there are multiple components at this site, can those different components be separated? Future work at this site might be able to resolve these questions.

LA 111429 is a large complex site with components spanning the Paleoindian to the early Historic period, except for the Protohistoric. The testing and research investigations have literally only touched the surface of the information potential of this site. There appears to be an extensive Folsom component, probably representing multiple occupations. Further exploration of the layer of sediment out of which the Folsom materials are eroding, is warranted to determine with a greater degree of confidence that this sediment layer dates to the Folsom period, as the initial OSL dates imply. Exploring the horizontal extent of this stratum under the later sand sheet in areas such as the Feature Area (Chapter 22) could help date this layer more closely and could reveal intact deposits dating to the Folsom occupation(s).

Several features investigated at LA 111429 contained materials useful in dating their period of use and also provided some information on subsistence. Investigation of unexcavated features at this site could yield further data, especially in the densely occupied section of the site referred to as the Feature Area, which contains Feature 11 that dates to the early Historic period. In addition, the existence of a paleosol dating to the Protohistoric period indicates that part of the landscape from that period is preserved at this site. Following that paleosol could enable researchers to encounter features and deposits dating to that little known period. Further investigation should also provide more information on the use of this locale during the Archaic and Formative periods.

LA 111435 is a fairly large site. Feature integrity and preservation vary in the western section of the site and are uncertain in the eastern section. Of great interest for this site was the recovery of radiocarbon dates for features indicating occupation during the Middle and possibly the Late Archaic in addition to the dominant Mesilla-phase component. It is the only site investigated that had a possible structure and more could be present. Further investigation of this site would provide more information on the Mesilla-phase occupation, and could provide ancillary data on the Archaic occupations.

LA 155963 is another very large multi-occupational locale that retains a considerable amount of potential for providing information on the Paleoindian through the Historic-period use of this area. Indeed, this is the only site investigated by this study that also has the potential to provide further information on Historic-period ranching activities. While the latter was not a focus of this study, features dating to the late Historic period were noted and recorded. The northern section of LA 155963 (Section A) evidenced use during the Folsom, Late Archaic, Formative, Protohistoric, and early Historic periods. In most cases, these were short-term uses of the locale, which left few materials behind. However, the number of features in this part of the site, and the potential for others to occur under later eolian deposits, suggest that the northern part of the site retains considerable information potential. Similarly, the central part of the site (Section B) contains extensive remains from the Formative period, as well as numerous thermal features exhibiting various levels of deflation that may mostly date to the Archaic period because they lack associated pottery. Indeed, of 82 unexcavated features in this part of the site, nine have sherds in association and all but 11 have associated chipped stone artifacts. Thermally altered chipped stone artifacts were noted at 20 of the latter. Both Archaic and Formative-period occupations appear to be represented in the southeastern part of the site (Section C). Although that area is badly deflated, there is some potential for the existence of dateable features.

Part of Feature 1 at LA 155964 remains unexcavated and has the potential to provide further information on the early Historic period use of the study area. Further surface stripping around this feature could recover related materials that might make it possible to establish the ethnic identity of these occupants. Examination of other features at this site could help establish whether a multicomponent situation does indeed exist.

Evidence for a spatially extensive Folsom-period occupation, as well as evidence for a more concentrated Mesilla-phase occupation, was found at LA 155968. Since limited subsurface investigations in parts of the site away from Feature 1 demonstrated that the potential exists for artifacts that have not been exposed on the surface by erosion, further and more extensive surface stripping could provide considerably more information on both of these periods of occupation and could perhaps enhance our ability to separate materials belonging to these components.

LA 155969 was the only site examined by this study that does not appear to retain further research potential. Cultural deposits at this site appear to have been completely deflated, and while coppice sand deposits could feasibly hide a few more artifacts, further studies at this site are not expected to recover any important information on the occupation of this location.

While our investigation of a feature at LA 156877 suggests that this site is highly deflated, the discovery of a partly intact but buried stain or ephemeral structure in the road-cut indicates that this site has the potential to contain other buried features and deposits. This, and the discovery of additional surface cultural features that have not been investigated, means there is some potential for those features to contain intact deposits that might allow for the definition of the period of occupation with which they are affiliated. Thus, this site retains the potential for providing further important information.

To summarize, seven of the sites investigated by this study have the potential to provide further information on the prehistoric through early historic use of this area. The sole exception is LA 155969, which yielded little data during our study and does not appear to have the potential to provide further information through a more intense examination. This study was successful in fulfilling its main goals. While many questions remain to be answered concerning the various occupations documented by this project, we have provided information important to an archaeological understanding of several of the periods of occupation.

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APPENDIX 1 | Spaceport • AN 453

Protein Residue Analysis of Sixteen Chipped Stone Artifacts and Three Soil Samples from Sites LA 111422, LA 111429, and LA 155963

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(LAS-324)

The use of chemical and molecular biological techniques in the analysis of archaeological materials can provide significant new information for the interpretation of their use. The identification of organic residue from lithic and ceramics artifacts, coprolites and soils have provided archaeologists with specific data regarding prehistoric exploitation of animals and plants. Although ancient protein residues may not be preserved in their original form, linear epitopes are generally conserved which can be identified by immunological methods (Abbas et al. 1994).

Immunological methods have been used to identify plant and animal residues on flaked and groundstone lithic artifacts (Allen et al. 1995; Gerlach et al. 1996; Henrikson et al. 1998; Hyland et al. 1990; Kooyman et al. 1992; Newman 1990, 1995; Petraglia et al. 1996; Shanks et al.1999; Yohe et al. 1991) and in Chumash paint pigment (Scott et al. 1996). Plant remains on artifacts also been identified through chemical (opal phytoliths), and morphological (use-wear), studies (Hardy and Garufi 1998; Jahren et al. 1997, Sobolik 1996). Plant and animal residues on ceramic artifacts have been identified through the use of gas-liquid chromatography, high performance liquid chromatography and mass spectrometry (Bonfield and Heron 1995; Evershed et al. 1992; Evershed and Tuross, 1996; Heron et al. 1991, Patrick et al. 1985). Serological methods have been used to determine blood groups in skeletal and soft tissue remains (Heglar 1972; Lee et al. 1989) and in the detection of hemoglobin from 4500-year-old bones (Ascenzi et al. 1985). Human leukocyte antigen (HLA) and deoxyribonucleic acid (DNA) determinations made on human and animal skeletal and soft tissue remains have demonstrated genetic relationships and molecular evolutionary distances (Hänni et al. 1995; Hansen and Gurtler 1983; Lowenstein 1985, 1986; Pääbo 1985, 1986, 1989; Pääbo et al. 1989). Successful identification of residues on stone tools, dated between 35-60,000 B.P., has been made by DNA analysis (Hardy et al. 1997), while recently, residues on surgical implements from the American Civil War were identified by immunological and DNA analysis (Newman et al. 1998). A recent study demonstrated the viability of identifiable immunoglobulin G in 1.6 million-year-old fossil bones from Venta Micena, Spain, (Torres et al. 2002). Horse exploitation was identified by immunological analysis of residues retained on Clovis points dated to ca. 11,200 B.P. (Kooyman et al. 2001).

The use of forensic techniques in the investigation of archaeological materials is appropriate as both disciplines deal with residues that have undergone changes, either deliberate or natural. Criminals habitually endeavor to remove bloodstains by such means as laundering, scrubbing with bleach, etc. yet; such degraded samples are still identified by immunological methods (Lee and De Forest 1976; Milgrom and Campbell 1970; Shinomiya et al. 1978, among others). Similarly it has been shown that immunological methods can be successfully applied to ancient human cremations (Cattaneo et al. 1992). Forensic wildlife laboratories use immunological techniques in their investigation of hunting violations and illegal trade, often from contaminated evidence (Bartlett and Davidson 1992; Guglich et al. 1993; Mardini 1984; McClymont et al. 1982). Immunological methods are also used to test the purity of food products such as canned luncheon meat and sausage, products which have undergone considerable degradation (Ashoor et al. 1988; Berger et al. 1988; King 1984). Thus the age and degradation of protein does not preclude detection (Gaensslen 1983:225).

Materials and Methods

The method of analysis used in this study of archaeological residues is cross-over immunoelectrophoresis (CIEP). Prior to the introduction of DNA fingerprinting this test was used by forensic laboratories to identify trace residues from crime scenes. Minor adaptations to the original method were made following procedures used by the Royal Canadian Mounted Police Serology Laboratory, Ottawa (1983). The solution used to remove possible residues is five percent ammonium hydroxide which is the most effective extractant for old and denatured proteins without interfering with subsequent testing (Dorrill and Whitehead 1979; Kind and Cleevely 1969). Artifacts are placed in shallow plastic dishes and 0.5 ml of five percent ammonia solution applied directly to each. Initial disaggregation is carried out by floating the dish and contents in an ultrasonic cleaning bath for five minutes. Extraction is continued by placing the dish and contents on a rotating mixer for thirty minutes. For large ground stone items, such as metates, stone bowls, etc., the ammonium hydroxide is applied directly to the worked surface, agitated periodically with a sterile orangewood stick, and allowed to sit for one half hour. The resulting solution is drawn off, placed in a numbered, sterile plastic vial and stored at -20ºC prior to testing. In the case of soil samples, one gram is placed in a vial and 0.5 ml of 1 M Tris buffer solution ($H_2NC[CH_2OH]_3$) is used instead of ammonium hydroxide. The vial is placed in a rotating mixer overnight. The resulting solution is drawn off, placed in a numbered, vial and stored at -20ºC prior to testing.

A series of paired wells is punched into an agarose gel. Approximately 2 μl. of antiserum is placed into one well and the same amount of the unknown sample extract is placed in the other. An electric current is then passed through the gel. The antiserum and unknown sample migrate through the gel and come into contact. If there is protein in the unknown which corresponds with the antiserum, an antigen-antibody reaction occurs and the protein precipitates out in a specific pattern. The precipitant is detected when the gel is pressed, dried and stained. Control positives are run simultaneously with all the unknown samples. Sterile equipment and techniques are used throughout the analysis.

The Samples

Sixteen artifacts and three soil samples were sites LA 111422, LA, 111429 and LA 155963 were submitted for immunological analysis by James L. Moore from the Office of Archaeological Studies. Residue was removed from the artifacts as discussed above. The residues were tested against plant and animal antisera (**Table App1.1**) as requested (**Table App1.3**). Animal antisera provided by Cappel Research and Lampire Biomedical, and plant antisera produced at the University of Calgary, provide family level identification only. The relationship of antisera to some of the possible species identified is shown in **Table App1.2**.

Results

Seven samples, FS 141, 1, 9, 24, 26, 104 and 583, tested positive for rabbit proteins. No other positive reactions were registered with available antisera (**Table App1.3**). The absence of identifiable proteins on an artifact may be due to poor preservation of protein, insufficient protein, or that they were not in contact with any of the organisms included in the available antisera.

Table App1.1. Antisera used in analysis.

Animal Antiserum	Source	Plant Antiserum	Source
Bear	"	Agave	University of Calgary
Bovine	"	Amaranth	"
Camel	Lampire Biomedical	Aster	"
Cat	Cappel Research	Capparid	"
Chicken	"	Cedar	"
Deer	"	Chenopod	"
Dog	"	Mesquite	"
Elephant	Lampire Biomedical	Pine	"
Guinea-Pig	Cappel Research		
Horse	"		
Human	"		
Rabbit	"		
Rat	"		
Sheep	"		
Swine	"		
Trout/Salmon	Lampire Biomedical		

Table App1.2. Possible species identified.

Antiserum to:	Reacts with:
Bear	Black, grizzly, etc
Bovine	Bison, cow, musk ox
Camel	All camelids (New & Old world)
Cat	Bobcat, cougar, lynx, etc.
Chicken	Quail, grouse, & other gallinaceous fowl
Deer	Deer, elk, moose
Dog	Coyote, dog, wolf
Elephantidae	Elephant, mammoth
Guinea-Pig	Beaver, guinea-Pig, porcupine, squirrel
Horse	Horse, donkey, kiang, etc.
Human	Human
Rabbit	Rabbit, hare, pika
Rat	All rat & mouse species
Sheep	Bighorn & other sheep
Swine	Pig, possibly javelina
Trout	Trout and salmon species
Agave	Agave, yucca
Amaranthaceae	Amaranth, pigweed, *quelite*, etc.
Asteraceae	Rabbitbrush, sagebrush, sunflower, thistle
Capparidaeceae	Beeplant, bladderpod, stinkweed, etc.
Cedar	Cedar, cypress, juniper
Chenopodiaceae	Goosefoot, greasewood, pickleweed, saltbrush, etc.
Mesquite	Mesquite, palo verde, other legumes
Pinon	Fir, hemlock, pine, spruce

Table App1.3. Results.

Las #	Site #	FS	Art. No.	Art. Type	Analysis	Results
1	LA 111422	36	1	Corner-notched arrow point	Animal	Negative
2	LA 111429	1	1	Folsom point	Animal	Negative
3	LA 111429	4	1	scraper	Plant and animal	Negative
4	LA 111429	141	1	scraper	Plant and animal	Rabbit
5	LA 111429	139	1	Paleoindian point	Animal	Negative
6	LA 155963	1	1	Folsom point	Animal	Rabbit
7	LA 155963	9	1	scraper	Plant and animal	Rabbit
8	LA 155963	15	1	Folsom point	Animal	Negative
9	LA 155963	20	1	Paleoindian point	Animal	Negative
10	LA 155963	24	1	Arrow points	Animal	Rabbit
11	LA 155963	26	1	unnotched arrow point	Animal	Rabbit
12	LA 155963	102	1	Folsom point	Animal	Negative
13	LA 155963	104	1	San Pedro point	Animal	Rabbit
14	LA 155963	1044	1	San Pedro point	Animal	Negative
15	LA 111429	137 soil	1	Soil Sample	Animal	Negative
16	LA 155963	583 soil	1	Soil Sample	Animal	Rabbit
17	LA 111422	68 soil	1	Soil Sample	Animal	Negative
18	LA155963	24	2	Arrow points	Animal	Negative

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Appendix 2 | Phytolith and Starch Analysis of Roasting Pit Fill

PHYTOLITH AND STARCH ANALYSIS OF ROASTING PIT FILL FROM SITES LA 155964 AND LA 111429, NEW MEXICO

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INTRODUCTION

Late Prehistoric roasting pits from sites LA 155964 and LA 111429 were examined for phytolith and starch remains. Previous flotation samples from these features have not provided conclusive macrobotanical evidence as to their function. The goal of this study is to better understand the types of plant material processed or cooked using these features through phytolith and starch analysis.

METHODS

Phytolith and Starch Grain Extraction from Sediment

First, 15 ml of sediment from each sample was placed in a 500 ml beaker with 70% nitric acid (HNO_3) and boiled for 1 hour, then rinsed to neutral pH with water. Next, a 10% solution of potassium hydroxide (KOH) was added to each sample and thoroughly mixed. KOH aids in the removal of organic humic substances not removed by nitric acid. After the addition of KOH, the samples were allowed to settle by gravity for two hours, after which, the humates liberated from the sediments were decanted. The samples were then rinsed to neutral pH with water. Once these steps were complete, a 5% solution of sodium hexametaphosphate was mixed into each sample to suspend clay-sized particles. The samples were allowed to settle by gravity for two hours, after which, the clay-sized particles that were still in suspension were decanted. This step was repeated four more times until the supernatant was clear after two hours of settling time. The samples were then transferred to 50 ml centrifuge tubes and freeze-dried using a vacuum system, which freezes out all moisture at -107 °C and < 10 millitorr. The dried samples were then mixed with sodium polytungstate (SPT, density 2.3 g/ml) and centrifuged to separate the phytolith and starch grain fraction, which will float, from most of the inorganic silica fraction, which will not. Because a lot of silt-sized inorganic material was floated with SPT, each sample was again dried under vacuum and then mixed with potassium cadmium iodide (density 2.3 g/ml). At this stage, a small portion of each sample was retained for phytolith examination and the remainder of each sample was mixed with SPT at a density of 1.8 g/ml. This allowed for most of the phytolith fraction and other inorganic particles to drop out of suspension, leaving behind starches and other particles with lighter densities. Both the phytolith fraction and the starch grain fraction of each sample was rinsed in alcohol to remove any remaining water. After several alcohol rinses, the samples were mounted in optical immersion oil for counting with a light microscope at a magnification of 500x. A total count of 200 taxonomically significant phytoliths was completed, after which, each slide was scanned for rare phytolith types and for starch grains. A percentage phytolith diagram that includes frequency data for any starch grains observed was produced using Tilia 2.0 and TGView 2.0.2.

DISCUSSION

Sites LA 155964 and LA 111429 were recorded as part of the Spaceport America project, which is located at the center of the Jornada del Muerto desert and xeric shrubland region. This area has no permanent water sources but has been used from Paleoindian through present times. The general area can be characterized as Chihuahuan Desertscrub. Honey mesquite (*Prosopis glandulosa*) is the primary shrub species, particularly on dune ridges. Research investigations at 8 sites resulted in the excavation of five large roasting pits. Three date to the Late Archaic/Early Mesilla/Mesilla phase. The other two pit features were larger, packed with fire-cracked rock, and date to the Protohistoric to modern era; however, artifacts associated with these features do not indicate that they are so late. It is these latter two pit features that are the focus of the current phytolith and starch grain study (Table 1). Numerous flotation samples have not provided any evidence as to what the pits were used to prepare (McBride, Chapter 17). Results of the phytolith and starch grain analyses of these features are organized and discussed next by site number.

LA 155964

Fill from Feature 1 was submitted for phytolith and starch grain analysis. Modern vegetation at site LA 155964 was noted to include mesquite (*Prosopis glandulosa*), dwarf desert holly (*Acourtia nana*), warty carpetweed (*Kallstroemia parviflora*), and silverleaf nightshade (*Solanum elaeagnifolium*). Present, but less frequently noted, were tobosa grass (*Pleuraphis mutica*), creosotebush (*Larrea tridentata*), soaptree yucca (*Yucca elata*), little-leaf sumac (*Rhus microphylla*), graythorn (*Ziziphus obtusifolia*), cholla (*Cylindropuntia* spp.), prickly pear (*Opuntia* spp.), Mormon tea (*Ephedra* spp.), thymeleaf spurge (*Chamaesyce serphllifolia*), rattlesnake weed, (*Chamaesyce albomarginata*), and four-wing saltbush (*Atriplex canescens*) (McBride, Chapter 20).

Feature 1 was a large fire-cracked rock-filled roasting pit that was at least 46 cm deep (Chapter 10). The 23 flotation samples from Feature 1 contained charred amaranth and bugseed (*Corispermum* spp.) seeds, yucca basal caudex, some with leaf and fiber fragments, grass stems, and cactus areoles, epidermis, and stem tissue. A macrobotanical sample from deep in the pit yielded a flat-stemmed cactus pad fragment. Fuel wood from the pit is largely mesquite with very small amounts of saltbush, tarbush, and yucca caudex and stem (McBride, Chapter 17). Multiple radiocarbon dates obtained on various pieces of charred plant material yielded calibrated dates of AD 1405 to 1740 (Boyer, Chapter 19).

Fill from Level 2 of Feature 1 was examined for phytoliths and starch grains. Phytoliths, mostly derived from grasses, were numerous, and a total of eight starch grains were recovered (**Figure App2.1**). It is typical for the majority of phytoliths in feature fill samples to be derived from grasses growing at or near to the site (environmental signal). Fill from roasting ovens may also contain a significant contribution of phytoliths derived from grasses used as a buffering layer of vegetation or as a source of moisture for steam. Grass phytolith identification is usually made to the subfamily level (Chloridoideae, Panicoideae, etc.); however, some phytoliths can be ascribed to genus and even species level. Therefore, it is important to have an inventory of the grasses growing within the project area.

Spaceport project area plant surveys have listed the presence of 11 Chloridoideae taxa as occurring: tobosa (*Pleuraphis mutica* syn. *Hilaria mutica*), black grama (*Bouteloua eriopoda*), mat grama (*Bouteloua simplex*), muhlys (*Muhlenbergia torreyi*, *M. porteri*), dropseeds (*Sporobolus airoides*, *S. cantractus*, *S. flexuosus*), burro grass (*Scleropogon brevifolius*), fluff grass (*Dasyochloa pulchella*), and desert lovegrass (*Eragrostis pectinacea* var. *miserrima*). Three Panicoideae grass taxa were observed: plains bristlegrass (*Setaria leucopila*), little bluestem (*Schizachyrium scoparium*), and vine mesquite (*Panicum obtusum*). One member of the Arundinoideae was observed, purple three-awn (*Aristida purpurea* var. *perplexa*). No members of the cool season, C3 metabolism grass family Pooideae were noted during the survey.

Not surprisingly, saddle phytoliths diagnostic of the Chloridoideae grass subfamily were the most common phytolith morphotype, observed at 46% relative abundance. What was surprising was the presence of phytoliths derived from Panicoideae grasses at 26% relative abundance. Chloridoid grasses, in particular, tobosa (*Pleuraphis mutica* syn. *Hilaria mutica*), overwhelmingly dominate the grass community assemblage at this site and in the project area in general. Thus, the presence of panicoid phytoliths at 26% relative abundance in the feature sample seems abnormally high, and suggests that a panicoid grass, possibly vine mesquite (*Panicum obtusum*), was intentionally utilized in this feature. *Panicum obtusum* grows in seasonally wet sand or gravel, especially on stream banks, ditches, roadsides, wet pastures, and rangeland. An interesting aspect of *Panicum obtusum* is that Apache, Chiricahua, and Mescalero groups ground the seeds, made them into a gravy and mixed it with meat (Moerman 1998). Starch grains that could be derived from Panicoideae seeds were recovered from this feature, and are discussed below with the other starch grains recovered.

Interestingly, phytoliths diagnostic of cool season, C3 grass subfamily Pooideae taxa were present at 7% relative abundance. Pooideae grasses were not noted in the project area plant survey. This suggests that conditions may have been slightly cooler, but most likely wetter during the period of time that this feature was in use. This is supported by the presence of silica microfossils from diatoms (*Aulacoseria* spp.) and freshwater sponges (Spongillidae) that were recovered in the phytolith extract. Although some pennate diatoms can grow in moist soils, filamentous diatoms from the genus *Aulacoseria* are planktonic and are typically associated with ponds, lakes, streams and rivers. Freshwater sponges inhabit ponds, lakes, and streams, and are found growing on the surfaces of aquatic plants, rocks and pieces of submerged wood. They typically thrive in water that is alkaline (above pH 7), and their abundance is negatively correlated with turbidity and sediment load (Barton and Addis 1997; Cohen 2003; Droscher and Waringer 2007; Harrison 1988). In some archaeological contexts, the presence of diatoms and sponge microfossils can be an indication that water was used to process or cook various foods, or that aquatic/wetland plants were utilized in some fashion, such as sources of steam in earth ovens. One achene (seed) cone cell phytolith diagnostic of the sedge (Cyperaceae) family, and most likely derived from a species of *Cyperus* was observed, suggesting that sedge seeds or whole plants were also used in association with this feature. It should also be mentioned that the Chloridoid grass alkali sacaton (*Sporobolus airoides*), which was noted in the project area plant survey, was used by Apache, Chiricahua and Mescalero groups to prevent the loss of steam by placing wet stems of this grass onto hot stones (Moerman 1998:542).

Also observed in the phytolith fraction were microscopic pieces of charred sunflower family (Asteraceae) achene epidermis material (**Fig. App2.2 A**). Technically, these are not phytoliths, so they were counted outside of the phytolith sum, but they are resistant to oxidation by nitric acid and can be recovered along with phytoliths. A total of 53 of these Asteraceae microfossils were observed during the 200 phytolith count. Although Asteraceae achenes such as those commonly exploited for subsistence (*Helianthus*, *Iva*, etc.) produce these types of microscopic fragments, it is currently unknown how diagnostic these are to edible Asteraceae achenes. The ones observed here most resemble those produced by *Helianthus* rather than *Iva*; however, they may simply be a part of the environmental signal or were attached to material used as fuel in this feature. It is interesting to note that *Helianthus annuus* achenes (seeds) were roasted in pits prior to consumption (Thoms 2008).

A total of eight starch grains were recovered from the Feature 1 fill represented by sample FS 8. Five of these grains were circular in outline, lenticular in cross section, and as such, are considered diagnostic of barley (*Hordeum* spp.), ryegrass (*Elymus* spp.) and western wheatgrass (*Agropyron smithii* syn. *Pascopyum smithii*) (**Fig. App2.2 B–F**). Although these starches cannot be ascribed to a particular grass, a phytolith typical of western wheat grass was observed in sample FS 138 from Feature 11 (site LA 111429). Also observed was one starch with an irregular/angular shape (**Fig. App2.2 G**) and two grains that are subangular to angular in shape (**Fig. App2.2 H–I**). These subangular to angular grains are found in the seeds of a wide variety of grasses, including some of those recorded in the project area plant survey. Notably, species of dropseed (*Sporobolus*), panic grass (*Panicum*), lovegrass (*Eragrostis*) and Indian ricegrass (*Achnatherum hymenoides*) produce subangular to angular starch grains. Interestingly, maize (*Zea mays*) also produces angular starch grains; however, no phytoliths diagnostic of maize cob material were observed in the two samples examined from the project area.

LA 111429

Site LA 111429 is located approximately 3.5 miles southeast of the previously discussed site. Vegetation observed growing at the site is dominated by tobosa grass, with patches of purple three-awn, fluffgrass, and mat grama (*Bouteloua simplex*). Concentrations of soaptree yucca and cholla occur sporadically, while espanta vaquero (*Tidestromia lanuginosa*) is abundant. Other plants that occur sporadically include stunted Mormon tea, an unknown composite, spike dropseed, nightshades (*Solanum* spp.), narrow leaf globemallow (*Sphaeralcea angustifolia*), wild zinnia, dwarf desert holly, hog potato (*Hoffmannseggia glauca*), purslane (*Portulaca* spp.), devil's claw, and others (Pamela McBride, Spaceport Plant Survey Chapter, please provide appropriate citation).

Feature 11 is a large caliche filled roasting pit located in the northern part of the site on the southern edge of a dune ridge. The 21 flotation samples contained evidence of prickly pear fruit and pad processing along with yucca caudex and leaf fragments, cheno-am, spruge, dropseed, and other grasses (McBride, Chapater 17). Samples comprising mesquite, saltbush, and yucca stem were submitted for radiocarbon analysis. Dates returned for these materials fall within the Spanish Colonial period — AD 1620 to 1685 (Boyer, Chapter 19).

Fill from Level 3 of Feature 11 was submitted for phytolith and starch grain analysis. Overall, the phytolith and starch record from this roasting pit feature is similar to that discussed for the roasting pit from site LA 155964; however, with some notable exceptions. Phytoliths diagnostic of Panicoideae grasses were present at 23% relative abundance, which is similar to that observed for Feature 1 from LA 1555964. This suggests that panicoid grasses, possibly *Panicum obtusum,* were much more abundant on the landscape during the period of time that this feature was used than they are today. A leaf epidermal sheet element diagnostic of the Panicoideae was recovered from this sample (**Fig. App3.3 A**), indicating that panicoid grass material was present in this feature. As discussed for the previous sample, *Panicum obtusum* grows in seasonally wet sand or gravel, especially on stream banks, ditches, roadsides, wet pastures, and rangeland. *Panicum obtusum* was utilized by Apache, Chiricahua, and Mescalero groups who ground the seeds, made them into a gravy and mixed it with meat (Moerman 1998:377). Starch grains that could be derived from Panicoideae seeds were also recovered from this feature, and are discussed below with the other starch grains recovered.

Phytoliths diagnostic of the cool season C3 grass subfamily Pooideae were present at 12% relative abundance, a rather high percentage considering that no cool season C3 grasses were noted in the project area plant survey. This strongly suggests that conditions may have been slightly cooler and wetter in the past. Slightly wetter conditions, in particular, an increase in monsoonal precipitation, would also account for the fact that Panicoideae grasses appear to be more prevalent here in the past than today. Panicoid grasses are warm season grasses; however, they typically require moderate to large amounts of precipitation to thrive. A leaf epidermal sheet element from a member of the Chloridoideae grass subfamily was observed (**Fig. App3.3 B**). This suggests that a chloridoid grass may have been used in a buffering or steam retaining layer in this roasting pit feature. As previous mentioned for site LA 155964, the chloridoid grass alkali sacaton (*Sporobolus airoides*) was used by Apache, Chiricahua and Mescalero groups to prevent the loss of steam in earth ovens by placing wet stems of this grass onto hot stones (Moerman 1998:542). It's possible that moist grass stems were placed onto hot rocks, then additional water may have been poured onto the stones to generate even more steam prior to covering the roasting pit with soil. There does seem to be an even greater moisture signal in this sample, as numerous diatom and freshwater sponge microfossils were observed, and a few phytoliths derived from the stems of a sedge (Cyperaceae) were also observed.

One phytolith diagnostic of dayflower (*Commelina erecta*) seed coat was observed (**Fig. App3.3 C**). Dayflower was not noted in the project area plant survey, but does occur in this region. Dayflower grows in rocky woods and hillsides, scrub oak woods, pine woods and barrens, sand dunes, hummocks, shale barrens, roadsides, railroad rights-of-way, fields, and is occasionally a weed in cultivated ground (Faden 2000). Dayflower seeds are not known to have been utilized for subsistence; however, the mucilaginous nature and high water content of its leaves and stems may have made it a desirable source of moisture for pit roasting.

Two dendriform phytoliths were observed in this sample. Dendriforms originate in the bract material (lemmas, paleas and glumes) that surrounds the seed (caryopsis) of some wild and domesticated grasses. They are very common in the bract material of C3 Pooideae grasses, some of which are domesticated cereals and many of which are native to North America. The presence of dendriforms in archaeological samples can be an indication that grass seeds were being processed or consumed. This is because the dendriform-bearing plant material that encapsulates the grass seed is never entirely removed from all of the grains during the parching and winnowing steps. These dendriforms can then be cooked, digested, and incorporated into the archaeological and geological records. Disarticulated dendriforms, such as the ones observed here, cannot be reliably ascribed to a particular grass, but they are most typical of C3 Pooideae grasses. Dendriforms can also be derived from the natural decay of plants on the landscape. Thus, in order to be considered an indicator of grass seed processing, they need to be recovered in numbers greater than what is expected for normal background levels. The recovery of two dendriforms out of a total of 200 phytoliths counted is not high enough to be considered unequivocal evidence for grass seed processing. However, it is interesting, based on the relatively high number of grass seed starch grains recovered from both of the roasting pit feature samples, that more dendriforms were not recovered. This suggests that the dendriform-bearing grass seed chaff was removed before they were cooked using this feature. Its even possible that these grass seeds were collected and processed elsewhere on the landscape and then incorporated into the foods cooked using these features.

A total of six starch grains were recovered from Feature 11 fill sample FS 138. A mostly spherical starch grain with some visible lamellae was observed **(Fig. App3.3 E)**. This grain is most likely derived from western wheatgrass (*Agropyron smithii* syn. *Pascopyum smithii*). Other evidence from this sample of processing western wheatgrass comes from the recovery of a phytolith typical, but not diagnostic, of those produced by this grass that was slightly stained brown from exposure to fire **(Fig. App3.3 D)**. A lenticular (in cross-section) starch that was diagnostic of barley (*Hordeum* spp.), ryegrass (*Elymus* spp.), and western wheatgrass (*Agropyron smithii* syn. *Pascopyum smithii*) was observed **(Fig. App3.3 F)**. This starch grain exhibits some distortion in shape from its more usual circular outline that is a sign of heat damage from cooking.

A small globular starch grain with a slightly eccentric hilum was observed **(Fig. App3.3 G)**. This starch grain is typical of a wide variety of grasses and cannot be identified to any greater taxonomic level. And finally, three subangular to angular starch grains were observed **(Fig. App3.3 H–J).** These subangular to angular grains are found in the seeds of a wide variety of grasses, including some of those recorded in the project area plant survey. Notably, species of dropseed (*Sporobolus*), panic grass (*Panicum*), lovegrass (*Eragrostis*) and Indian ricegrass (*Achnatherum hymenoides*) produce subangular to angular starch grains. Interestingly, maize (*Zea mays*) also produces angular starch grains; however, no phytoliths diagnostic of maize cob material were observed in the two samples examined from the project area.

SUMMARY AND CONCLUSIONS

Phytoliths and starch grains that appear to be directly associated to the use of Protohistoric to modern era roasting pits Features 1 and 11 at sites LA 155964 and LA 111429, respectively, were successfully recovered. Based on the combined phytolith and starch records, it appears that grass seeds were part of the foodstuffs processed or cooked using both of these features. Thoms (2009:582) has an interesting observation on the late use of earth ovens. He states “The widespread and common presence of earth ovens during the agricultural period fits quite well with the concept of land-use intensification in agriculturally marginal areas”. Based on grasses either observed here today, or most likely to have occurred here in the past, western wheatgrass (*Pascopyum smithii*), vine mesquite grass (*Panicum obtusum*), and species of dropseed (*Sporobolus* spp.) are the grass seeds most likely to be represented by the starch grains recovered in both of the roasting pit features examined. The ethnographic record indicates that *Achnatherum hymenoides*, *Sporobolus* spp. and *Panicum* spp. were especially important throughout the Southwest (Doebley 1984). Especially in the case of *Panicum obtusum*, the ethnographic record also suggests that these grass seeds may have been ground and mixed with meat prior to being cooked in these roasting pits (Moerman 1998). Together the ethnographic record, supported by the phytolith record, also suggests that *Sporobolus airoides* may have been used as a buffering layer of vegetation and/or a source of moisture for steam (Moerman 1998). The presence of diatom and freshwater sponge microfossils suggests that water may have been used to prepare some of the food or as a source of stream to facilitate the baking process. The presence of numerous microscopic pieces of charred sunflower family (Asteraceae) achene epidermis material suggests that Asteraceae seeds may have also been gathered and cooked using these features; however, they may also simply be a part of the environmental record. To better answer this question, analysis of control samples taken from levels representing similar time periods as the fill samples, but well outside of the features, may help to further differentiate the environmental portion of the phytolith record from the subsistence portion of the record.

Although the grasses observed within the project area today likely reflect most of the species present during the use of these features, the phytolith record suggests that their proportions on the landscape may have been different. In particular, Panicoideae and Pooideae taxa, grasses that typically require more moisture than Chloridoideae grasses, may have been more abundant. Cool season, C3 grasses such as Indian ricegrass (*Achnatherum hymenoides*), western wheatgrass (*Pascopyrum smithii*), wild barley (*Hordeum* spp.), and ryegrass (*Elymus* spp.) were not noted in the project area, but may have occurred here in the past under slightly different climatic and land use conditions. Also, many of these C3 grasses were considered extremely palatable by livestock, and their populations were decimated due to overgrazing. In fact, it appears that grasses such as western wheatgrass and Indian ricegrass were once prominent components of the Southwest landscape, but had gone extinct in many areas between 1870 and 1930 (Bohrer 1975). Of the grasses that are observed on the landscape today, some have documented use as sources of food. *Panicum obtusum* (vine mesquite grass) seeds were utilized by Apache, Chiricahua and Mescalero groups; while *Sporobolus airoides* (alkali sacaton) and *Sporobolus flexuosus* (mesa dropseed) seeds were used occasionally during periods of famine by Hopi groups (Moerman 1998). Although these particular species of *Eragrostis* were not observed in the project area, *Eragrostis mexicana* seeds were parched, ground and the flour cooked into a mush (Cocopa). *Eragrostis secundiflora* seeds were eaten as a food by the Paiute (Moerman 1998).

Finally, this study is a good example of how site level and project level plant surveys, when combined with macrofloral and microfloral analyses, can provide greater interpretability of the archaeological record. Also, due to differences in preservation and taphonomy, subsistence related investigations need to incorporate macrofloral, pollen, starch, and phytolith analyses to gain the most comprehensive picture of plant-based subsistence. Any one of these analyses undertaken alone only presents part of the record, and by extension, only part of the story.

Table App2.1. LA 111429 and LA 155964, provenience data for samples.

Site No.	Sample No.	Feature No.	Unit	Level	Depth (cmbd)	Provenience/ Description	Analysis
LA 155964	FS 8	1	699N 4999E	2	9.93-9.95	Upper fill from center of large, basin-shaped roasting pit with abundant charcoal and fire-cracked rock; charcoal-stained sandy loam	Phytolith Starch
LA 111429	FS 138	11	7542N 9463E	3	8.88-9.91	Upper fill from center of large, bowl-shaped, flat-bottomed roasting pit with abundant charcoal and fire-cracked rock; charcoal-stained sand with some loam	Phytolith Starch

Figure App2.1. LA 111429 and LA 155964, phytolith and starch diagram for feature fill.

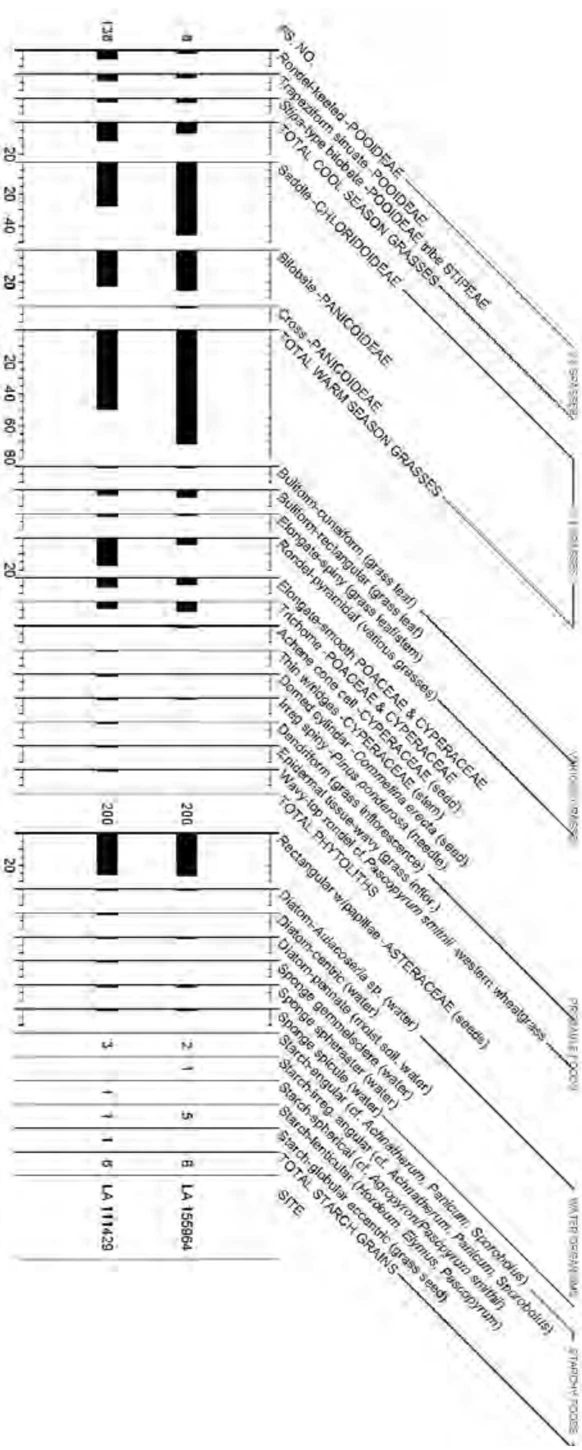

Figure App2.2. LA 155964, Feature 1, FS 8. A–J: selected microbotanical remains recovered from feature fill.

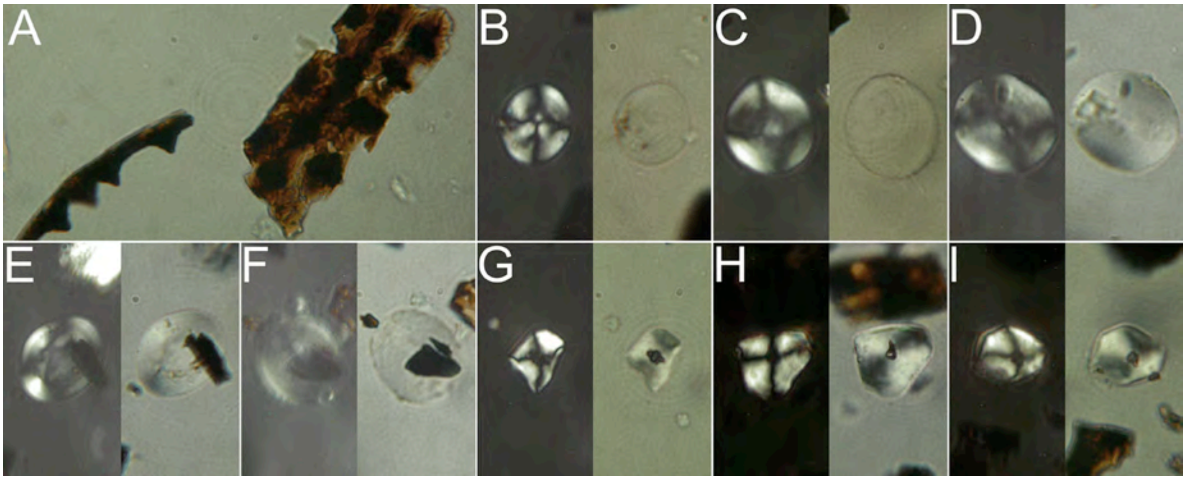

Figure App2.2. LA 155964, Feature 1, FS 8; A–J: selected microbotanical remains recovered from feature fill.

All micrographs taken at 500x magnification.

A) Microscopic pieces of charred sunflower family (Asteraceae) achene epidermis material.

B–F) Starch grains diagnostic of barley (*Hordeum* spp.), ryegrass (*Elymus* spp.) and western wheatgrass (*Agropyron smithii* syn. *Pascopyum smithii*). These grains could be derived from any one of these grasses.

G–I) Irregular/angular grains typical of a wide variety of grasses, including some of those recorded in the project area plant survey. Notably, species of dropseed (*Sporobolus*), panic grass (*Panicum*), lovegrass (*Eragrostis*) and Indian ricegrass (*Achnatherum hymenoides*) produce subangular to angular starch grains. Interestingly, maize (*Zea mays*) also produces angular starch grains; however, no phytoliths diagnostic of maize cob material were observed in the two samples examined from the project area.

Figure App2.3. LA 111429, Feature 11, FS 138. A–J: selected microbotanical remains.

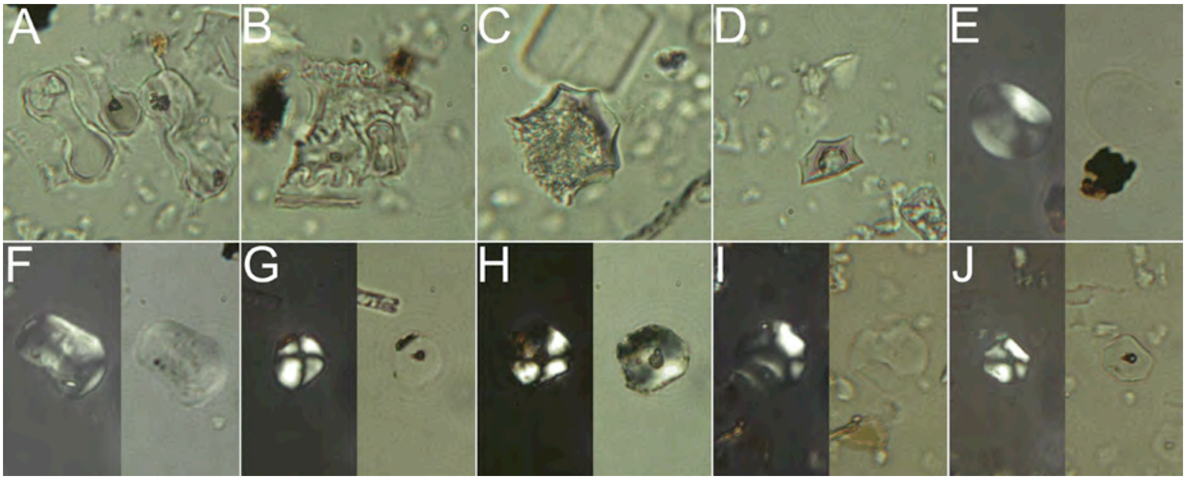

Figure App2.3. LA 111429, Feature 11, FS 138. A–J: selected microbotanical remains.

All micrographs taken at 500x magnification.

A) Leaf epidermal sheet element phytolith diagnostic of Panicoideae grasses.

B) Leaf epidermal sheet element phytolith diagnostic of Chloridoideae grasses.

C) Seed coat phytolith diagnostic of dayflower (*Commelina erecta*).

D) Wavy-top rondel typical of those produced by western wheatgrass (*Pascopyrum smithii*). This phytolith is stained brown from exposure to fire.

E) Spherical starch grain with some visible lamellae that is most likely derived from western wheatgrass (*Pascopyrum smithii*).

F) Lenticular (in cross-section) starch diagnostic of barley (*Hordeum* spp.), ryegrass (*Elymus* spp.) and western wheatgrass (*Pascopyrum smithii*). This starch grain exhibits some distortion in shape due to heat damage from cooking.

G) Small globular starch grain with a slightly eccentric hilum. This starch grain is typical of a wide variety of grasses and cannot be ascribed to any particular taxa.

H–J) Subangular to angular grains typical of a wide variety of grasses, including some of those recorded in the project area plant survey. Notably, species of dropseed (*Sporobolus*), panic grass (*Panicum*), lovegrass (*Eragrostis*) and Indian ricegrass (*Achnatherum hymenoides*) produce subangular to angular starch grains. Interestingly, maize (*Zea mays*) also produces angular starch grains; however, no phytoliths diagnostic of maize cob material were observed in the two samples examined from the project area.

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Appendix 3 | X-Ray Fluorescence Analysis of Obsidian Artifacts

GEOARCHAEOLOGICAL XRF LAB

ARCHAEOLOGICAL X-RAY FLUORESCENCE SPECTROMETRY LABORATORY
8100 Wyoming Blvd., Ste M4-158 Albuquerque, NM 87113 USA

LETTER REPORT

AN ENERGY-DISPERSIVE X-RAY FLUORESCENCE ANALYSIS OF OBSIDIAN ARTIFACTS FROM LA 111429 AND LA 155963, SOUTHERN NEW MEXICO

26 March 2013

James Moore
Office of Archaeological Studies
Museum of New Mexico

Dear Jim,

I have taken the liberty of submitting a letter report, given the short time frame. The assemblage from these two sites is quite diverse, with sources throughout Arizona and New Mexico (**Table App3.1, below**). Many of these sources are available in the Rio Grande Quaternary alluvium (Mount Taylor, Cerro Toledo Rhyolite, Bear Springs Peak), but the rest do not erode into Rio Grande alluvial contexts or erode into stream basins a great distance from these sites (Shackley 2005, 2012). One source, not yet published, McDaniel Tank, is a newly discovered source in the San Mateo Mountains southwest of Socorro. Specific instrumental methods can be found at http://www.swxrflab.net/anlysis.htm, and Shackley (2005). Source assignment was made by comparison to source standard data in the laboratory and Shackley (2005). Analysis of the USGS RGM-1 standard indicates high machine precision for the elements of interest (**Table App3.1**).

Sincerely,

M. Steven Shackley, Ph.D.
Director
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http://www.swxrflab.net/

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Table App3.1. Elemental concentrations for the archaeological samples; all measurements in parts per million (ppm).

Sample	Ti	Mn	Fe	Rb	Sr	Y	Zr	Nb	Source
LA111429									
54.13	296	117	8512	0	38	4	11	3	too small
54.36	863	689	14392	338	13	44	99	59	Unknown[1]
56	916	475	13247	189	15	49	180	21	Valles Rhy. (Cerro del Medio)
234	769	436	11042	209	26	31	122	26	Mule Mtns (Mule Cr)
246	1005	488	11731	226	25	34	125	27	Antelope Cr (Mule Cr)
LA155963									
24	342	588	11707	539	12	89	135	230	Horace Mesa (Mt Taylor)
28	610	508	12304	218	8	62	180	93	Cerro Toledo Rhy
39	781	408	10602	120	44	19	103	54	Canovas Canyon Rhy (Bears Springs Pk)
44	504	462	11757	200	8	64	168	102	Cerro Toledo Rhy
45	636	371	10185	143	12	21	71	43	El Rechuelos
53	585	479	12042	208	8	67	169	98	Cerro Toledo Rhy
55	933	431	11264	125	48	20	102	52	Canovas Canyon Rhy (Bears Springs Pk)
83	679	461	12072	194	11	60	172	97	Cerro Toledo Rhy
243	316	121	8597	0	42	1	10	0	not obsidian?
244	312	119	8831	3	42	1	13	0	not obsidian?
282	451	584	11584	500	10	89	126	214	Horace Mesa (Mt Taylor)
427	1169	616	12195	217	29	28	100	16	too small
437	698	436	10727	184	23	33	110	21	Mule Mtns (Mule Cr)
442	2624	727	15030	174	197	35	260	35	McDaniel Tank, NM
455	708	336	11579	148	11	43	160	55	Valles Rhy (Cerro del Medio)
458	1048	497	13170	197	14	54	154	82	Cerro Toledo Rhy
487	651	503	12335	215	8	61	170	89	Cerro Toledo Rhy
488	785	549	12743	223	10	62	175	99	Cerro Toledo Rhy
495	943	509	11408	214	27	33	121	23	Gwynn/Ewe Canyons
527	1141	491	11241	99	84	23	120	31	Cow Canyon
568	715	400	12177	251	21	43	102	26	Antelope Cr (Mule Cr)
624	917	387	11294	231	23	34	143	20	Antelope Cr (Mule Cr)
RGM1-S4	1515	271	13584	148	106	24	216	12	standard
RGM1-S4	1509	287	13793	151	108	24	223	8	standard
RGM1-S4	1515	271	13584	148	106	24	216	20	standard

[1] The "unknown" and "not obsidian" designations could be a result of the very small sample sizes including thinness.

Appendix 4 | Ground Stone Inventory

Table App4.1. Ground stone inventory.

Site	FS	Site Area	Provenience	Feature Type	Artifact	Final Function	Material	Condition	Heat	Count
LA 111429	36	North	Feature 22 excavation	FCR scatter	manos, one hand	heating element	sandstone	fragment	fractured	1
	37	North	Surface strip area 1	–	indeterminate	heating element	rhyolite	fragment	fractured	1
	142	North	Surface Strip area 5	near F 11 roasting pit	metates, nfs	indeterminate	sandstone	fragment	indeterminate	1
	160	North	Surface Strip area 7	near F 11 roasting pit	choppers	choppers & tabular tools	limestone	whole	none	1
	186	North	Surface Strip area 7	near F 11 roasting pit	metates, nfs	metate	sandstone	fragment	none	1
	187	North	Surface Strip area 7	near F 11 roasting pit	metates, slab	heating element	sandstone	fragment	fractured	2
	188	North	Surface Strip area 7	near F 11 roasting pit	metates, slab	heating element	sandstone	fragment	fractured	1
	201	North	Surface Strip area 7	near F 11 roasting pit	metates, nfs	heating element	sandstone	fragment	fractured	1
	234	South	Surface Strip area 10	ground stone area	manos, one hand	indeterminate	sandstone	fragment	indeterminate	1
	232	South	Surface Strip area 11	ground stone area	manos, one hand	heating element	sandstone	fragment	fractured	1
	242	South	Surface Strip area 10	ground stone area	manos, nfs	heating element	sandstone	fragment	fractured	1
	255	South	Surface Strip area 9	SS 9, Paleoindian area 3	metates, nfs	heating element	sandstone	fragment	burned and/or sooted	1
	267	South	Feature 6 excavation	F 6 FCR scatter	manos, one hand	mano	sandstone	fragment	none	1
	268	South	Feature 6 excavation	F 6 FCR scatter	metates, nfs	heating element	sandstone	fragment	fractured	2
	268	South	Feature 6 excavation	F 6 FCR scatter	metates, nfs	metate	quartzite	fragment	fractured	1
	268	South	Feature 6 excavation	F 6 FCR scatter	choppers	choppers & tabular tools	quartzite	fragment	none	1
	270	North	Feature 11 excavation	large rock-filled roasting pit	manos, one hand	heating element	sandstone	fragment	reddened, fractured	1
	271	North	Feature 11 excavation	large rock-filled roasting pit	manos, one hand	heating element	sandstone	fragment	fractured	1
	283	South	Surface collection	ground stone area	manos, one hand	mano	trachyte	whole	none	1
	284	South	Surface collection	ground stone area	manos, one hand	mano	trachyte	whole	none	1
	285	South	Surface collection	ground stone area	metates, basin	metate	sandstone	fragment	none	1
	286	South	Surface collection	ground stone area	manos, one hand	heating element	quartzite	whole	crazed	1
	287	South	Surface collection	ground stone area	metates, nfs	metate	sandstone	fragment	none	1
	288	South	Surface collection	ground stone area	manos, one hand	mano	quartzite	whole	none	1
	289	South	Surface collection	ground stone area	manos, nfs	indeterminate	quartzitic sandstone	fragment	indeterminate	1
	290	South	Surface collection	ground stone area	manos, one hand	heating element	trachyte	fragment	fractured	1
	313	North	Feature 11 excavation	large rock-filled roasting pit	metates, slab	heating element	sandstone	fragment	burned and/or sooted	1
	316	North	Feature 11 excavation	large rock-filled roasting pit	metates, slab	heating element	sandstone	fragment	burned and/or sooted	1

(Table App4.1, continued)

Site	FS	Site Area	Provenience	Feature Type	Artifact	Final Function	Material	Condition	Heat	Count
	317	North	Feature 11 excavation	large rock-filled roasting pit	metates, nfs	heating element	quartzitic sandstone	fragment	burned and/or sooted	1
Site Total										30
LA111435	24	–	Feature 3 excavation	hearth	manos, one hand	heating element	sandstone	fragment	fractured	1
	35	–	Feature 10 surface strip	fire-cracked rock w/ stain	manos, nfs	heating element	nonvesicular basalt	fragment	fractured	2
	36	–	Feature 10 surface strip	fire-cracked rock w/ stain	manos, nfs	heating element	nonvesicular basalt	fragment	fractured	1
	46	–	F4 surface strip	small fire pit	indeterminate	indeterminate	nonvesicular basalt	fragment	fractured	1
	59	–	Feature 7 excavation	stain/rodent burrow	manos, two hand	cobble tool	limestone	whole	none	1
	61	–	Surface collection		metates, basin	metate	nonvesicular basalt	fragment	none	1
Site Total										7
Site		Site Area	Excavation Area	Ground Stone Area	Artifact	Final Function	Material	Condition	Heat	Count
LA 155963	31	C	Feat. 125 Surface Strip	small fire pit w/ FCR	metates, basin	heating element	nonvesicular basalt	fragment	fractured	1
	112	A	Surface Strip Area 5	Artifact Cluster 1	manos, one hand	heating element	quartzite	fragment	fractured	1
	159	A	Surface Strip Area 4	Feat. 18, 19, 20, SS4	metates, basin	heating element	sandstone	fragment	fractured	1
	160	A	Surface Strip Area 4	Feat. 18, 19, 20, SS4	metates, nfs	heating element	sandstone	fragment	fractured	1
	169	A	Surface Strip Area 4	Feat. 18, 19, 20, SS4	metates, basin	heating element	sandstone	fragment	fractured	1
	179	A	Surface Strip Area 4	Feat. 18, 19, 20, SS4	metates, nfs	heating element	sandstone	fragment	fractured	1
	180	A	Surface Strip Area 4	Feat. 18, 19, 20, SS4	metates, nfs	indeterminate	sandstone	fragment	indeterminate	1
	204	A	Surface Strip Area 4	Feat. 18, 19, 20, SS4	metates, nfs	heating element	sandstone	fragment	fractured	1
	206	A	Surface Strip Area 4	Feat. 18, 19, 20, SS4	metates, nfs	heating element	sandstone	fragment	fractured	1
	250	A	Surface Strip Area 4	Feat. 18, 19, 20, SS4	metates, nfs	heating element	sandstone	fragment	fractured	1
	350	B	Surface Strip Area 2	Area B Feat. 140-143	manos, two hand	cobble tools	quartzitic sandstone	whole	none	1
	390	A	Surface Strip Area 4	Feat. 18, 19, 20, SS4	metates, slab	metate	sandstone	whole	none	1
	448	A	Feature 13 excavation	Feat. 9, 4, 15, AC4	metates, basin/slab	metate	sandstone	fragment	none	1
	449	A	Surface Strip Area 4	Feat. 18, 19, 20, SS4	metates, slab	indeterminate	nonvesicular basalt	whole	indeterminate	1
	449	A	Surface Strip Area 4	Feat. 18, 19, 20, SS4	metates, nfs	metate	sandstone	fragment	none	1
	496	B	Surface Strip Area 2	Area B F140-143	indeterminate	heating element	sandstone	fragment	fractured	1
	504	A	Feat. 9 Surface Collection	Feat. 9, 4, 15, AC4	choppers	choppers & tabular tools	limestone	whole	none	1

(Table App4.1, continued)

Site	FS	Site Area	Provenience	Feature Type	Artifact	Final Function	Material	Condition	Heat	Count
	547	A	Feat. 14 Surface Collection	Feat. 9, 4, 15, AC4	manos, one hand	heating element	nonvesicular basalt	fragment	fractured	1
	560	A	Feat. 14 Surface		metates, nfs	indeterminate	sandstone	fragment	indeterminate	1
	613	A	Feat. Surface Collection	Feat. 9, 4, 15, AC4	metates, nfs	heating element	sandstone	fragment	fractured	1
Site Total										20
LA 155964	4	–	Feature 1 excavation	large rock-filled roasting pit	manos, nfs	heating element	limestone	fragment	burned and/or sooted, fractured, reddened	1
	39	–	Feature 1 excavation	large rock-filled roasting pit	tabular tools	heating element	limestone	whole	fractured	1
	41	–	Feature 1 excavation	large rock-filled roasting pit	metates, nfs	heating element	nonvesicular basalt	fragment	fractured	1
Site Total										3
LA 155968	33	–	67101N 472.64 E	surface collection	metates, nfs	heating element	sandstone	fragment	fractured	1
	64	–	648.99N 513.63E	surface collection	metates, nfs	metate	nonvesicular basalt	fragment	none	1
	456	–	663.73N 573.84E	surface collection	tabular knife	tabular knife	sandstone	fragment	none	1
Site Total										3
LA 156877	89	–	Feature 1 excavation	FCR scatter/deflated fire pit	metates, nfs	heating element	sandstone	fragment	fractured	1
	97	–	Feature 1 excavation	FCR scatter/deflated fire pit	metates, basin	metates	vesicular basalt	fragment	none	1
	98	–	Feature 1 excavation	FCR scatter/deflated fire pit	metates, nfs	metates	sandstone	fragment	none	1
Site Total										3

FCR = fire-cracked rock
nfs = not further specified

Appendix 5 | Summary of Regional Large Roasting Pits

Table App5.1. Summary of regional large roasting pits based on size, depth, and report descriptions; diameter 70 cm or greater.

Location	Site	Feature No.	Rock Fill	Size (m Diameter)	Depth (m)	Fill	Fuel Wood	Food Remains	Date (Range C14 Dates)	Reference
SPA	LA 111429	3	none	1.7 x 1.9	0.52	charcoal-stained soil	saltbush, yucca	none	AD 85–260	Chapter 7
		11	caliche	2.2	0.63	tightly packed caliche, charcoal, ash, stained soil	mesquite, saltbush, cholla, yucca	prickly pear, spurge, grass	AD 1620–1685	Chapter 7
	LA 111435	6	none	1.1	0.39	charcoal-stained soil	saltbush, yucca	goosefoot, purslane, hedgehog cactus, prickly pear cactus	AD 378–540	Chapter 8
	LA 155963	14	burned rock	0.7	0.10	soil, no charcoal	saltbush (stain outside of pit)	none	AD 430–591	Chapter 9
	LA 155964	1	cobble	2.8	0.46	tightly packed cobbles, charcoal, stained soil	mesquite, saltbush, tarbush, yucca	amaranth, goosefoot, bugseed, cactus, prickly pear, grass,	AD 1800–1940	Chapter 10
	LA 155968	1	none	1.3 x 1.5	0.56	charcoal-stained soil	saltbush, mesquite, cholla, tarbush, yucca	yucca	AD 656–887	Chapter 11
SE Hobbs	LA 132494	14	rock	.8 x .7	0.25	burned rock, no charcoal	none	–	1000–800 BC	Jones et al.
		9	burned caliche at base	.78 x .50	0.37	charcoal-stained soil	Fabaceae (woody legume)	none	AD 540–660	Jones et al. 2010:169–171
	LA 130738	4	burned caliche	1.5 x 1.2	0.15	charcoal-stained soil	mesquite, woody legume	none	AD 410–600	Jones et al. 2010: 212
		5	burned caliche	1.13 x	0.20	charcoal-stained soil	mesquite, woody legume	none		Jones et al. 2010: 212
	LA 8055	65	burned rock	1.26 x	0.18	charcoal-stained soil	mesquite	none	AD 980–1170	Jones et al. 2010:254
		68	burned caliche	.86 x .67	0.21	sand with charcoal flecks	–	–	–	Jones et al. 2010:272
SE Carlsbad	LA 132518	22.1	lined with burned rock	1.10 x .84	0.34	ring midden pit: charcoal-stained soil	woody legume, hard wood	mussel shell	1210–970 BC	Jones et al. 2010:441
		23	burned rock	1.52 x	0.26	soil with charcoal flecks	woody legume	none	–	Jones et al. 2010:400
		26	burned rock	1.72 x	0.29	soil with charcoal flecks	indeterminant wood	charred agave-like	1040–850 BC	Jones et al. 2010:402
	LA 130730	7.1	burned cobbles	2.1 x 1.4	0.25	rock edges and top; charcoal	juniper, woody legume	agave fibers	920–950 BC	Jones et al. 2010: 451
		10.1	burned cobbles	3.0 x 2.4	0.46	ring midden pit; soil with	mesquite, juniper	agave fibers, shell	1450–1300 BC	Jones et al. 2010:
		26	burned rock	1.57 x	0.15	charcoal-stained soil	indeterminate wood	agave fibers	1270–940 BC	Jones et al. 2010:
	LA 130727	8.1	burned limestone cobbles	1.55 x 1.54	0.24	ring midden pit; soil	–	–	–	Jones et al. 2010: 519
		8.2	burned rock	.72 x .63	0.17	ring midden pit; soil with sparse charcoal	woody legume	–	2830–2460 BC	Jones et al. 2010: 519
	LA 132520	17	burned rock	.71 x .69	0.18	rock at base; soil	–	–	–	Jones et al. 2010: 572
		18	burned rock	.83 x .68	0.19	soil, rock at base	–	–	–	Jones et al. 2010: 575
		14	burned rock	1.23 x	0.11	soil	–	–	–	Jones et al. 2010: 582
	LA 132522	11	burned rock	2.18	0.22	charcoal-stained soil	woody legume, oak, buckhorn-	none	AD 1430–1630	Jones et al. 2010:646,
		11.1	burned rock	.75 X .63	0.17	charcoal-stained soil	woody legume	none	AD 1300–1430	Jones et al.
		10.1	burned cobbles	1.44 x 1.3	0.23	soil with charcoal flecks	pine/juniper	none		Jones et al. 2010: 653
		10.3	burned rock	.75 x .52	"slightly exca-vated"	rock	nearby woody legume	–	nearby BC 2140 to 1910	Jones et al. 2010: 656
		10.4	burned rock	1.08 x	0.15	soil with charcoal flecks	woody legume, juniper	shell?	380–160 BC	Jones et al. 2010:
		9.1	burned rock	.70 x .50	0.15	soil	–	–	–	Jones et al. 2010: 664
		13	burned rock	.74 x .68	0.20	soil	–	–	–	Jones et al. 2010: 664
		8	small burned	1.9 x 1.73	0.25	soil with charcoal flecks	pine/juniper	none	400–210 BC	Jones et al. 2010:
		5	burned rock	1.08 x .84	no pit	deflated; some charcoal	–	–	–	Jones et al. 2010: 671

(Table App5.1, continued)

Location	Site	Feature No.	Rock Fill	Size (m Diameter)	Depth (m)	Fill	Fuel Wood	Food Remains	Date (Range C14 Dates)	Reference
	LA 132525	1	burned limestone	1.1 x .84	0.21	soil with charcoal flecks and	woody legume, buckhorn-type	none	500–240 BC	Jones et al. 2010:
		5	burned limestone	1.5 x 1.2	0.22	charcoal-stained soil	woody legume, buckhorn-type	–	350–40 BC	Jones et al. 2010: 701
	LA 130723	35	burned rock	1.0 x .83	0.15	soil with charcoal flecks	hardwood	none	–	Jones et al. 2010: 715, 724
		36.1	burned rock	1.7	0.22	soil with abundant charcoal	hardwood, juniper, woody legume	none	790–430 BC	Jones et al. 2010: 715, 734
		36.5	burned rock	2.0	0.15	charcoal-stained soil	juniper	none	900–790 BC	Jones et al. 2010: 715, 739
		36.7	burned rock	2.4 x 1.86	0.28	soil with abundant charcoal	hardwood	none	–	Jones et al. 2010: 715, 739
		36.10	burned rock	4.25 x 2.6	0.25	charcoal-stained soil	–	–	Archaic	Jones et al. 2010: 715, 740
		36.10.1	burned rock	2.1 x 1.85	0.13	charcoal-stained soil	hardwood, woody legume	none	940–810 BC	Jones et al. 2010: 715, 740
		36.10.2	none	2.9 x 2.0	0.15	charcoal-stained soil	hardwood	none	820–780 BC	Jones et al. 2010: 715, 742
		36.16	none	.98 x .84	0.23	charcoal-stained soil	woody legume, saltbush, juniper	none	–	Jones et al. 2010: 716, 743
		36.17	tabular rock lined	1.5 x .90	0.16	charcoal-stained soil	juniper	none	–	Jones et al. 2010: 716, 743–744
		36.20	burned rock	0.8	0.12	soil with charcoal flecks	indeterminate wood	none	–	Jones et al. 2010: 716, 744
		40	burned rock	0.81	0.10	charcoal-stained soil	juniper, woody legume	none	AD 1180–1280	Jones et al. 2010: 716, 725
		43	burned rock	.87 x .62	0.13	charcoal-stained soil	–	–	–	Jones et al. 2010: 716, 726
		45	none	0.8	0.12	charcoal-stained soil	–	–	–	Jones et al. 2010: 716, 729
	LA 130721	1.2	burned rock	.92 x .95	0.21	rock filled; soil	juniper	none	370–200 BC	Jones et al. 2010: 769
SW/ Mesilla Bolson	LA 132529	1.6	burned rock	1.76 x	0.11	charcoal-stained soil	mesquite, buckhorn family	none	500–240 BC	Jones et al. 2010:
	LA 129532	2	none	1.0 x 1.5	0.10	charcoal-stained soil	mesquite	–	AD 1430–1640	Jones et al. 2010r: 829
		3	none	1.5 x 1.1	0.15	lightly charcoal-stained soil	mesquite	none	800–540 BC	Jones et al. 2010: 829,
		4	none	2.3 x .80	0.07	lightly charcoal-stained soil	none	none	–	Jones et al. 2010: 832
	LA 129533	5	burned caliche	1.9 x .60	0.08	charcoal-stained soil	mesquite	none	AD 1310–1440	Jones et al. 2010:
	LA 129538	2	burned caliche	1.0 x .50	0.10	charcoal-stained soil	mesquite	none	790–410 BC	Jones et al. 2010:
		3	burned caliche	.80 x .50	0.09	charcoal-stained soil	mesquite	none	790–390 BC	Jones et al. 2010r: 908–909
SW West Potrillo	LA 129548	3	none	2.5 x 1.5	0.46	charcoal-stained soil	mesquite, saltbush	none	400–200 BC	Jones et al. 2010: 924
	isolated	1	none?	1.35 x .60	0.20	charcoal-stained soil?	saltbush	none	AD 610–690	Jones et al. 2010: 939
SW Mimbres Basin	LA 54812	4	sparse	1.25 x 1.03	0.30	charcoal-stained soil with sparse burned rock	mesquite, saltbush, wood legume	none	1040–850 BC	Jones et al. 2010: 1105
	LA 59652	33.1	few	.80 x .75	0.28	soil, ash	–	abundant fauna, some burned	–	Jones et al. 2010: 1217
		16	none	1.23 x 1.04	0.36	soil with charcoal flecks	saltbush, mesquite	abundant fauna, some burned	AD 650–780	Jones et al. 2010: 1217

(Table App5.1, continued)

Location	Site	Feature No.	Rock Fill	Size (m Diameter)	Depth (m)	Fill	Fuel Wood	Food Remains	Date (Range C14 Dates)	Reference
		40	few?	.72 x .63	0.32	soil with charcoal flecks and burned rock	juniper, saltbush-type, mesquite	abundant fauna, some burned; goosefoot, mesquite seed, corn	AD 690–890	Jones et al. 2010s: 1218
		34	none	1.17 x	0.27	soil with charcoal flecks	mesquite	–	AD 430–650	Jones et al. 2010: 1232
	LA 144921	3	none	1.25 x	0.20	charcoal-stained soil	saltbush, mesquite	–	–	Jones et al. 2010: 1326
		6	few	.85 x .40	0.11	charcoal stained with pockets of charcoal	mesquite, saltbush	fauna, mesquite seed, corn	AD 220–400	Jones et al. 2010: 1326
		8(?)	none	.94 x .56	0.17	hearth? Soil with charcoal	saltbush	mesquite seeds	AD 220–400	Jones et al. 2010: 1327
		13	none	1.21 x	0.16	sand with ash and charcoal	woody legume	cheno-am	–	Jones et al. 2010: 1328
		18(?)	none	.50 x .75	~.20	charcoal-stained soil	saltbush, indeterminate wood	–	–	Jones et al. 2010: 1328, 1331
	LA 129562	12	sparse	1.03 x .95	0.26	soil with charcoal flecks and	mesquite	–	AD 260–240	Jones et al. 2010:1415
SW Lordsburg Basin	LA 129563	2	none	.80 x .61	0.35	charcoal-stained soil	saltbush, mesquite	–	AD 50–230	Jones et al. 2010: 1465, 1468
		3	none	.88 x .44	0.22	charcoal-stained soil	saltbush	–	360–60 BC	Jones et al. 2010: 1468
		9	none	.95 x .54	0.14	charcoal-stained and flecked	mesquite	–	AD 410–770	Jones et al. 2010: 1468
		10	none	.77 x .55	0.14	charcoal stained soil with pieces and flecks	mesquite, cholla, saltbush	–	AD 150–390	Jones et al. 2010: 1468
SW Peloncillo Mts.	LA 129571	1.1	burned rock	2.46 x 1.0	.70-.95	3 uses, burned rock and burned soil	juniper, mesquite	dense agave fiber and leaves	AD 1470–1670	Jones et al. 2010: 1512
SW Big Burro Mts.	LA 121159	14	rock-lined	0.8	0.30	charcoal-stained soil and dense charcoal	juniper, mt. mahogany	corn cupule, chenoams, pigweed,	–	Railey 2000: 233; Huckell 2000:529
	LA 78089	2	deflated	2	0.40	–	–	–	Early Pithouse	Turnbow and Reycraft 2000:62
		7	burned rock	1.0 x .85	0.36	–	–	–	Late Archaic	Turnbow and Reycraft 2000:61
		10	burned rock	0.9 x .82	0.18	–	juniper, oak, mt. mahogany	chenopodium, corn phytolith	Late Archaic	Turnbow and Reycraft 2000:61, 73; Huckell 2000:528, 546
		11	none	1.2 x 1.22	0.19	–	–	–	Late Archaic	Turnbow and Reycraft 2000:61
		12	none	1.2	0.26	–	juniper	corn phytolith, walnut shells, pigweed	390–355 BC	Turnbow and Reycraft 2000:62, 73
		19	burned rock	.8 x .64	0.18	–	–	–	Late Archaic	Turnbow and Reycraft 2000:61
		24	none	0.8	0.34	–	–	–	Late Archaic	Turnbow and Reycraft 2000:62
		31	none	1.0 x .95	0.53	–	juniper	corn kernel, corn cupule, chenopodium	Late Archaic	Turnbow and Reycraft 2000:62; Huckell
		39	burned rock	1.3 x 1.18	0.36	–	–	corn phytolith	Late Archaic	Turnbow and Reycraft 2000:62, 73
		42	burned rock	1.5 x 1.13	0.60	–	none	corn cupules & glumes, corn phytolith, walnut seed, grass	365–45 BC	Turnbow and Reycraft 2000:62, 73; Huckell 2000:550

(Table App5.1, continued)

Location	Site	Feature No.	Rock Fill	Size (m Diameter)	Depth (m)	Fill	Fuel Wood	Food Remains	Date (Range C14 Dates)	Reference
		46	burned rock	1.6 x .85	0.25	–	none	prickly pear phytoliths	Early Pithouse	Turnbow and Reycraft 2000: 62, 76; Huckell 2000: 528
		60	burned rock	1.1 x .73	0.11	–	juniper, mt. mahogany	none	Early Pithouse	Turnbow and Reycraft 2000:62, Huckell
	LA 99631	1	burned rock	deflated	0.21	–	–	–	Late Archaic	Turnbow 2000:125
		2	burned rock	.76 x .96	0.14	–	–	–	Late Archaic	Turnbow 2000:125
		12	burned rock	1.25	0.20	–	none	juniper seeds	Late Archaic	Turnbow 2000:126; Huckell 2000:543
		15	burned rock	.70 x .63	0.06	–	–	–	Late Archaic	Turnbow 2000:126
		18	abundant burned rock	.86 x .80	0.32	multi-use, soil with charcoal and rock; rock base	juniper	none	Late Archaic	Turnbow 2000:126, 148; Huckell 2000: 528
		45	burned rock	.84 x .95	0.11	–	–	–	Late Archaic	Turnbow 2000:126
		67	burned rock	.70 x .60	0.30	–	–	–	Late Archaic	Turnbow 2000:126
		82	abundant burned rock	0.8	0.27	–	mt. mahogany, juniper	none	Late Archaic	Turnbow 2000:126; Huckell 2000: 528
		93	sparse	.80 x .75	0.25	–	–	–	Late Archaic	Turnbow 2000:126
		101	burned rock	.80 x .64	0.13	–	–	–	Late Archaic	Turnbow 2000:126
		103	abundant burned rock	1.30 x 1.06	0.23	rock base	juniper, mt. mahogany	chenoams	Late Archaic	Turnbow 2000:126; Huckell 2000: 528, 539
		107	burned rock	.70 x .64	0.12	–	–	–	Late Archaic	Turnbow 2000:126
		108	burned rock	.98 x .77	0.29	–	mt. mahogany	none	Late Archaic	Turnbow 2000:126; Huckell 2000: 528
		118	burned rock	.85 x .80	0.18	–	oak, mt. mahogany, juniper	amaranth, chenopodium	Late Archaic	Turnbow 2000:126; Huckell 2000: 528, 539
		120	burned rock	.95 x .90	0.22	–	–	–	Late Archaic	Turnbow 2000:126
		127	burned rock	1.2 x 1.1	0.28	–	–	–	Late Archaic	Turnbow 2000:126
		156	burned rock	1.48 x	0.26	–	–	–	Late Archaic	Turnbow 2000:126
		175	burned rock	1.07 x .87	0.20	–	–	–	Late Archaic	Turnbow 2000:126
Fort Bliss (Texas)	41EP3469	1	burned rock	1.4 x 1.2	0.20	charcoal-stained soil	hardwood	–	AD 1150–1280	Condon et al. 2007: 144
Fort Bliss	LA 97941	3-B2	sparse cobbles	3.55 x 3.50	0.45	charcoal-stained soil	mesquite, saltbush	burned rabbit bones	AD 750–1050	Condon et al. 2008: 116–118
		5B	few?	1.27 x .90	0.10	charcoal-stained soil	mesquite	–	AD 1800–2000	Condon et al. 2008:
		12B	none	1.50 x	0.10	charcoal-stained soil	–	–	–	Condon et al. 2008:
		13B	sparse caliche	.85 x 1.20	0.12	charcoal-stained soil	hardwood	none	AD 1200–1400	Condon et al. 2008:
		14B	sparse caliche	1.35 x 1.20	0.23	charcoal-stained soil	mesquite	none	AD 300–550	Condon et al. 2008: 131–133
		15B	caliche	.75 x .60	0.07	charcoal-stained soil	–	–	–	Condon et al. 2008:
		16B	none	1.2 x 1.0	0.23	charcoal-stained soil	–	–	–	Condon et al. 2008: 133–134
	LA 97944	3A	rock	1.63 x	0.44	charcoal-stained soil	hardwood	none	AD 750–1000	Condon et al. 2008:
	LA 97943	11A	none	1.0 x .70	0.10	charcoal-stained soil	saltbush, mesquite, creosote	corn	AD 760–980	Condon et al. 2008:
		10	rock in lower fill	3.2	0.63	charcoal-stained soil	saltbush, mesquite, creosote	corn, juniper, prickly pear, and yucca	AD 1000–1200	Condon et al. 2008: 197
		26(?)	burned rock	.70 x .60	0.20	charcoal-stained soil	mesquite	none	AD 700–900	Condon et al. 2008: 204–206

(Table App5.1, continued)

Location	Site	Feature No.	Rock Fill	Size (m Diameter)	Depth (m)	Fill	Fuel Wood	Food Remains	Date (Range C14 Dates)	Reference
		32	burned cobbles	.70 x .80	0.10	charcoal-stained soil	–	–	–	Condon et al. 2008: 211–212
		34(?)	nonene	1.63 x .87	0.30	charcoal stained soil	–	–	–	Condon et al. 2008:
		38(?)	sparse caliche	1.7 x 1.2	0.30	charcoal stained soil	–	–	–	Condon et al. 2008:
	LA 126395	21	one	1.35	0.30	charcoal stained soil	–	–	–	Church and Sale
	LA 117704	8	burned rock	> 1.5	.20?	charcoal-stained soil	mesquite, creosote	fish/bird/corn lipids	1500–1120 BC	Quigg et al. 2002:84, 97–100
	LA 117705	12	burned limestone	.70 x .75	0.21	mottled charcoal-stained soil	–	–	AD 780–940	Quigg et al.
		20	burned rock	.80 x .85	0.09	grayish brown matrix with ash pocket	–	–	–	Quigg et al. 2002:141–143
	LA 117706	1	burned limestone	1.3	0.11	loose sand with no charcoal	–	–	–	Quigg et al. 2002:159
		2	burned limestone	0.8	0.12	loose sand with no charcoal	–	residue similar to piñon and mescal	on residue 6610–5960BC	Quigg et al. 2002:160–163
		5	burned limestone	1.1 x 1.5	0.30	charcoal-stained soil	–	residue similar to piñon and mescal	on residue 6670–6590 BC	Quigg et al. 2002:164–165
	LA 117710	FF	burned limestone	1.6 x 1.0	0.12	soil lacking charcoal	–	–	–	Quigg et al.
	LA 117712	1	burned limestone	1.2	~.30?	darkly stained soil and burned sticks	creosote, broomweed, mesquite, saltbush	agave bases and leaves	AD 1660–1995; residue AD	Quigg et al. 2002:207–214
	LA 117713	1a	burned limestone	1.3 x .80	0.20	mottled charcoal-stained soil	creosote, saltbush	corn-like lipids	AD 1040–1290	Quigg et al.
		1b	burned limestone	.90 x .95	0.12	multiple layers of charcoal stained soil	mesquite, creosote	–	AD 1080–1200	Quigg et al. 2002:243–247
		2	burned limestone cobbles	0.8	0.08	rock lined; charcoal stained	saltbush, creosote	yucca parts, agave base	AD 1140–1260	Quigg et al. 2002:250–254
	LA 117721	A(1)	burned rock	1.0 x 1.0	0.15	rock and loose fill	none	none	–	Quigg et al.
US 54 Tularosa Basin	LA 6829	41	traces	1.17 x .93	0.18	–	–	–	AD 1010–1290	Railey et al. 2002
		46	traces	.85 x .80	0.37	–	–	–	AD 1180–1310 and AD 1370–1380	Railey et al. 2002
		62	traces	.72 x .71	0.28	–	–	–	AD 1050–1100 and	Railey et al. 2002
		185	10 pieces of granite	1.1 x .91	0.11	–	–	–	AD 1050–1100 and	Railey et al. 2002
	LA 115256	3	nonene?	0.97	0.16	charcoal-stained soil	mesquite and saltbush	–	AD 330–580	Railey et al. 2002
	LA 115262	2	caliche and rock	.73 x .68	0.12	–	–	–	370 BC – AD	Railey et al. 2002
		4	traces	1.32 x	0.37	–	–	–	2340–2010 BC	Railey et al. 2002
		24	caliche and rock	1.3 x 1.08	0.24	–	–	–	520–200 BC	Railey et al. 2002
	LA 115265	3	caliche	.89 x .58	0.08	–	mesquite and saltbush	corn kernels, amaranth, cheno-ams	AD 870–1220/ early Dona	Railey et al. 2002
	LA 126181	4	nonene	0.77	0.13	–	–	–	AD 260–640	Railey et al. 2002
		7	nonene	.70 x .65	0.14	–	–	–	AD 390–630	Railey et al. 2002
		15	nonene	0.9	0.16	–	–	–	AD 400–640	Railey et al. 2002
		24	nonene	.70 x .63	0.32	–	–	–	AD 1050–1100 and AD 1140–1290	Railey et al. 2002
	LA 128699	20	–	1.61 x 1.23	0.34	–	–	–	2190–2170/2150–1740 BC	Railey et al. 2002

(Table App5.1, continued)

Location	Site	Feature No.	Rock Fill	Size (m Diameter)	Depth (m)	Fill	Fuel Wood	Food Remains	Date (Range C14 Dates)	Reference
		31	–	.80 x .70	0.10	ash stained	–	–	AD 330–460/ 480–520	Railey et al. 2002
		33	rock	.85 x .70	0.40	ash stained	–	–	160 BC AD 90	Railey et al. 2002
		47		.90 x .85	0.50	ash stained	–	–	2010–1690 BC	Railey et al. 2002
		58	rock	1.07 x	0.35	ash stained	–	–	2480–2140 BC	Railey et al. 2002
		78	rock	.76 x .50	0.28	ash stained	–	–	AD 220–640	Railey et al. 2002
		81	rock	.94 x .90	0.17	ash stained	–	grass pollen; mesquite or corn residue	AD 420–610	Railey et al. 2002
		82	rock	1.1 x .74	0.20	ash stained	–	–	AD 540–690	Railey et al. 2002
		83	rock	.74 x .72	0.19	ash stained	–	–	2140–1770 BC	Railey et al. 2002
		92	–	1.07 x 1.05	0.67	ash stained	–	–	2130–2080/20 60–1760 BC	Railey et al. 2002
		98	–	1.18 x 1.16	0.68	ash stained	–	–	2130–2080/20 60–1760 BC	Railey et al. 2002
	LA 128700	29	nonene	1.44 x 1.1	0.21	–	–	none	AD 720–740 and AD	Railey et al. 2002
		35	–	.85 x .70	0.14	–	–	none	AD 130–350	Railey et al. 2002
		38	–	.73 x .81	0.10	–	–	none	AD 1010–1260	Railey et al. 2002
		43	–	.73 x .65	0.13	–	–	none; prickly pear	AD 1039–1280	Railey et al. 2002
	LA 128708	2	3 rock cluster	2.2 x 1.7	0.43	charcoal stained	mesquite and saltbush -- not distinguished by sample or part (plus grass and amaranth	maize or mesquite residue	160 BC–AD 120	Railey et al. 2002
		39	–	.76 x .65	0.09	–		–	790–360 BC	Railey et al. 2002
		41	–	.75 x .55+	0.27	–		–	1300–900 BC	Railey et al. 2002
		42	–	1.22 x .79	0.18	–		–	AD 570–790	Railey et al. 2002
		44	–	.75 x .70	0.15	–		–	AD 650–900	Railey et al. 2002
		45	–	.80 x .70	0.21	–		–	40 BC–AD 120	Railey et al. 2002
El Paso/ Santa Teresa	LA 86774	2	1 piece caliche	1.84	0.10	charcoal stained	mesquite	dropseed	AD 555–780	Moore 1996:148–156
		7	nonene	1.04 x .88	0.20	charcoal stained	mesquite and saltbush	–	115 BC– AD	Moore 1996:148–156
		8	nonene	1.16 x .76	0.10	charcoal stained	none	sunflower, dropseed	–	Moore 1996:148–156
		9	3 pieces rock	1	0.29	charcoal stained	–	–	–	Moore 1996:148–156
		10	nonene	.95 x .85	0.33	charcoal stained	–	portulaca	–	Moore 1996:148–156
	LA 86780	4	caliche	1.44 x .92	0.11	charcoal stained	mesquite	none	405–180 BC	Moore 1996:167–210
		6	nonene	.86 x .83	0.12	charcoal stained	–	–	–	Moore 1996:167–210
		7	1 piece caliche	.70 x .50	0.06	charcoal stained	mesquite	dropseed	2910–2595 BC	Moore 1996:167–210
		9	rock	.74 x .70	0.14	charcoal stained	mesquite	none	760–635 BC and 560–380	Moore 1996:167–210
		10	nonene	1.18 x .92	0.08	charcoal stained	none	none	–	Moore 1996:167–210
		19	nonene	1.24 x	0.10	charcoal stained	none	none	–	Moore 1996:167–210
		21	rock	.72 x .68	0.12	charcoal stained	none	none	–	Moore 1996:167–210
		22	nonene	1.24 x .60	0.08	charcoal stained	none	none	–	Moore 1996:167–210
		23	nonene	1.06 x .92	0.10	charcoal stained	none	none	–	Moore 1996:167–210
T. Basin Alamo-gordo	LA 119530	4	nonene?	.68 x .95	0.40	ash and charcoal stained	none	mustard, purslane, grass, saltbush fruit	–	Turnbow and Kuroto 2008
		40	rock	.80 x .76	0.10	charcoal stained	none	purslane, goosefoot	360–280 BC and	Turnbow and Kuroto 2008
		41	rock	.71 x .78	0.49	charcoal stained	none	none were identifiable	160 BC–AD	Turnbow and Kuroto

(Table App5.1, continued)

Location	Site	Feature No.	Rock Fill	Size (m Diameter)	Depth (m)	Fill	Fuel Wood	Food Remains	Date (Range C14 Dates)	Reference
South-east	ENM	5	rock	.55 X .70	0.10	charcoal stained	oak	none?	AD 260 ± 150	Lord and Reynolds
	ENM 10418	16	nonene	1.60	0.60	charcoal filled	–	spurge	–	Lord and Reynolds
		17	nonene	0.80	0.50	charcoal filled	–	–	–	Lord and Reynolds
		30	caliche	1.9 x 1.73	0.10	charcoal filled	–	mesquite	AD 1190 ± 70	Lord and Reynolds
		31	caliche	0.80	0.20	charcoal filled	–	mesquite	AD 660 ± 70	Lord and Reynolds
		36	nonene	0.75	0.27	charcoal filled	–	spurge, *Setaria*	880 BC ± 140	Lord and Reynolds
		BB (99)	rock	.72 x .42	0.18	charcoal filled	–	spurge, mesquite	AD 1610 ± 80	Lord and Reynolds
El Paso	41EP496	7	rock	3.6 x 3.3	0.10	carbonaceous soil	–	–	AD 40–550	Carmichael 1985c
		10	rock	1.9 x 2.2	0.22	carbonaceous sand	–	–	1045–60 BC	Carmichael 1985c
	41EP492	2	rock	1.50	0.31	carbonaceous soil	–	–	–	Carmichael 1985c
		3	rock ring	2.1 x 1.85	0.10	carbonaceous soil	–	–	2145–1420 BC (?)	Carmichael 1985c
		23	rock	2.6 x 2.0	0.40	carbonaceous soil	juniper	none	–	Carmichael 1985c
		34	rock	2.5 x 2.2	0.32	ash and charcoal stained	mesquite	none	1210–805 BC	Carmichael 1985c
	41EP325	5	rock	1.1 x .90	0.10	light charcoal stained	none	none	–	Fields and Girard 1983
		17	rock	.75 x .50	0.15	soil	–	–	–	Fields and Girard 1983
		21	rock	1.5 x 1.6	0.10	charcoal stained	none	none	AD 520 ± 70	Fields and Girard 1983
		27	rock	0.80	0.15	densely packed rock; charcoal stained	none	none	2160 BC ± 160	Fields and Girard 1983
		31	rock	1.15	0.10	light charcoal stained	none	none	Early Mesilla	Fields and Girard 1983
		32	rock	1.90	0.20	densely packed rock; darkly stained	none	unknown plant	650 BC ± 120	Fields and Girard 1983

FCR = fire-cracked rock
nfs = not further specified

APPENDIX 6 | RADIOCARBON ANALYSIS DATA

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March 12, 2012

Dr. Robert Dello-Russo
Office of Archaeological Studies
P.O. Box 2087
Santa Fe, NM 87504
USA

RE: Radiocarbon Dating Results For Samples 422-F1-74-s , 429-F3-302-y, 429-F11-321s, 429-F11-321y, 429-Hall 1, 429-Hall 2, 435-F3-23-t, 435-F6-38-y, 435-F6-39-s, 435-F6-39-y, 435-F7-50-s, 435-F8-49-y, 435-F8-98-y, 435-F8-102-s, 435-F10-30-s, 963-F1-404-m, 963-F1-404-s, 963-F6-621mo, 963-F8-485-y, 963-F8-486, 963-F9-511-m, 963-F14-574-s, 963-F15-585, 963-F125-25-s, 963-F141-618-m, 963-F141-618-s, 963-F141-619-m, 964-F1-24-y yucca caudex, 964-F1-33-c, 964-F1-44-t, 968-F1-473-y, 968-F1-475-t, 968-F1-475-y, 968-F1-479-s, 968-F1-480-u, 964-F1-24-y yucca stem

Dear Dr. Dello-Russo:

Enclosed are the radiocarbon dating results for 36 samples recently sent to us. They each provided plenty of carbon for accurate measurements and all the analyses proceeded normally. As usual, the method of analysis is listed on the report with the results and calibration data is provided where applicable.

As always, no students or intern researchers who would necessarily be distracted with other obligations and priorities were used in the analyses. We analyzed them with the combined attention of our entire professional staff.

If you have specific questions about the analyses, please contact us. We are always available to answer your questions.

Our invoice has been sent separately. Thank you for your prior efforts in arranging payment. As always, if you have any questions or would like to discuss the results, don't hesitate to contact me.

Sincerely,

Darden Hood
Digital signature on file

BETA ANALYTIC INC.
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REPORT OF RADIOCARBON DATING ANALYSES

Dr. Robert Dello-Russo — Report Date: 3/12/2012

Office of Archaeological Studies — Material Received: 3/1/2012

Sample Data	Measured Radiocarbon Age	13C/12C Ratio	Conventional Radiocarbon Age(*)
Beta - 317545	1250 +/- 30 BP	-11.1 o/oo	1480 +/- 30 BP

SAMPLE : 422-F1-74-s
ANALYSIS : AMS-Standard delivery
MATERIAL/PRETREATMENT : (charred material): acid/alkali/acid
2 SIGMA CALIBRATION : Cal AD 540 to 640 (Cal BP 1410 to 1310)

Sample Data	Measured Radiocarbon Age	13C/12C Ratio	Conventional Radiocarbon Age(*)
Beta - 317546	1800 +/- 30 BP	-21.9 o/oo	1850 +/- 30 BP

SAMPLE : 429-F3-302-y
ANALYSIS : AMS-Standard delivery
MATERIAL/PRETREATMENT : (charred material): acid/alkali/acid
2 SIGMA CALIBRATION : Cal AD 80 to 240 (Cal BP 1870 to 1710)

Sample Data	Measured Radiocarbon Age	13C/12C Ratio	Conventional Radiocarbon Age(*)
Beta - 317547	100.1 +/- 0.4 pMC	-10.9 o/oo	220 +/- 30 BP

SAMPLE : 429-F11-321s
ANALYSIS : AMS-Standard delivery
MATERIAL/PRETREATMENT : (charred material): acid/alkali/acid
2 SIGMA CALIBRATION : Cal AD 1640 to 1680 (Cal BP 310 to 270) AND Cal AD 1740 to 1760 (Cal BP 210 to 190) Cal AD 1760 to 1800 (Cal BP 190 to 150) AND Cal AD 1940 to post 1950 (Cal BP 10 to post 1950)

Sample Data	Measured Radiocarbon Age	13C/12C Ratio	Conventional Radiocarbon Age(*)
Beta - 317548	170 +/- 30 BP	-19.7 o/oo	260 +/- 30 BP

SAMPLE : 429-F11-321y
ANALYSIS : AMS-Standard delivery
MATERIAL/PRETREATMENT : (charred material): acid/alkali/acid
2 SIGMA CALIBRATION : Cal AD 1520 to 1560 (Cal BP 420 to 390) AND Cal AD 1630 to 1670 (Cal BP 320 to 280) Cal AD 1780 to 1800 (Cal BP 170 to 150) AND Cal AD 1950 to 1950 (Cal BP 0 to 0)

Dates are reported as RCYBP (radiocarbon years before present, "present" = AD 1950). By international convention, the modern reference standard was 95% the 14C activity of the National Institute of Standards and Technology (NIST) Oxalic Acid (SRM 4990C) and calculated using the Libby 14C half-life (5568 years). Quoted errors represent 1 relative standard deviation statistics (68% probability) counting errors based on the combined measurements of the sample, background, and modern reference standards. Measured 13C/12C ratios (delta 13C) were calculated relative to the PDB-1 standard.

The Conventional Radiocarbon Age represents the Measured Radiocarbon Age corrected for isotopic fractionation, calculated using the delta 13C. On rare occasion where the Conventional Radiocarbon Age was calculated using an assumed delta 13C, the ratio and the Conventional Radiocarbon Age will be followed by "*". The Conventional Radiocarbon Age is not calendar calibrated. When available, the Calendar Calibrated result is calculated from the Conventional Radiocarbon Age and is listed as the "Two Sigma Calibrated Result" for each sample.

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REPORT OF RADIOCARBON DATING ANALYSES

Dr. Robert Dello-Russo

Report Date: 3/12/2012

Sample Data	Measured Radiocarbon Age	13C/12C Ratio	Conventional Radiocarbon Age(*)
Beta - 317549 SAMPLE : 429-Hall 1 ANALYSIS : AMS-Standard delivery MATERIAL/PRETREATMENT : (organic sediment): acid washes 2 SIGMA CALIBRATION : Cal AD 1420 to 1450 (Cal BP 530 to 500)	350 +/- 30 BP	-18.4 o/oo	460 +/- 30 BP
Beta - 317550 SAMPLE : 429-Hall 2 ANALYSIS : AMS-Standard delivery MATERIAL/PRETREATMENT : (organic sediment): acid washes 2 SIGMA CALIBRATION : Cal AD 1410 to 1450 (Cal BP 540 to 500)	340 +/- 30 BP	-15.7 o/oo	490 +/- 30 BP
Beta - 317551 SAMPLE : 435-F3-23-t ANALYSIS : AMS-Standard delivery MATERIAL/PRETREATMENT : (charred material): acid/alkali/acid 2 SIGMA CALIBRATION : Cal BC 1210 to 1010 (Cal BP 3160 to 2960)	2900 +/- 30 BP	-24.6 o/oo	2910 +/- 30 BP
Beta - 317552 SAMPLE : 435-F6-38-y ANALYSIS : AMS-Standard delivery MATERIAL/PRETREATMENT : (charred material): acid/alkali/acid 2 SIGMA CALIBRATION : Cal AD 380 to 440 (Cal BP 1570 to 1510) AND Cal AD 450 to 460 (Cal BP 1500 to 1490) Cal AD 480 to 530 (Cal BP 1470 to 1420)	1560 +/- 30 BP	-20.8 o/oo	1630 +/- 30 BP

Dates are reported as RCYBP (radiocarbon years before present, "present" = AD 1950). By international convention, the modern reference standard was 95% the 14C activity of the National Institute of Standards and Technology (NIST) Oxalic Acid (SRM 4990C) and calculated using the Libby 14C half-life (5568 years). Quoted errors represent 1 relative standard deviation statistics (68% probability) counting errors based on the combined measurements of the sample, background, and modern reference standards. Measured 13C/12C ratios (delta 13C) were calculated relative to the PDB-1 standard.

The Conventional Radiocarbon Age represents the Measured Radiocarbon Age corrected for isotopic fractionation, calculated using the delta 13C. On rare occasion where the Conventional Radiocarbon Age was calculated using an assumed delta 13C, the ratio and the Conventional Radiocarbon Age will be followed by "*". The Conventional Radiocarbon Age is not calendar calibrated. When available, the Calendar Calibrated result is calculated from the Conventional Radiocarbon Age and is listed as the "Two Sigma Calibrated Result" for each sample.

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REPORT OF RADIOCARBON DATING ANALYSES

Dr. Robert Dello-Russo

Report Date: 3/12/2012

Sample Data	Measured Radiocarbon Age	13C/12C Ratio	Conventional Radiocarbon Age(*)
Beta - 317553	1370 +/- 30 BP	-10.8 o/oo	1600 +/- 30 BP

SAMPLE : 435-F6-39-s
ANALYSIS : AMS-Standard delivery
MATERIAL/PRETREATMENT : (charred material): acid/alkali/acid
2 SIGMA CALIBRATION : Cal AD 400 to 540 (Cal BP 1550 to 1410)

Sample Data	Measured Radiocarbon Age	13C/12C Ratio	Conventional Radiocarbon Age(*)
Beta - 317554	1580 +/- 30 BP	-22.3 o/oo	1620 +/- 30 BP

SAMPLE : 435-F6-39-y
ANALYSIS : AMS-Standard delivery
MATERIAL/PRETREATMENT : (charred material): acid/alkali/acid
2 SIGMA CALIBRATION : Cal AD 390 to 540 (Cal BP 1560 to 1410)

Sample Data	Measured Radiocarbon Age	13C/12C Ratio	Conventional Radiocarbon Age(*)
Beta - 317555	2190 +/- 30 BP	-10.3 o/oo	2430 +/- 30 BP

SAMPLE : 435-F7-50-s
ANALYSIS : AMS-Standard delivery
MATERIAL/PRETREATMENT : (charred material): acid/alkali/acid
2 SIGMA CALIBRATION : Cal BC 750 to 690 (Cal BP 2700 to 2640) AND Cal BC 660 to 640 (Cal BP 2620 to 2590)
Cal BC 590 to 580 (Cal BP 2540 to 2530) AND Cal BC 570 to 400 (Cal BP 2520 to 2350)

Sample Data	Measured Radiocarbon Age	13C/12C Ratio	Conventional Radiocarbon Age(*)
Beta - 317556	1140 +/- 30 BP	-22.4 o/oo	1180 +/- 30 BP

SAMPLE : 435-F8-49-y
ANALYSIS : AMS-Standard delivery
MATERIAL/PRETREATMENT : (charred material): acid/alkali/acid
2 SIGMA CALIBRATION : Cal AD 770 to 900 (Cal BP 1180 to 1050) AND Cal AD 920 to 940 (Cal BP 1030 to 1010)

Dates are reported as RCYBP (radiocarbon years before present, "present" = AD 1950). By international convention, the modern reference standard was 95% the 14C activity of the National Institute of Standards and Technology (NIST) Oxalic Acid (SRM 4990C) and calculated using the Libby 14C half-life (5568 years). Quoted errors represent 1 relative standard deviation statistics (68% probability) counting errors based on the combined measurements of the sample, background, and modern reference standards. Measured 13C/12C ratios (delta 13C) were calculated relative to the PDB-1 standard.

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Sample Data	Measured Radiocarbon Age	13C/12C Ratio	Conventional Radiocarbon Age(*)
Beta - 317557 SAMPLE : 435-F8-98-y ANALYSIS : AMS-Standard delivery MATERIAL/PRETREATMENT : (charred material): acid/alkali/acid 2 SIGMA CALIBRATION : Cal AD 880 to 990 (Cal BP 1060 to 960)	1070 +/- 30 BP	-22.3 o/oo	1110 +/- 30 BP
Beta - 317558 SAMPLE : 435-F8-102-s ANALYSIS : AMS-Standard delivery MATERIAL/PRETREATMENT : (charred material): acid/alkali/acid 2 SIGMA CALIBRATION : Cal AD 880 to 990 (Cal BP 1060 to 960)	890 +/- 30 BP	-11.5 o/oo	1110 +/- 30 BP
Beta - 317559 SAMPLE : 435-F10-30-s ANALYSIS : AMS-Standard delivery MATERIAL/PRETREATMENT : (charred material): acid/alkali/acid 2 SIGMA CALIBRATION : Cal BC 2920 to 2880 (Cal BP 4870 to 4830)	4070 +/- 30 BP	-11.3 o/oo	4290 +/- 30 BP
Beta - 317560 SAMPLE : 963-F1-404-m ANALYSIS : AMS-Standard delivery MATERIAL/PRETREATMENT : (charred material): acid/alkali/acid 2 SIGMA CALIBRATION : Cal AD 1430 to 1470 (Cal BP 520 to 480)	410 +/- 30 BP	-23.3 o/oo	440 +/- 30 BP

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Sample Data	Measured Radiocarbon Age	13C/12C Ratio	Conventional Radiocarbon Age(*)
Beta - 317561	140 +/- 30 BP	-12.7 o/oo	340 +/- 30 BP

SAMPLE : 963-F1-404-s
ANALYSIS : AMS-Standard delivery
MATERIAL/PRETREATMENT : (charred material): acid/alkali/acid
2 SIGMA CALIBRATION : Cal AD 1450 to 1640 (Cal BP 500 to 310)

Sample Data	Measured Radiocarbon Age	13C/12C Ratio	Conventional Radiocarbon Age(*)
Beta - 317562	10 +/- 30 BP	-22.1 o/oo	60 +/- 30 BP

SAMPLE : 963-F6-621mo
ANALYSIS : AMS-Standard delivery
MATERIAL/PRETREATMENT : (charred material): acid/alkali/acid
2 SIGMA CALIBRATION : Cal AD 1690 to 1730 (Cal BP 260 to 220) AND Cal AD 1810 to 1840 (Cal BP 140 to 110)
Cal AD 1840 to 1850 (Cal BP 110 to 100) AND Cal AD 1860 to 1860 (Cal BP 90 to 90) AND
Cal AD 1870 to 1920 (Cal BP 80 to 30) AND Cal AD Post 1950

Sample Data	Measured Radiocarbon Age	13C/12C Ratio	Conventional Radiocarbon Age(*)
Beta - 317563	690 +/- 30 BP	-22.3 o/oo	730 +/- 30 BP

SAMPLE : 963-F8-485-y
ANALYSIS : AMS-Standard delivery
MATERIAL/PRETREATMENT : (charred material): acid/alkali/acid
2 SIGMA CALIBRATION : Cal AD 1260 to 1290 (Cal BP 690 to 660)

Sample Data	Measured Radiocarbon Age	13C/12C Ratio	Conventional Radiocarbon Age(*)
Beta - 317564	640 +/- 30 BP	-20.2 o/oo	720 +/- 30 BP

SAMPLE : 963-F8-486
ANALYSIS : AMS-Standard delivery
MATERIAL/PRETREATMENT : (organic sediment): acid washes
2 SIGMA CALIBRATION : Cal AD 1260 to 1290 (Cal BP 690 to 660)

Dates are reported as RCYBP (radiocarbon years before present, "present" = AD 1950). By international convention, the modern reference standard was 95% the 14C activity of the National Institute of Standards and Technology (NIST) Oxalic Acid (SRM 4990C) and calculated using the Libby 14C half-life (5568 years). Quoted errors represent 1 relative standard deviation statistics (68% probability) counting errors based on the combined measurements of the sample, background, and modern reference standards. Measured 13C/12C ratios (delta 13C) were calculated relative to the PDB-1 standard.

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Sample Data	Measured Radiocarbon Age	13C/12C Ratio	Conventional Radiocarbon Age(*)
Beta - 317565	220 +/- 30 BP	-23.2 o/oo	250 +/- 30 BP

SAMPLE : 963-F9-511-m
ANALYSIS : AMS-Standard delivery
MATERIAL/PRETREATMENT : (charred material): acid/alkali/acid
2 SIGMA CALIBRATION : Cal AD 1530 to 1540 (Cal BP 420 to 410) AND Cal AD 1550 to 1550 (Cal BP 400 to 400)
Cal AD 1630 to 1670 (Cal BP 320 to 280) AND Cal AD 1780 to 1800 (Cal BP 170 to 150)
AND Cal AD 1940 to 1950 (Cal BP 0 to 0)

Sample Data	Measured Radiocarbon Age	13C/12C Ratio	Conventional Radiocarbon Age(*)
Beta - 317566	1300 +/- 30 BP	-10.5 o/oo	1540 +/- 30 BP

SAMPLE : 963-F14-574-s
ANALYSIS : AMS-Standard delivery
MATERIAL/PRETREATMENT : (charred material): acid/alkali/acid
2 SIGMA CALIBRATION : Cal AD 430 to 600 (Cal BP 1520 to 1360)

Sample Data	Measured Radiocarbon Age	13C/12C Ratio	Conventional Radiocarbon Age(*)
Beta - 317567	1760 +/- 30 BP	-13.6 o/oo	1950 +/- 30 BP

SAMPLE : 963-F15-585
ANALYSIS : AMS-Standard delivery
MATERIAL/PRETREATMENT : (organic sediment): acid washes
2 SIGMA CALIBRATION : Cal BC 30 to 30 (Cal BP 1980 to 1980) AND Cal BC 20 to 10 (Cal BP 1970 to 1960)
Cal AD 0 to 90 (Cal BP 1950 to 1860) AND Cal AD 100 to 120 (Cal BP 1850 to 1830)

Sample Data	Measured Radiocarbon Age	13C/12C Ratio	Conventional Radiocarbon Age(*)
Beta - 317568	960 +/- 30 BP	-10.9 o/oo	1190 +/- 30 BP

SAMPLE : 963-F125-25-s
ANALYSIS : AMS-Standard delivery
MATERIAL/PRETREATMENT : (charred material): acid/alkali/acid
2 SIGMA CALIBRATION : Cal AD 730 to 740 (Cal BP 1220 to 1210) AND Cal AD 770 to 900 (Cal BP 1180 to 1060)
Cal AD 920 to 940 (Cal BP 1030 to 1010)

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Sample Data	Measured Radiocarbon Age	13C/12C Ratio	Conventional Radiocarbon Age(*)
Beta - 317569	1360 +/- 30 BP	-24.2 o/oo	1370 +/- 30 BP

SAMPLE : 963-F141-618-m
ANALYSIS : AMS-Standard delivery
MATERIAL/PRETREATMENT : (charred material): acid/alkali/acid
2 SIGMA CALIBRATION : Cal AD 640 to 680 (Cal BP 1310 to 1270)

Beta - 317570	1010 +/- 30 BP	-11.6 o/oo	1230 +/- 30 BP

SAMPLE : 963-F141-618-s
ANALYSIS : AMS-Standard delivery
MATERIAL/PRETREATMENT : (charred material): acid/alkali/acid
2 SIGMA CALIBRATION : Cal AD 690 to 880 (Cal BP 1260 to 1060)

Beta - 317571	1240 +/- 30 BP	-22.6 o/oo	1280 +/- 30 BP

SAMPLE : 963-F141-619-m
ANALYSIS : AMS-Standard delivery
MATERIAL/PRETREATMENT : (charred material): acid/alkali/acid
2 SIGMA CALIBRATION : Cal AD 660 to 780 (Cal BP 1290 to 1170)

Beta - 317572	80 +/- 30 BP	-22.8 o/oo	120 +/- 30 BP

SAMPLE : 964-F1-24-y yucca caudex
ANALYSIS : AMS-Standard delivery
MATERIAL/PRETREATMENT : (charred material): acid/alkali/acid
2 SIGMA CALIBRATION : Cal AD 1670 to 1780 (Cal BP 280 to 170) AND Cal AD 1800 to 1940 (Cal BP 150 to 10)
Cal AD Post 1950

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Sample Data	Measured Radiocarbon Age	13C/12C Ratio	Conventional Radiocarbon Age(*)
Beta - 317573	101.5 +/- 0.4 pMC	-10.8 o/oo	110 +/- 30 BP

SAMPLE : 964-F1-33-c
ANALYSIS : AMS-Standard delivery
MATERIAL/PRETREATMENT : (charred material): acid/alkali/acid
2 SIGMA CALIBRATION : Cal AD 1680 to 1760 (Cal BP 270 to 190) AND Cal AD 1770 to 1780 (Cal BP 180 to 170)
Cal AD 1800 to 1940 (Cal BP 150 to 10) AND Cal AD Post 1950

Beta - 317574	50 +/- 30 BP	-23.4 o/oo	80 +/- 30 BP

SAMPLE : 964-F1-44-t
ANALYSIS : AMS-Standard delivery
MATERIAL/PRETREATMENT : (charred material): acid/alkali/acid
2 SIGMA CALIBRATION : Cal AD 1680 to 1730 (Cal BP 260 to 220) AND Cal AD 1810 to 1930 (Cal BP 140 to 20)
Cal AD Post 1950

Beta - 317575	1230 +/- 30 BP	-21.2 o/oo	1290 +/- 30 BP

SAMPLE : 968-F1-473-y
ANALYSIS : AMS-Standard delivery
MATERIAL/PRETREATMENT : (charred material): acid/alkali/acid
2 SIGMA CALIBRATION : Cal AD 660 to 780 (Cal BP 1290 to 1170)

Beta - 317576	1200 +/- 30 BP	-23.5 o/oo	1220 +/- 30 BP

SAMPLE : 968-F1-475-t
ANALYSIS : AMS-Standard delivery
MATERIAL/PRETREATMENT : (charred material): acid/alkali/acid
2 SIGMA CALIBRATION : Cal AD 690 to 750 (Cal BP 1260 to 1200) AND Cal AD 760 to 890 (Cal BP 1190 to 1060)

Dates are reported as RCYBP (radiocarbon years before present, "present" = AD 1950). By international convention, the modern reference standard was 95% the 14C activity of the National Institute of Standards and Technology (NIST) Oxalic Acid (SRM 4990C) and calculated using the Libby 14C half-life (5568 years). Quoted errors represent 1 relative standard deviation statistics (68% probability) counting errors based on the combined measurements of the sample, background, and modern reference standards. Measured 13C/12C ratios (delta 13C) were calculated relative to the PDB-1 standard.

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Sample Data	Measured Radiocarbon Age	13C/12C Ratio	Conventional Radiocarbon Age(*)
Beta - 317577	1170 +/- 30 BP	-21.2 o/oo	1230 +/- 30 BP

SAMPLE : 968-F1-475-y
ANALYSIS : AMS-Standard delivery
MATERIAL/PRETREATMENT : (charred material): acid/alkali/acid
2 SIGMA CALIBRATION : Cal AD 690 to 880 (Cal BP 1260 to 1060)

Sample Data	Measured Radiocarbon Age	13C/12C Ratio	Conventional Radiocarbon Age(*)
Beta - 317578	1100 +/- 30 BP	-12.3 o/oo	1310 +/- 30 BP

SAMPLE : 968-F1-479-s
ANALYSIS : AMS-Standard delivery
MATERIAL/PRETREATMENT : (charred material): acid/alkali/acid
2 SIGMA CALIBRATION : Cal AD 660 to 730 (Cal BP 1290 to 1220) AND Cal AD 740 to 770 (Cal BP 1210 to 1180)

Sample Data	Measured Radiocarbon Age	13C/12C Ratio	Conventional Radiocarbon Age(*)
Beta - 317579	1250 +/- 30 BP	-23.0 o/oo	1280 +/- 30 BP

SAMPLE : 968-F1-480-u
ANALYSIS : AMS-Standard delivery
MATERIAL/PRETREATMENT : (charred material): acid/alkali/acid
2 SIGMA CALIBRATION : Cal AD 660 to 780 (Cal BP 1290 to 1170)

Sample Data	Measured Radiocarbon Age	13C/12C Ratio	Conventional Radiocarbon Age(*)
Beta - 317582	100 +/- 30 BP	-23.4 o/oo	130 +/- 30 BP

SAMPLE : 964-F1-24-y yucca stem
ANALYSIS : AMS-Standard delivery
MATERIAL/PRETREATMENT : (charred material): acid/alkali/acid
2 SIGMA CALIBRATION : Cal AD 1670 to 1780 (Cal BP 280 to 170) AND Cal AD 1800 to 1900 (Cal BP 150 to 50)
Cal AD 1900 to 1940 (Cal BP 50 to 0) AND Cal AD 1950 to post 1950 (Cal BP 0 to post 1950)

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CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-11.1:lab. mult=1)

Laboratory number: **Beta-317545**

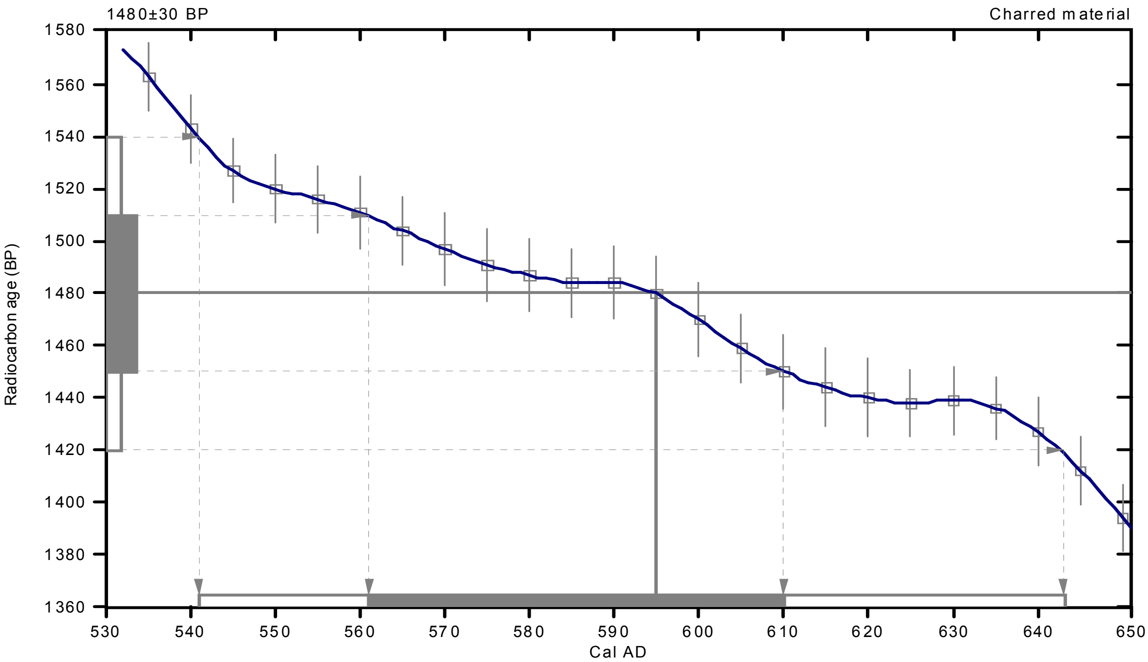
Conventional radiocarbon age: **1480±30 BP**

2 Sigma calibrated result: (95% probability) **Cal AD 540 to 640 (Cal BP 1410 to 1310)**

Intercept data

Intercept of radiocarbon age with calibration curve: Cal AD 600 (Cal BP 1360)

1 Sigma calibrated result: (68% probability) Cal AD 560 to 610 (Cal BP 1390 to 1340)



References:

Database used

INTCAL09

References to INTCAL09 database

Heaton,et.al.,2009, Radiocarbon 51(4):1151-1164, Reimer,et.al, 2009, Radiocarbon 51(4):1111-1150, Stuiver,et.al,1993, Radiocarbon 35(1):137-189, Oeschger,et.al.,1975,Tellus 27:168-192

Mathematics used for calibration scenario

A Simplified Approach to Calibrating C14 Dates

Talma, A. S., Vogel, J. C., 1993, Radiocarbon 35(2):317-322

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CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-21.9:lab. mult=1)

Laboratory number: **Beta-317546**

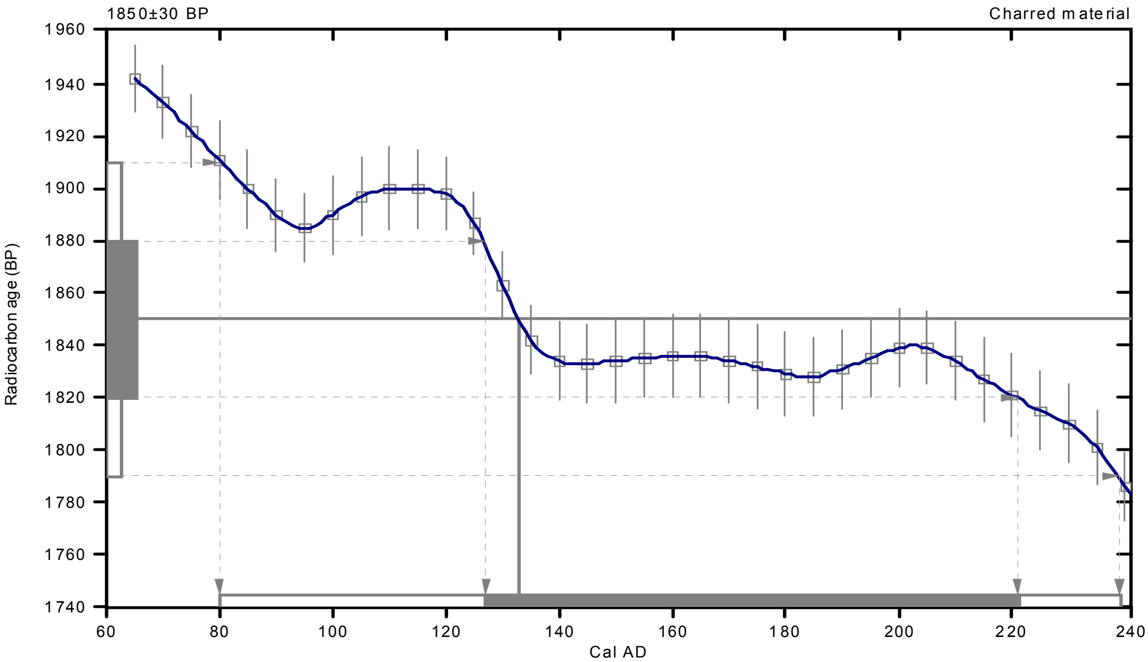
Conventional radiocarbon age: **1850±30 BP**

2 Sigma calibrated result: (95% probability) **Cal AD 80 to 240 (Cal BP 1870 to 1710)**

Intercept data

Intercept of radiocarbon age with calibration curve: Cal AD 130 (Cal BP 1820)

1 Sigma calibrated result: (68% probability) Cal AD 130 to 220 (Cal BP 1820 to 1730)



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CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-10.9:lab. mult=1)

Laboratory number: **Beta-317547**

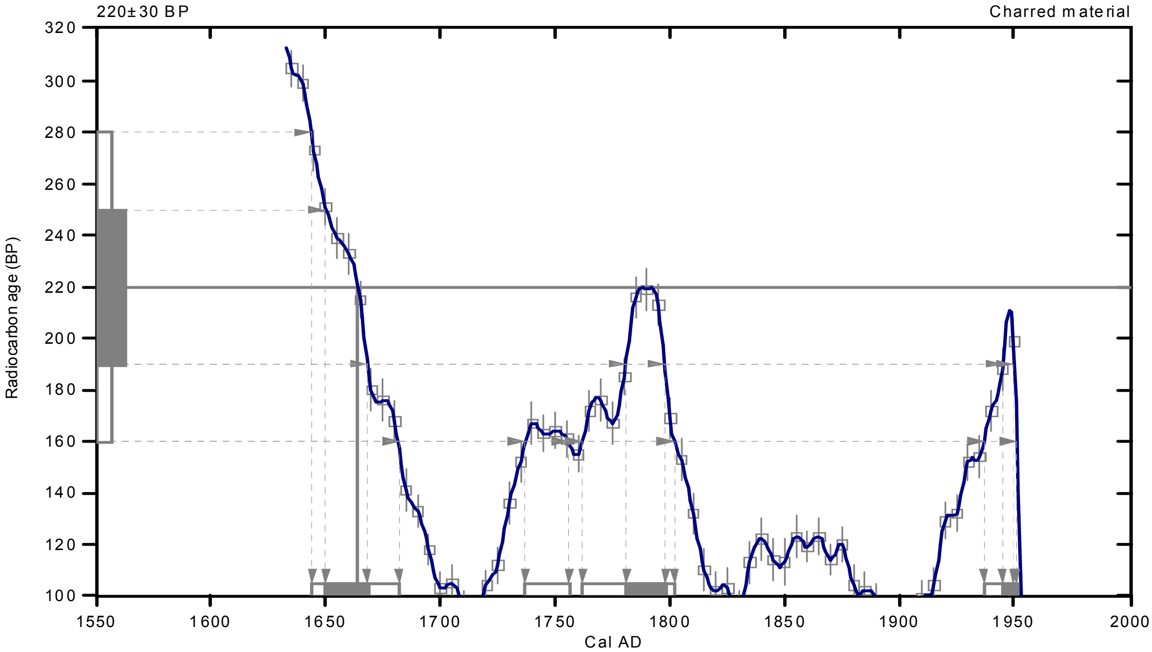
Conventional radiocarbon age: **220±30 BP**

2 Sigma calibrated results: (95% probability) **Cal AD 1640 to 1680 (Cal BP 310 to 270) and**
Cal AD 1740 to 1760 (Cal BP 210 to 190) and
Cal AD 1760 to 1800 (Cal BP 190 to 150) and
Cal AD 1940 to post 1950 (Cal BP 10 to post 1950)

Intercept data

Intercept of radiocarbon age with calibration curve: Cal AD 1660 (Cal BP 290)

1 Sigma calibrated results: (68% probability) Cal AD 1650 to 1670 (Cal BP 300 to 280) and
Cal AD 1780 to 1800 (Cal BP 170 to 150) and
Cal AD 1940 to 1950 (Cal BP 0 to 0)



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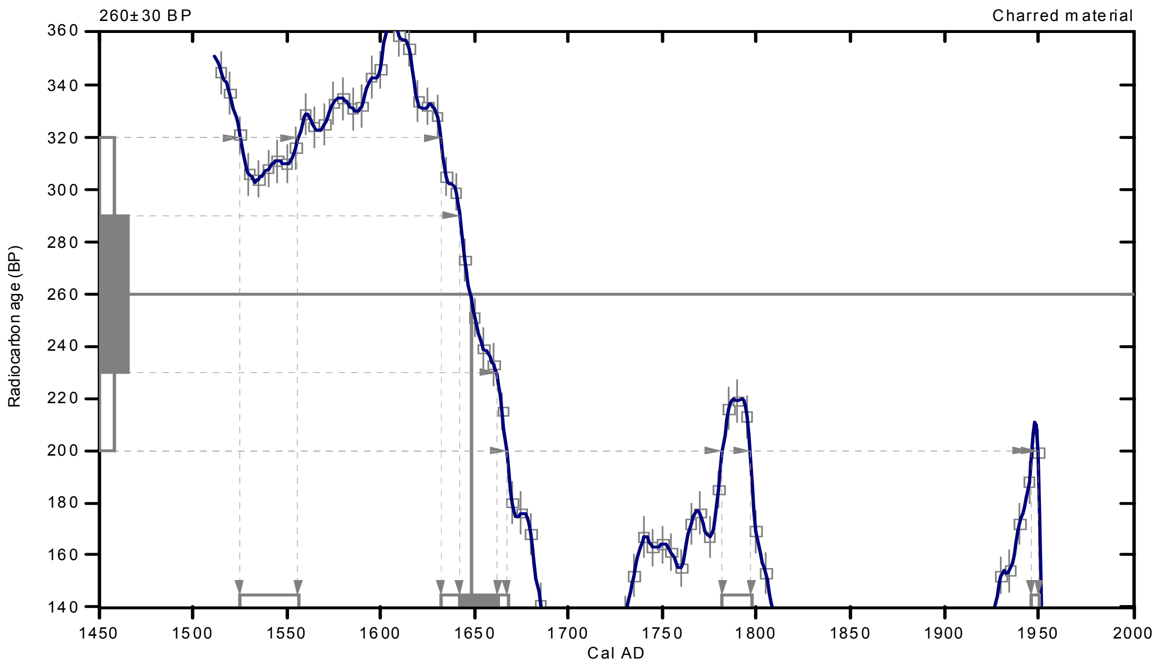
CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-19.7:lab. mult=1)

Laboratory number:	**Beta-317548**
Conventional radiocarbon age:	**260±30 BP**
2 Sigma calibrated results: (95% probability)	**Cal AD 1520 to 1560 (Cal BP 420 to 390) and Cal AD 1630 to 1670 (Cal BP 320 to 280) and Cal AD 1780 to 1800 (Cal BP 170 to 150) and Cal AD 1950 to 1950 (Cal BP 0 to 0)**

Intercept data

Intercept of radiocarbon age with calibration curve:	Cal AD 1650 (Cal BP 300)
1 Sigma calibrated result: (68% probability)	Cal AD 1640 to 1660 (Cal BP 310 to 290)



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CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-18.4:lab. mult=1)

Laboratory number: **Beta-317549**

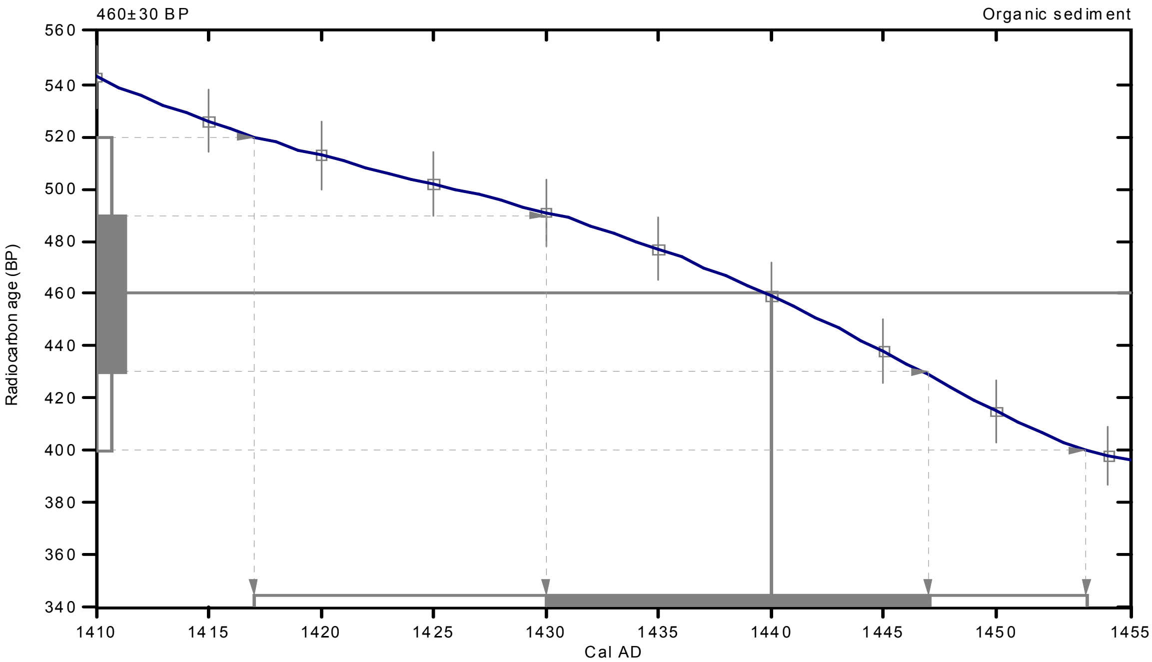
Conventional radiocarbon age: **460±30 BP**

2 Sigma calibrated result: (95% probability) **Cal AD 1420 to 1450 (Cal BP 530 to 500)**

Intercept data

Intercept of radiocarbon age with calibration curve: Cal AD 1440 (Cal BP 510)

1 Sigma calibrated result: (68% probability) Cal AD 1430 to 1450 (Cal BP 520 to 500)



References:

Database used

INTCAL09

References to INTCAL09 database

Heaton,et.al.,2009, Radiocarbon 51(4):1151-1164, Reimer,et.al, 2009, Radiocarbon 51(4):1111-1150, Stuiver,et.al,1993, Radiocarbon 35(1):137-189, Oeschger,et.al.,1975,Tellus 27:168-192

Mathematics used for calibration scenario

A Simplified Approach to Calibrating C14 Dates

Talma, A. S., Vogel, J. C., 1993, Radiocarbon 35(2):317-322

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CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-15.7:lab. mult=1)

Laboratory number: **Beta-317550**

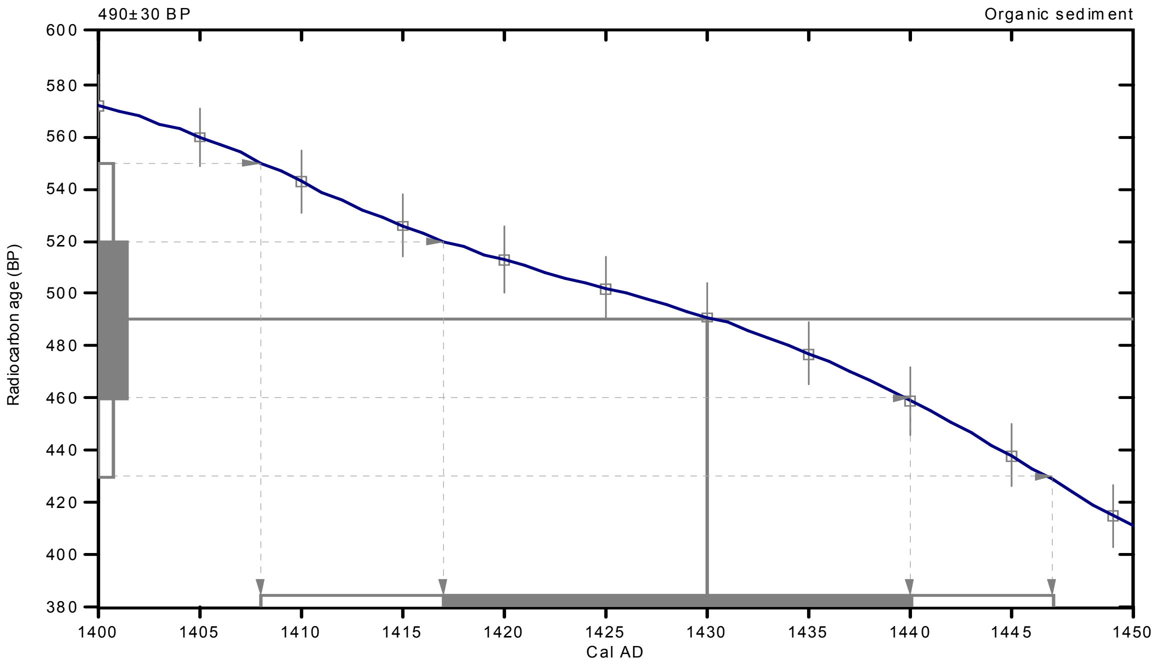
Conventional radiocarbon age: **490±30 BP**

2 Sigma calibrated result: **Cal AD 1410 to 1450 (Cal BP 540 to 500)**
(95% probability)

Intercept data

Intercept of radiocarbon age with calibration curve: Cal AD 1430 (Cal BP 520)

1 Sigma calibrated result: Cal AD 1420 to 1440 (Cal BP 530 to 510)
(68% probability)



References:

Database used
INTCAL09
References to INTCAL09 database
Heaton,et.al.,2009, Radiocarbon 51(4):1151-1164, Reimer,et.al, 2009, Radiocarbon 51(4):1111-1150, Stuiver,et.al,1993, Radiocarbon 35(1):137-189, Oeschger,et.al.,1975,Tellus 27:168-192
Mathematics used for calibration scenario
A Simplified Approach to Calibrating C14 Dates
Talma, A. S., Vogel, J. C., 1993, Radiocarbon 35(2):317-322

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CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-24.6:lab. mult=1)

Laboratory number: **Beta-317551**

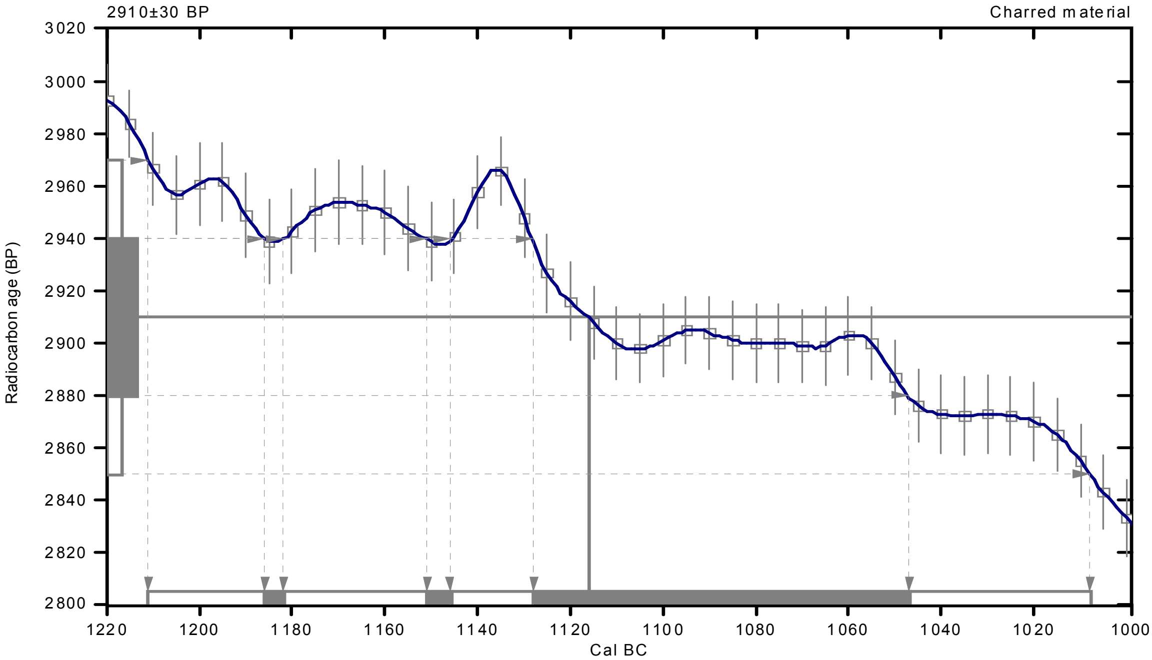
Conventional radiocarbon age: **2910±30 BP**

2 Sigma calibrated result: (95% probability) **Cal BC 1210 to 1010 (Cal BP 3160 to 2960)**

Intercept data

Intercept of radiocarbon age with calibration curve: Cal BC 1120 (Cal BP 3070)

1 Sigma calibrated results: (68% probability)
Cal BC 1190 to 1180 (Cal BP 3140 to 3130) and
Cal BC 1150 to 1150 (Cal BP 3100 to 3100) and
Cal BC 1130 to 1050 (Cal BP 3080 to 3000)



References:

Database used

INTCAL09

References to INTCAL09 database

Heaton,et.al.,2009, Radiocarbon 51(4):1151-1164, Reimer,et.al, 2009, Radiocarbon 51(4):1111-1150, Stuiver,et.al,1993, Radiocarbon 35(1):137-189, Oeschger,et.al.,1975,Tellus 27:168-192

Mathematics used for calibration scenario

A Simplified Approach to Calibrating C14 Dates

Talma, A. S., Vogel, J. C., 1993, Radiocarbon 35(2):317-322

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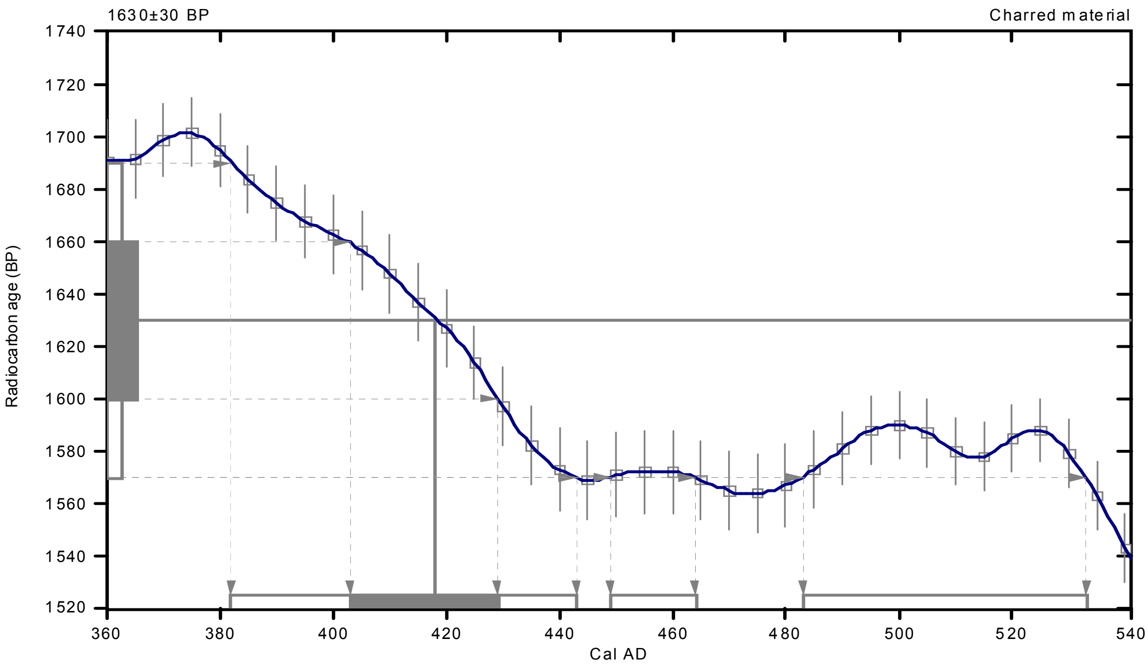
CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-20.8:lab. mult=1)

Laboratory number:	**Beta-317552**
Conventional radiocarbon age:	**1630±30 BP**
2 Sigma calibrated results: (95% probability)	**Cal AD 380 to 440 (Cal BP 1570 to 1510) and Cal AD 450 to 460 (Cal BP 1500 to 1490) and Cal AD 480 to 530 (Cal BP 1470 to 1420)**

Intercept data

Intercept of radiocarbon age with calibration curve:	Cal AD 420 (Cal BP 1530)
1 Sigma calibrated result: (68% probability)	Cal AD 400 to 430 (Cal BP 1550 to 1520)



References:

Database used

INTCAL09

References to INTCAL09 database

Heaton,et.al.,2009, Radiocarbon 51(4):1151-1164, Reimer,et.al, 2009, Radiocarbon 51(4):1111-1150, Stuiver,et.al,1993, Radiocarbon 35(1):137-189, Oeschger,et.al.,1975,Tellus 27:168-192

Mathematics used for calibration scenario

A Simplified Approach to Calibrating C14 Dates

Talma, A. S., Vogel, J. C., 1993, Radiocarbon 35(2):317-322

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CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-10.8:lab. mult=1)

Laboratory number: **Beta-317553**

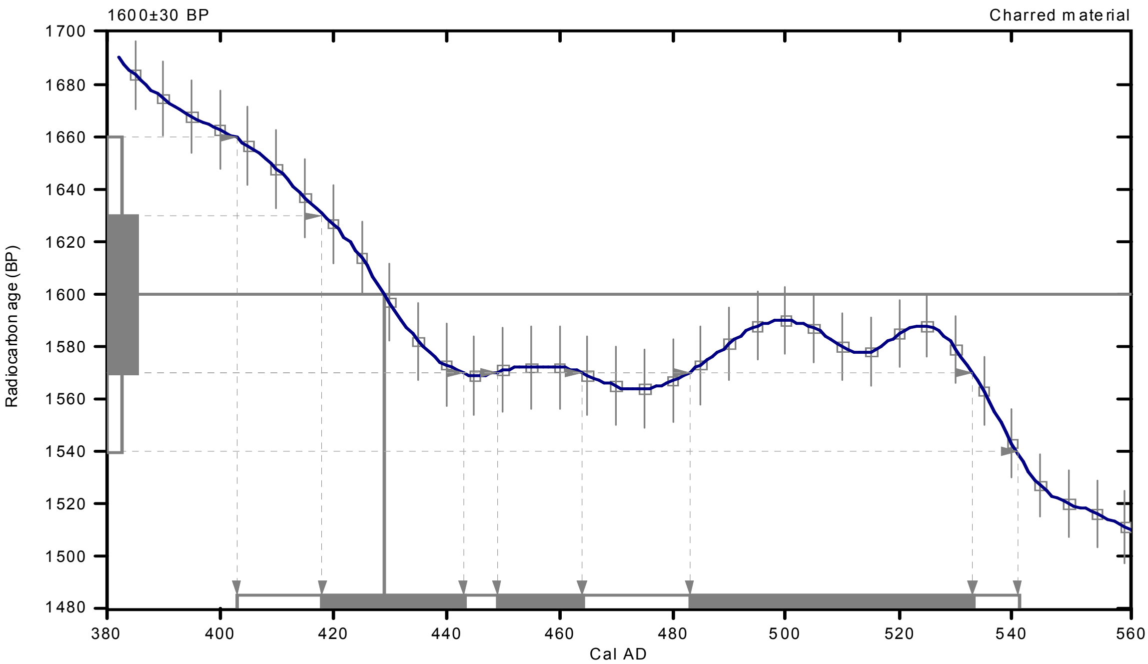
Conventional radiocarbon age: **1600±30 BP**

2 Sigma calibrated result: (95% probability) **Cal AD 400 to 540 (Cal BP 1550 to 1410)**

Intercept data

Intercept of radiocarbon age with calibration curve: Cal AD 430 (Cal BP 1520)

1 Sigma calibrated results: (68% probability)
Cal AD 420 to 440 (Cal BP 1530 to 1510) and
Cal AD 450 to 460 (Cal BP 1500 to 1490) and
Cal AD 480 to 530 (Cal BP 1470 to 1420)



References:

Database used

INTCAL09

References to INTCAL09 database

Heaton,et.al.,2009, Radiocarbon 51(4):1151-1164, Reimer,et.al, 2009, Radiocarbon 51(4):1111-1150, Stuiver,et.al,1993, Radiocarbon 35(1):137-189, Oeschger,et.al.,1975,Tellus 27:168-192

Mathematics used for calibration scenario

A Simplified Approach to Calibrating C14 Dates

Talma, A. S., Vogel, J. C., 1993, Radiocarbon 35(2):317-322

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CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-22.3:lab. mult=1)

Laboratory number: **Beta-317554**

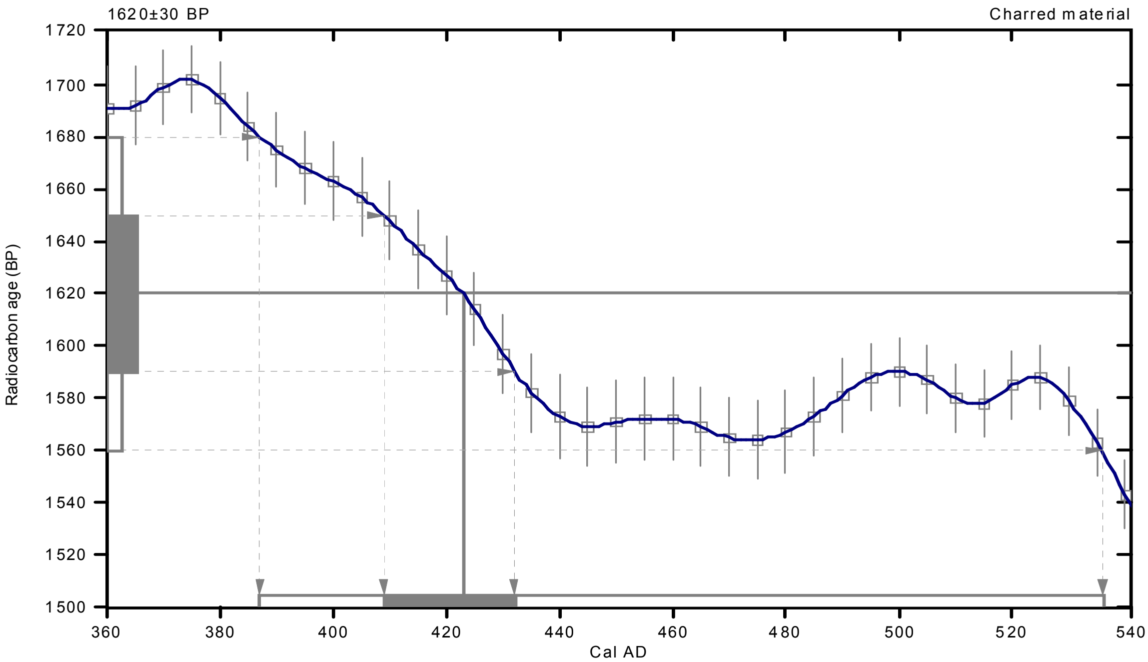
Conventional radiocarbon age: **1620±30 BP**

2 Sigma calibrated result: (95% probability) **Cal AD 390 to 540 (Cal BP 1560 to 1410)**

Intercept data

Intercept of radiocarbon age with calibration curve: Cal AD 420 (Cal BP 1530)

1 Sigma calibrated result: (68% probability) Cal AD 410 to 430 (Cal BP 1540 to 1520)



References:

Database used

INTCAL09

References to INTCAL09 database

Heaton,et.al.,2009, Radiocarbon 51(4):1151-1164, Reimer,et.al, 2009, Radiocarbon 51(4):1111-1150, Stuiver,et.al,1993, Radiocarbon 35(1):137-189, Oeschger,et.al.,1975,Tellus 27:168-192

Mathematics used for calibration scenario

A Simplified Approach to Calibrating C14 Dates

Talma, A. S., Vogel, J. C., 1993, Radiocarbon 35(2):317-322

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CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-10.3:lab. mult=1)

Laboratory number: **Beta-317555**

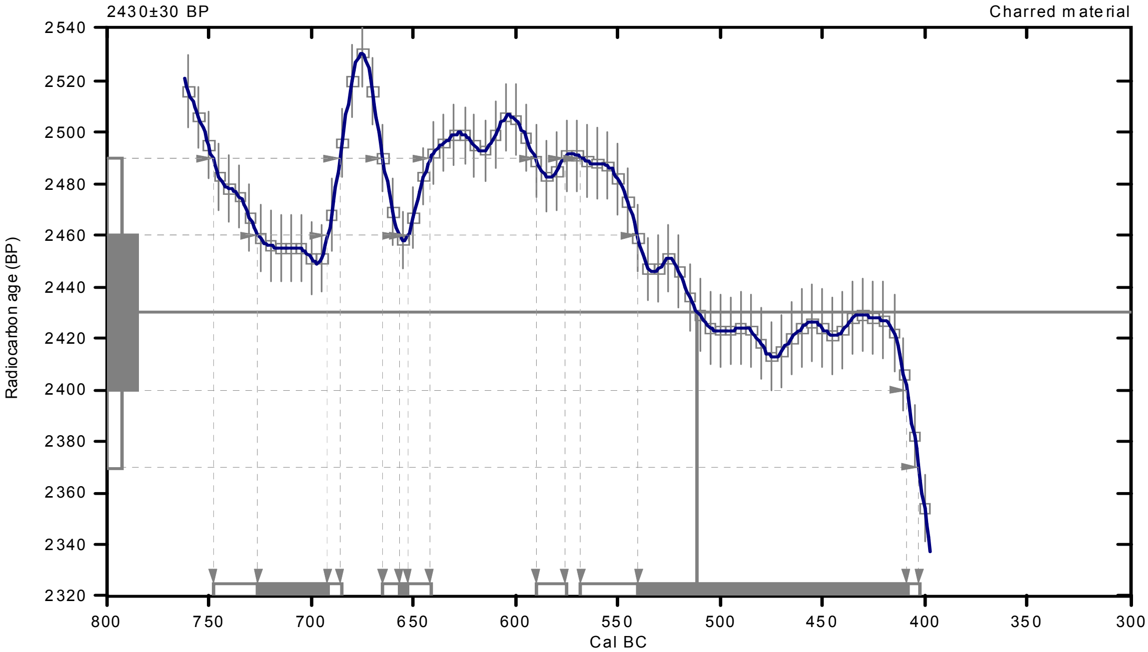
Conventional radiocarbon age: **2430±30 BP**

2 Sigma calibrated results: **Cal BC 750 to 690 (Cal BP 2700 to 2640) and**
(95% probability) **Cal BC 660 to 640 (Cal BP 2620 to 2590) and**
Cal BC 590 to 580 (Cal BP 2540 to 2530) and
Cal BC 570 to 400 (Cal BP 2520 to 2350)

Intercept data

Intercept of radiocarbon age
with calibration curve: Cal BC 510 (Cal BP 2460)

1 Sigma calibrated results: Cal BC 730 to 690 (Cal BP 2680 to 2640) and
(68% probability) Cal BC 660 to 650 (Cal BP 2610 to 2600) and
Cal BC 540 to 410 (Cal BP 2490 to 2360)



References:

Database used
INTCAL09
References to INTCAL09 database
Heaton,et.al.,2009, Radiocarbon 51(4):1151-1164, Reimer,et.al, 2009, Radiocarbon 51(4):1111-1150, Stuiver,et.al,1993, Radiocarbon 35(1):137-189, Oeschger,et.al.,1975,Tellus 27:168-192
Mathematics used for calibration scenario
A Simplified Approach to Calibrating C14 Dates
Talma, A. S., Vogel, J. C., 1993, Radiocarbon 35(2):317-322

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CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-22.4:lab. mult=1)

Laboratory number: **Beta-317556**

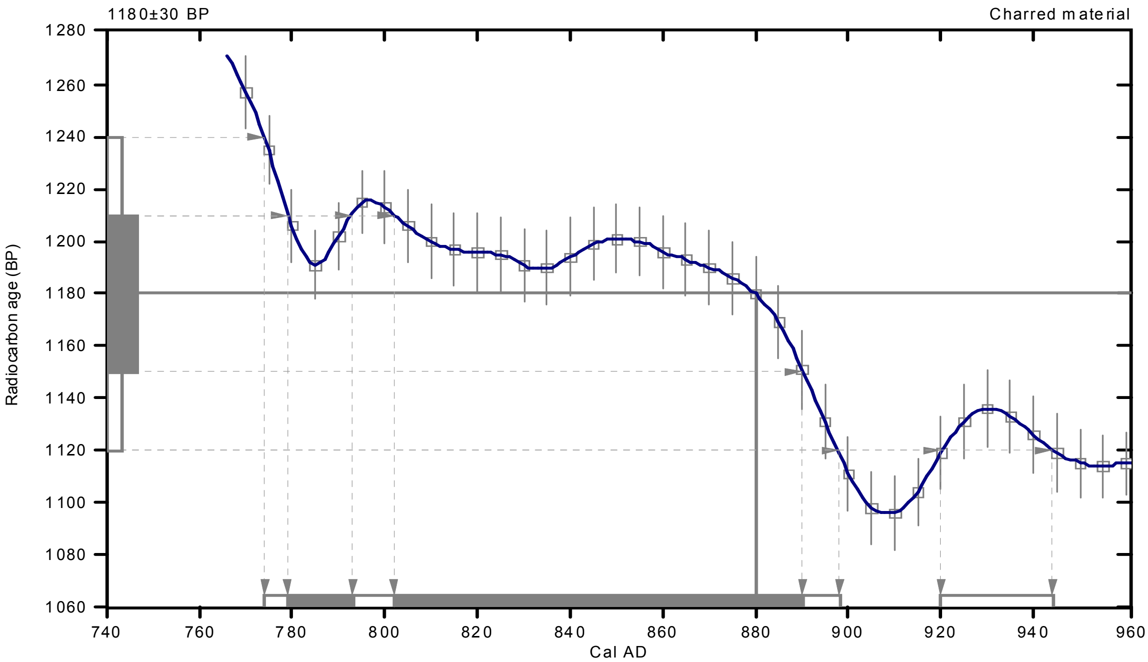
Conventional radiocarbon age: **1180±30 BP**

2 Sigma calibrated results: **Cal AD 770 to 900 (Cal BP 1180 to 1050) and**
(95% probability) **Cal AD 920 to 940 (Cal BP 1030 to 1010)**

Intercept data

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

1 Sigma calibrated results: Cal AD 780 to 790 (Cal BP 1170 to 1160) and
(68% probability) Cal AD 800 to 890 (Cal BP 1150 to 1060)



References:

Database used
INTCAL09
References to INTCAL09 database
Heaton,et.al.,2009, Radiocarbon 51(4):1151-1164, Reimer,et.al, 2009, Radiocarbon 51(4):1111-1150, Stuiver,et.al,1993, Radiocarbon 35(1):137-189, Oeschger,et.al.,1975,Tellus 27:168-192
Mathematics used for calibration scenario
A Simplified Approach to Calibrating C14 Dates
Talma, A. S., Vogel, J. C., 1993, Radiocarbon 35(2):317-322

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CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-22.3:lab. mult=1)

Laboratory number: **Beta-317557**

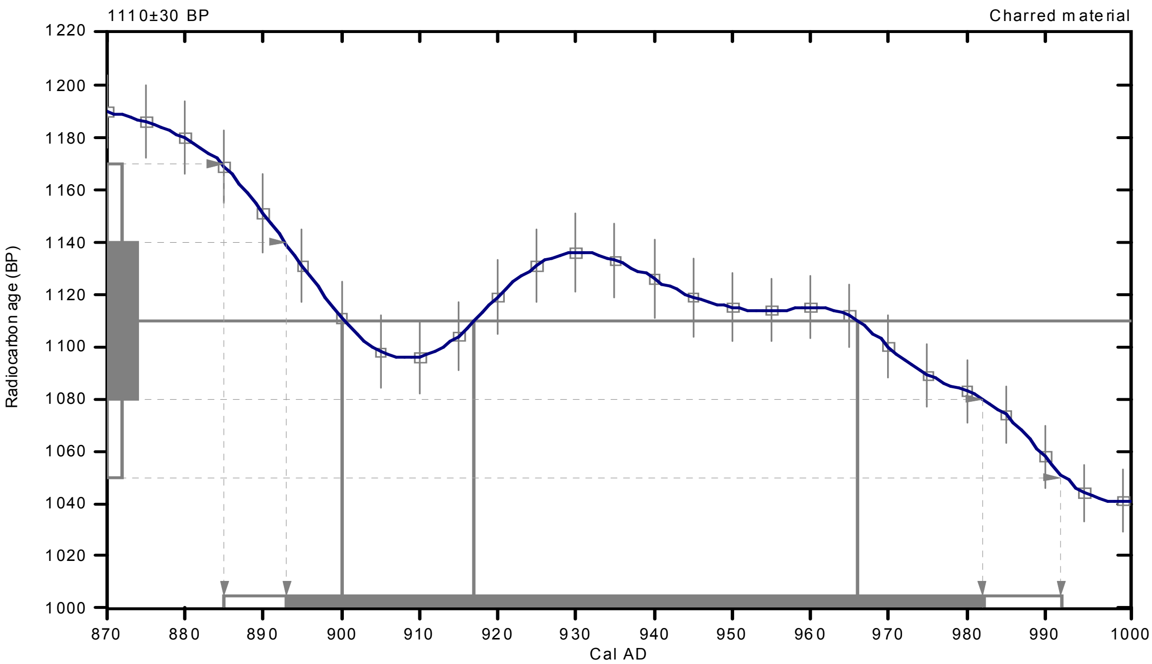
Conventional radiocarbon age: **1110±30 BP**

2 Sigma calibrated result: (95% probability) **Cal AD 880 to 990 (Cal BP 1060 to 960)**

Intercept data

Intercepts of radiocarbon age with calibration curve: Cal AD 900 (Cal BP 1050) and Cal AD 920 (Cal BP 1030) and Cal AD 970 (Cal BP 980)

1 Sigma calibrated result: (68% probability) Cal AD 890 to 980 (Cal BP 1060 to 970)



References:

Database used

INTCAL09

References to INTCAL09 database

Heaton,et.al.,2009, Radiocarbon 51(4):1151-1164, Reimer,et.al, 2009, Radiocarbon 51(4):1111-1150, Stuiver,et.al,1993, Radiocarbon 35(1):137-189, Oeschger,et.al.,1975,Tellus 27:168-192

Mathematics used for calibration scenario

A Simplified Approach to Calibrating C14 Dates

Talma, A. S., Vogel, J. C., 1993, Radiocarbon 35(2):317-322

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CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-11.5:lab. mult=1)

Laboratory number: **Beta-317558**

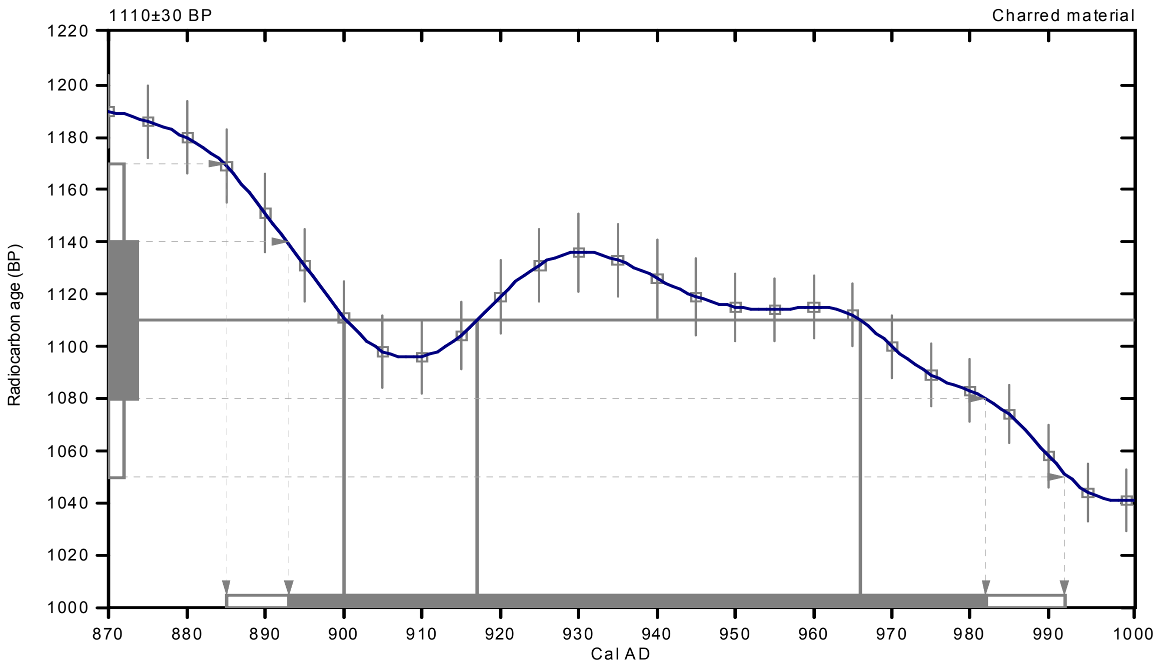
Conventional radiocarbon age: **1110±30 BP**

2 Sigma calibrated result: (95% probability) **Cal AD 880 to 990 (Cal BP 1060 to 960)**

Intercept data

Intercepts of radiocarbon age with calibration curve: Cal AD 900 (Cal BP 1050) and
Cal AD 920 (Cal BP 1030) and
Cal AD 970 (Cal BP 980)

1 Sigma calibrated result: (68% probability) Cal AD 890 to 980 (Cal BP 1060 to 970)



References:

Database used
INTCAL09

References to INTCAL09 database
Heaton,et.al.,2009, Radiocarbon 51(4):1151-1164, Reimer,et.al, 2009, Radiocarbon 51(4):1111-1150, Stuiver,et.al,1993, Radiocarbon 35(1):137-189, Oeschger,et.al.,1975,Tellus 27:168-192

Mathematics used for calibration scenario
A Simplified Approach to Calibrating C14 Dates
Talma, A. S., Vogel, J. C., 1993, Radiocarbon 35(2):317-322

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CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-11.3:lab. mult=1)

Laboratory number: **Beta-317559**

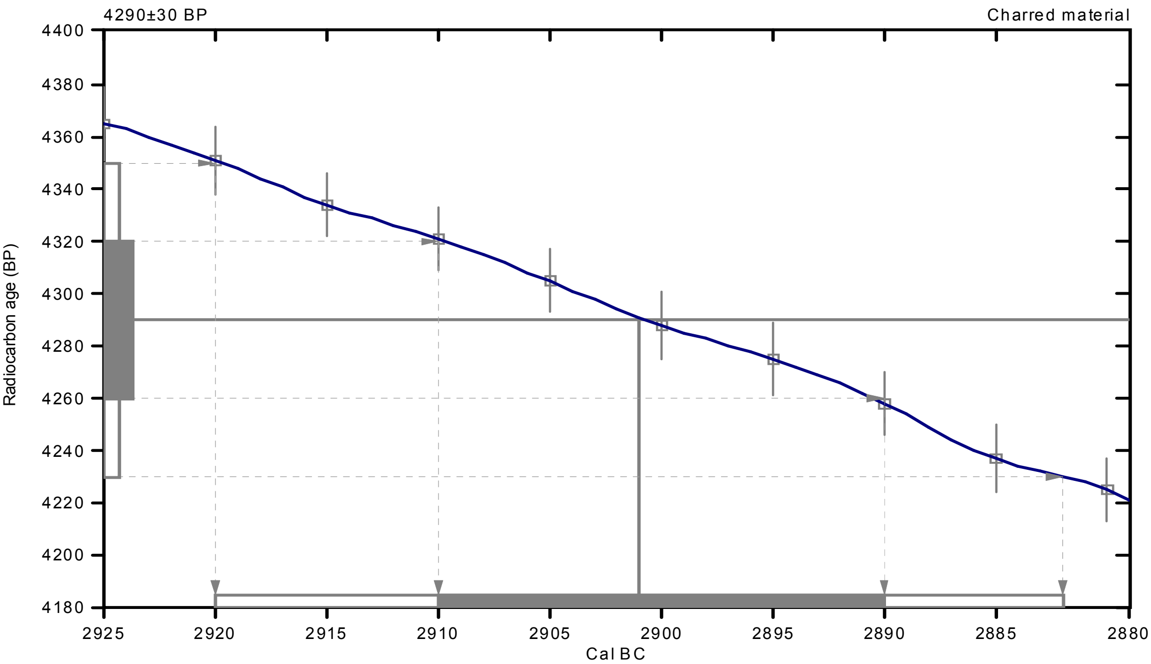
Conventional radiocarbon age: **4290±30 BP**

2 Sigma calibrated result: (95% probability) **Cal BC 2920 to 2880 (Cal BP 4870 to 4830)**

Intercept data

Intercept of radiocarbon age with calibration curve: Cal BC 2900 (Cal BP 4850)

1 Sigma calibrated result: (68% probability) Cal BC 2910 to 2890 (Cal BP 4860 to 4840)



References:

Database used

INTCAL09

References to INTCAL09 database

Heaton,et.al.,2009, Radiocarbon 51(4):1151-1164, Reimer,et.al, 2009, Radiocarbon 51(4):1111-1150, Stuiver,et.al,1993, Radiocarbon 35(1):137-189, Oeschger,et.al.,1975,Tellus 27:168-192

Mathematics used for calibration scenario

A Simplified Approach to Calibrating C14 Dates

Talma, A. S., Vogel, J. C., 1993, Radiocarbon 35(2):317-322

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CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-23.3:lab. mult=1)

Laboratory number: **Beta-317560**

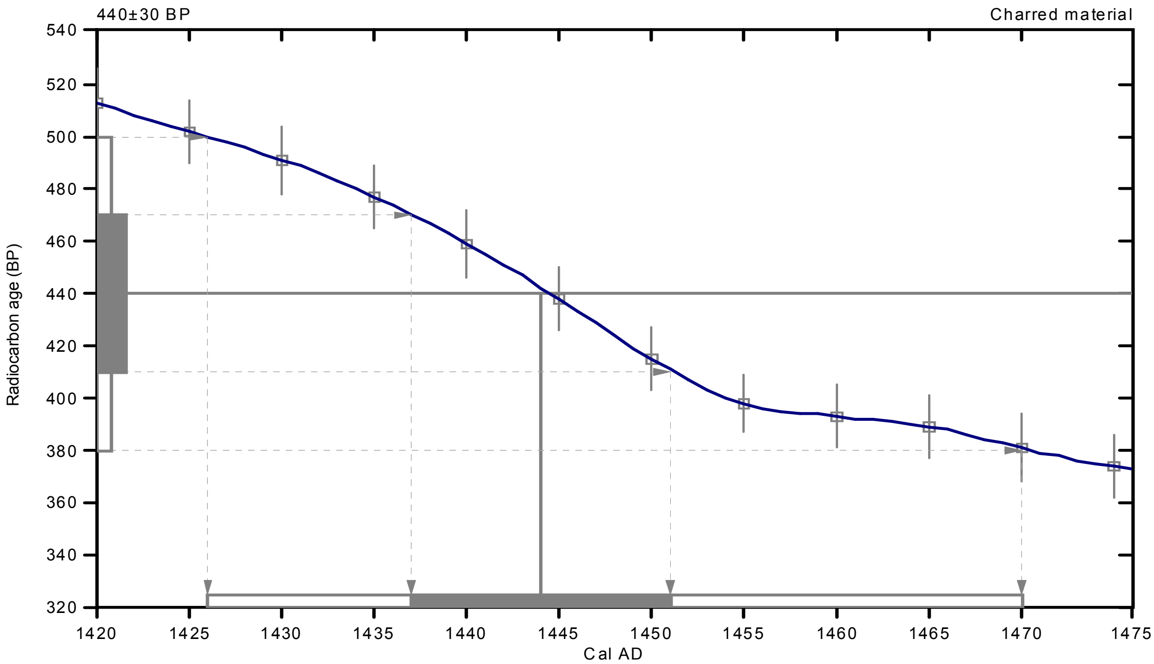
Conventional radiocarbon age: **440±30 BP**

2 Sigma calibrated result: (95% probability) **Cal AD 1430 to 1470 (Cal BP 520 to 480)**

Intercept data

Intercept of radiocarbon age with calibration curve: Cal AD 1440 (Cal BP 510)

1 Sigma calibrated result: (68% probability) Cal AD 1440 to 1450 (Cal BP 510 to 500)



References:

Database used

INTCAL09

References to INTCAL09 database

Heaton,et.al.,2009, Radiocarbon 51(4):1151-1164, Reimer,et.al, 2009, Radiocarbon 51(4):1111-1150, Stuiver,et.al,1993, Radiocarbon 35(1):137-189, Oeschger,et.al.,1975,Tellus 27:168-192

Mathematics used for calibration scenario

A Simplified Approach to Calibrating C14 Dates

Talma, A. S., Vogel, J. C., 1993, Radiocarbon 35(2):317-322

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CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-12.7:lab. mult=1)

Laboratory number: **Beta-317561**

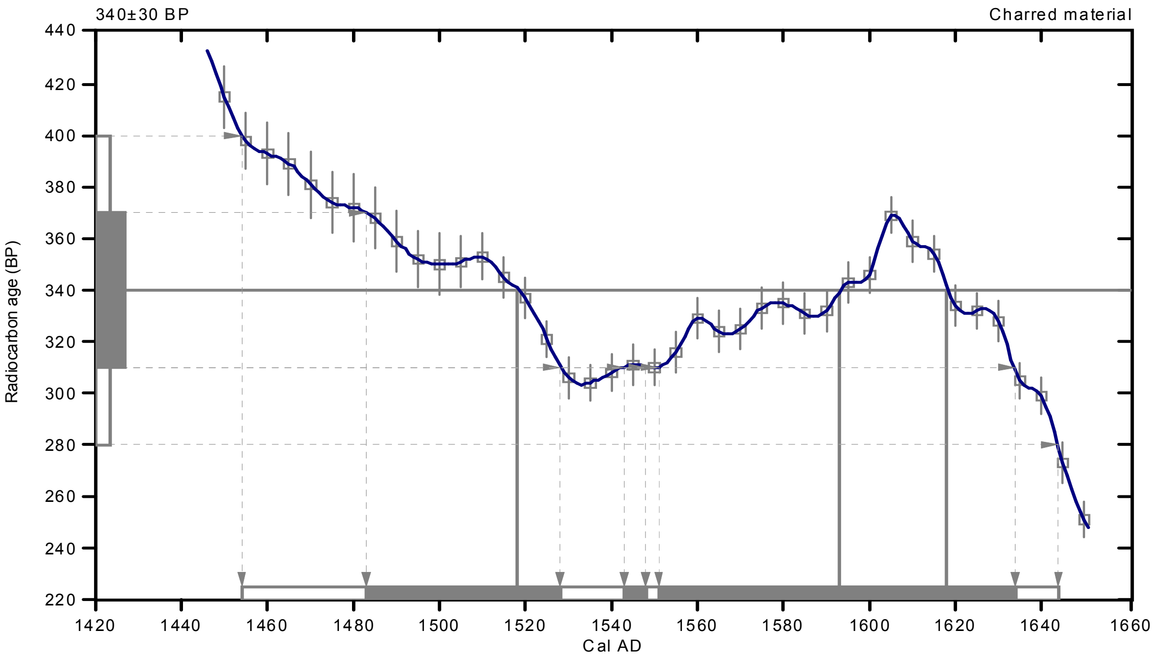
Conventional radiocarbon age: **340±30 BP**

2 Sigma calibrated result: (95% probability) **Cal AD 1450 to 1640 (Cal BP 500 to 310)**

Intercept data

Intercepts of radiocarbon age with calibration curve: Cal AD 1520 (Cal BP 430) and Cal AD 1590 (Cal BP 360) and Cal AD 1620 (Cal BP 330)

1 Sigma calibrated results: (68% probability) Cal AD 1480 to 1530 (Cal BP 470 to 420) and Cal AD 1540 to 1550 (Cal BP 410 to 400) and Cal AD 1550 to 1630 (Cal BP 400 to 320)



References:

Database used

INTCAL09

References to INTCAL09 database

Heaton,et.al.,2009, Radiocarbon 51(4):1151-1164, Reimer,et.al, 2009, Radiocarbon 51(4):1111-1150, Stuiver,et.al,1993, Radiocarbon 35(1):137-189, Oeschger,et.al.,1975,Tellus 27:168-192

Mathematics used for calibration scenario

A Simplified Approach to Calibrating C14 Dates

Talma, A. S., Vogel, J. C., 1993, Radiocarbon 35(2):317-322

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CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-22.1:lab. mult=1)

Laboratory number: **Beta-317562**

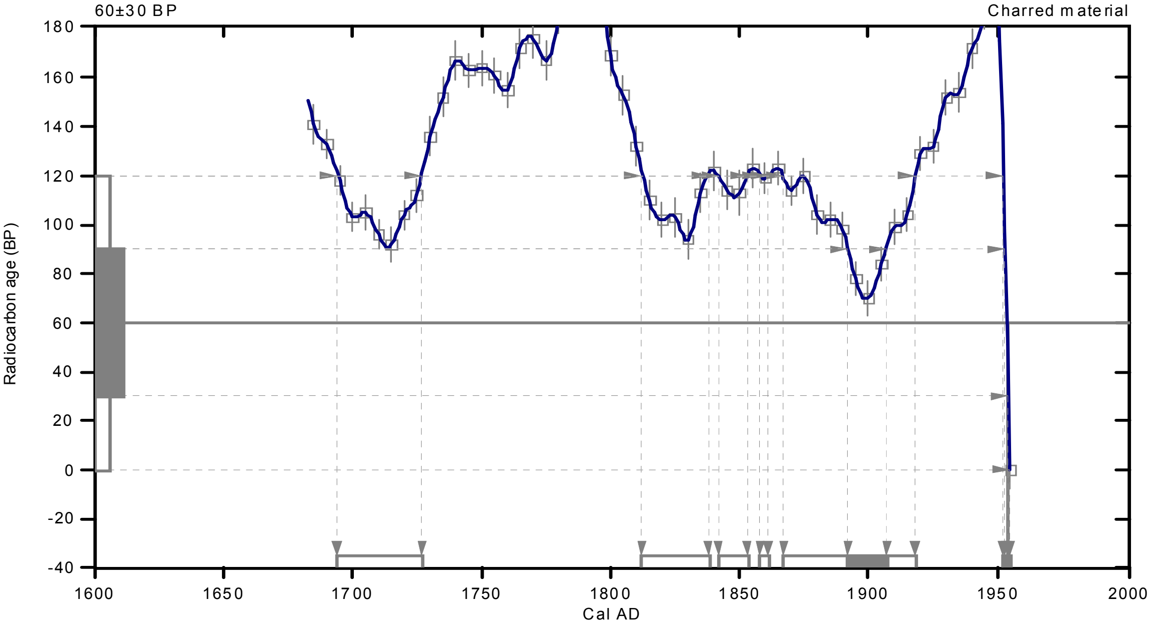
Conventional radiocarbon age: **60±30 BP**

2 Sigma calibrated results: (95% probability)
Cal AD 1690 to 1730 (Cal BP 260 to 220) and
Cal AD 1810 to 1840 (Cal BP 140 to 110) and
Cal AD 1840 to 1850 (Cal BP 110 to 100) and
Cal AD 1860 to 1860 (Cal BP 90 to 90) and
Cal AD 1870 to 1920 (Cal BP 80 to 30) and
Cal AD Post 1950

Intercept data

Intercept of radiocarbon age with calibration curve: Cal AD Post 1950

1 Sigma calibrated results: (68% probability)
Cal AD 1890 to 1910 (Cal BP 60 to 40) and
Cal AD Post 1950



References:

Database used
INTCAL09

References to INTCAL09 database
Heaton,et.al.,2009, Radiocarbon 51(4):1151-1164, Reimer,et.al, 2009, Radiocarbon 51(4):1111-1150, Stuiver,et.al,1993, Radiocarbon 35(1):137-189, Oeschger,et.al.,1975,Tellus 27:168-192

Mathematics used for calibration scenario
A Simplified Approach to Calibrating C14 Dates
Talma, A. S., Vogel, J. C., 1993, Radiocarbon 35(2):317-322

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CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-22.3:lab. mult=1)

Laboratory number: **Beta-317563**

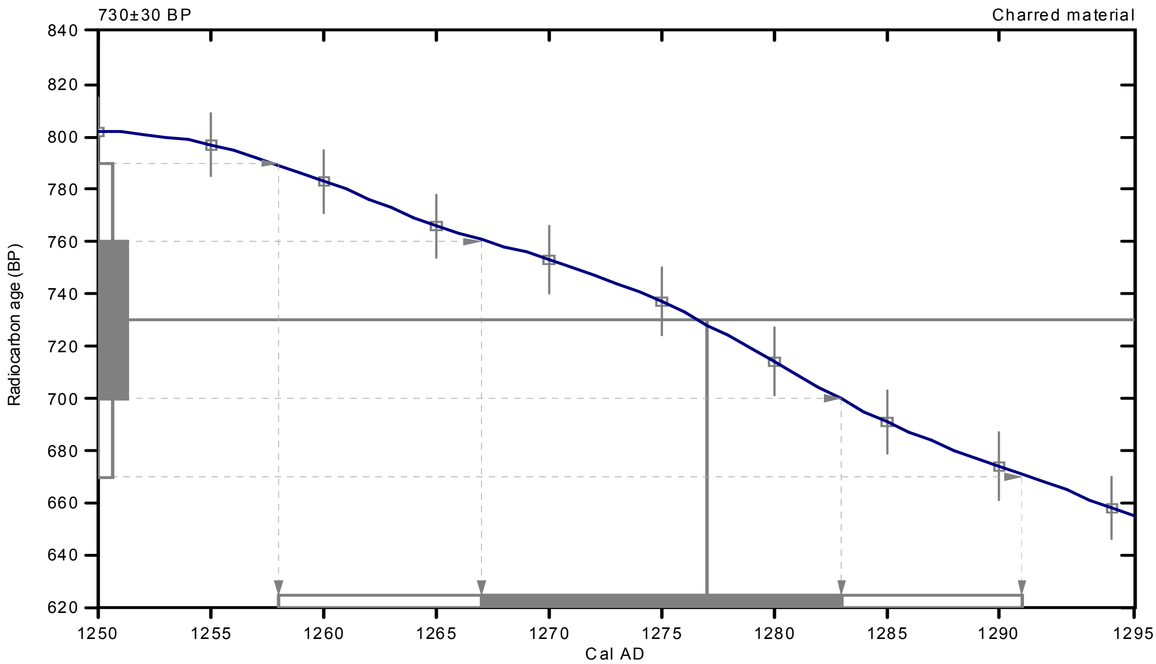
Conventional radiocarbon age: **730±30 BP**

2 Sigma calibrated result: **Cal AD 1260 to 1290 (Cal BP 690 to 660)**
(95% probability)

Intercept data

Intercept of radiocarbon age
with calibration curve: Cal AD 1280 (Cal BP 670)

1 Sigma calibrated result: Cal AD 1270 to 1280 (Cal BP 680 to 670)
(68% probability)



References:

Database used

INTCAL09

References to INTCAL09 database

Heaton,et.al.,2009, Radiocarbon 51(4):1151-1164, Reimer,et.al, 2009, Radiocarbon 51(4):1111-1150, Stuiver,et.al,1993, Radiocarbon 35(1):137-189, Oeschger,et.al.,1975,Tellus 27:168-192

Mathematics used for calibration scenario

A Simplified Approach to Calibrating C14 Dates

Talma, A. S., Vogel, J. C., 1993, Radiocarbon 35(2):317-322

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CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-20.2:lab. mult=1)

Laboratory number: **Beta-317564**

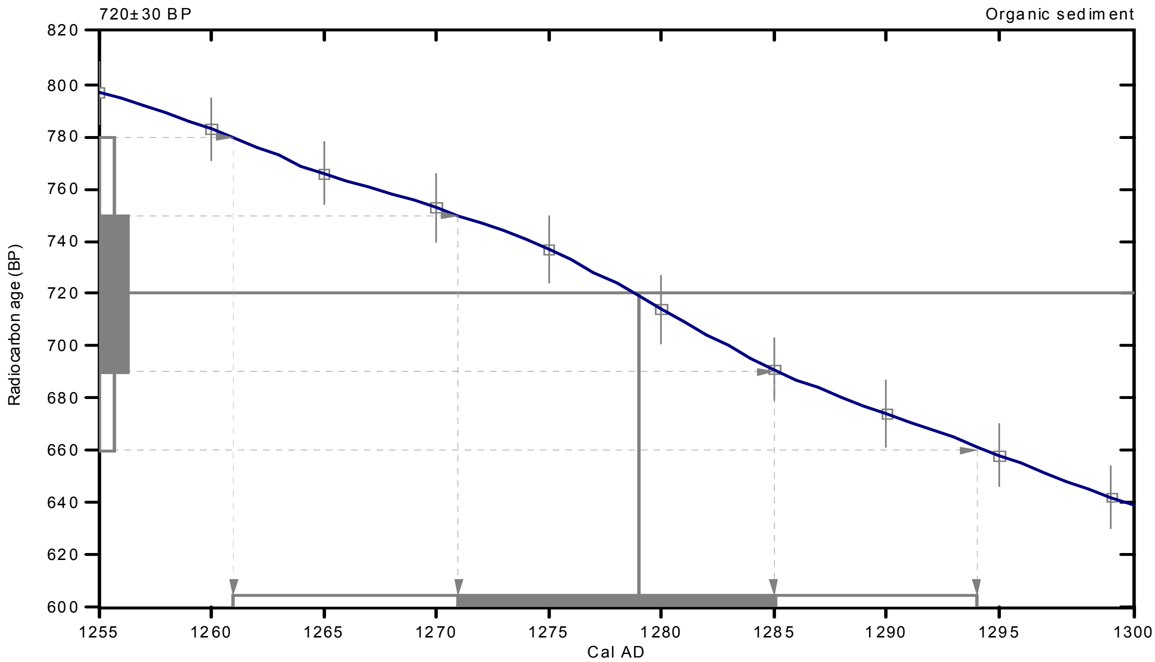
Conventional radiocarbon age: **720±30 BP**

2 Sigma calibrated result: (95% probability) **Cal AD 1260 to 1290 (Cal BP 690 to 660)**

Intercept data

Intercept of radiocarbon age with calibration curve: Cal AD 1280 (Cal BP 670)

1 Sigma calibrated result: (68% probability) Cal AD 1270 to 1280 (Cal BP 680 to 660)



References:

Database used
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References to INTCAL09 database
Heaton,et.al.,2009, Radiocarbon 51(4):1151-1164, Reimer,et.al, 2009, Radiocarbon 51(4):1111-1150, Stuiver,et.al,1993, Radiocarbon 35(1):137-189, Oeschger,et.al.,1975,Tellus 27:168-192

Mathematics used for calibration scenario
A Simplified Approach to Calibrating C14 Dates
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CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-23.2:lab. mult=1)

Laboratory number: **Beta-317565**

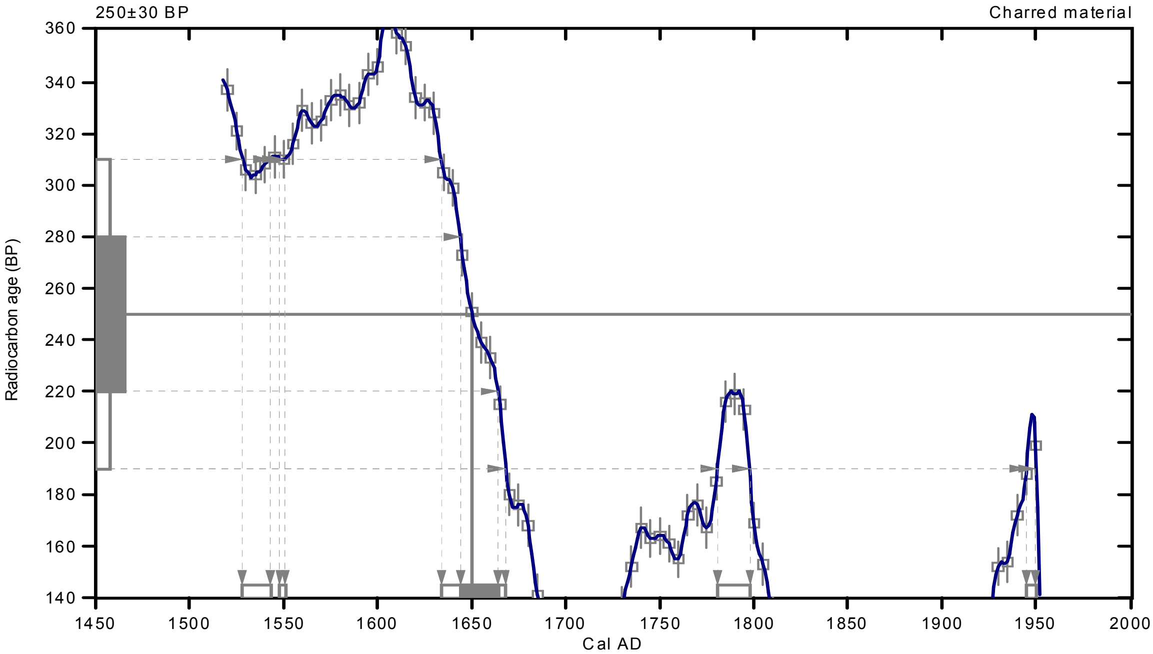
Conventional radiocarbon age: **250±30 BP**

2 Sigma calibrated results:
(95% probability)
Cal AD 1530 to 1540 (Cal BP 420 to 410) and
Cal AD 1550 to 1550 (Cal BP 400 to 400) and
Cal AD 1630 to 1670 (Cal BP 320 to 280) and
Cal AD 1780 to 1800 (Cal BP 170 to 150) and
Cal AD 1940 to 1950 (Cal BP 0 to 0)

Intercept data

Intercept of radiocarbon age with calibration curve: Cal AD 1650 (Cal BP 300)

1 Sigma calibrated result: (68% probability) Cal AD 1640 to 1660 (Cal BP 310 to 290)



References:

Database used
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References to INTCAL09 database
Heaton,et.al.,2009, Radiocarbon 51(4):1151-1164, Reimer,et.al, 2009, Radiocarbon 51(4):1111-1150, Stuiver,et.al,1993, Radiocarbon 35(1):137-189, Oeschger,et.al.,1975,Tellus 27:168-192
Mathematics used for calibration scenario
A Simplified Approach to Calibrating C14 Dates
Talma, A. S., Vogel, J. C., 1993, Radiocarbon 35(2):317-322

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CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-10.5:lab. mult=1)

Laboratory number: **Beta-317566**

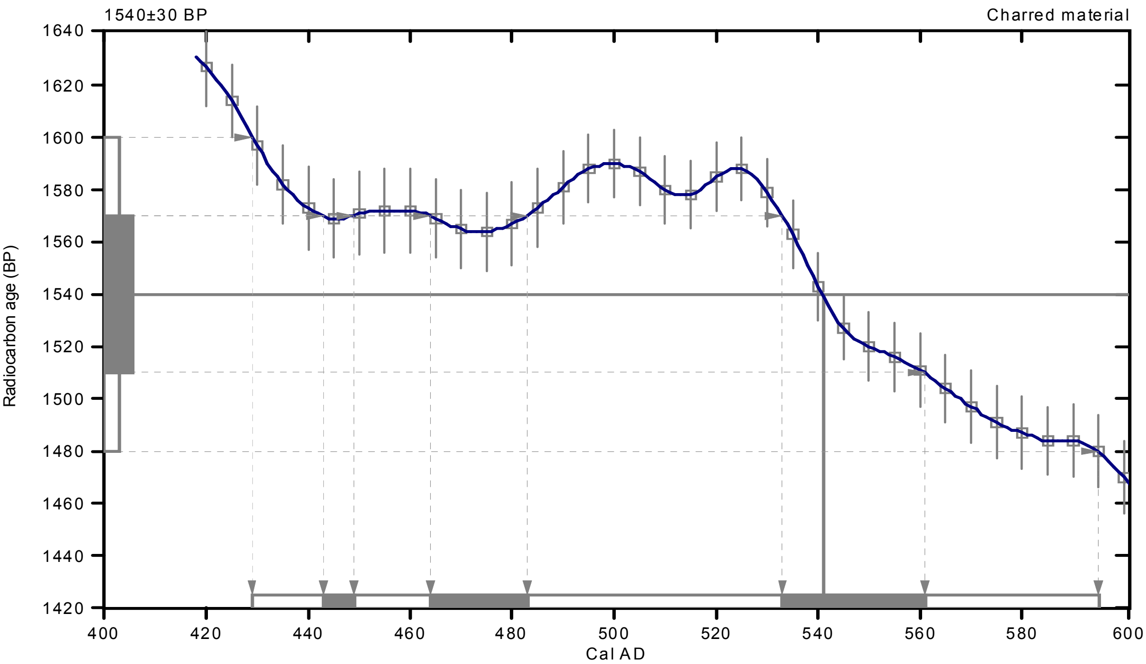
Conventional radiocarbon age: **1540±30 BP**

2 Sigma calibrated result: (95% probability) **Cal AD 430 to 600 (Cal BP 1520 to 1360)**

Intercept data

Intercept of radiocarbon age with calibration curve: Cal AD 540 (Cal BP 1410)

1 Sigma calibrated results: (68% probability)
Cal AD 440 to 450 (Cal BP 1510 to 1500) and
Cal AD 460 to 480 (Cal BP 1490 to 1470) and
Cal AD 530 to 560 (Cal BP 1420 to 1390)



References:

Database used
INTCAL09
References to INTCAL09 database
Heaton,et.al.,2009, Radiocarbon 51(4):1151-1164, Reimer,et.al, 2009, Radiocarbon 51(4):1111-1150, Stuiver,et.al,1993, Radiocarbon 35(1):137-189, Oeschger,et.al.,1975,Tellus 27:168-192
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CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-13.6:lab. mult=1)

Laboratory number: **Beta-317567**

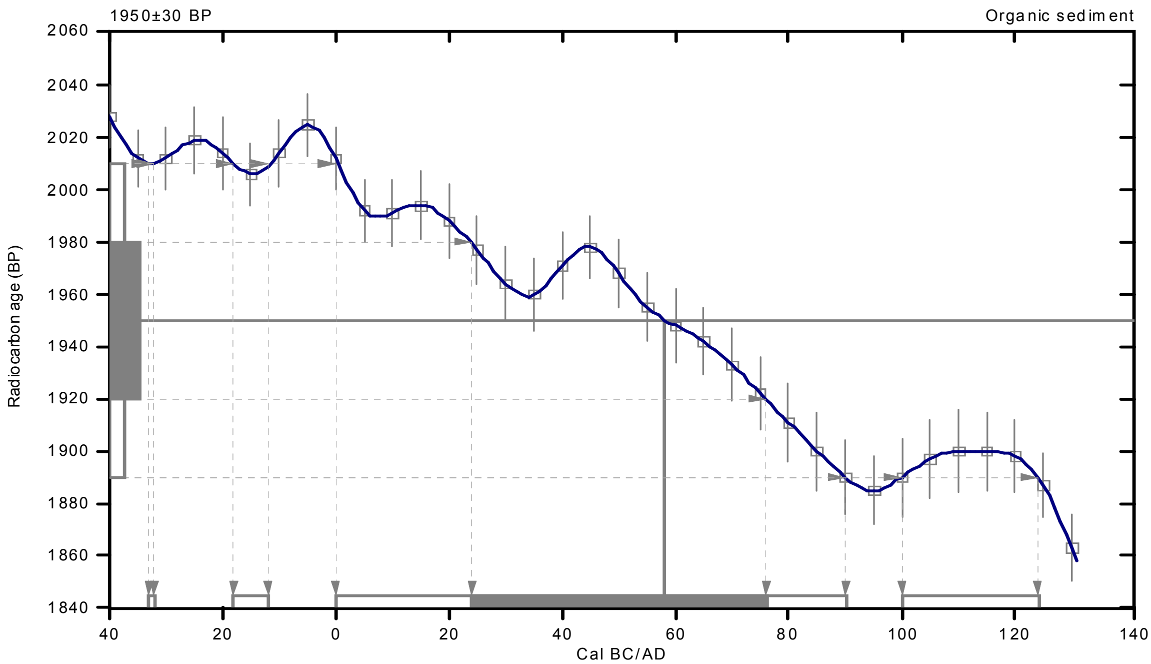
Conventional radiocarbon age: **1950±30 BP**

2 Sigma calibrated results: (95% probability)
Cal BC 30 to 30 (Cal BP 1980 to 1980) and
Cal BC 20 to 10 (Cal BP 1970 to 1960) and
Cal AD 0 to 90 (Cal BP 1950 to 1860) and
Cal AD 100 to 120 (Cal BP 1850 to 1830)

Intercept data

Intercept of radiocarbon age with calibration curve: Cal AD 60 (Cal BP 1890)

1 Sigma calibrated result: (68% probability) Cal AD 20 to 80 (Cal BP 1930 to 1870)



References:

Database used
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References to INTCAL09 database
Heaton,et.al.,2009, Radiocarbon 51(4):1151-1164, Reimer,et.al, 2009, Radiocarbon 51(4):1111-1150, Stuiver,et.al,1993, Radiocarbon 35(1):137-189, Oeschger,et.al.,1975,Tellus 27:168-192
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CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-10.9:lab. mult=1)

Laboratory number: **Beta-317568**

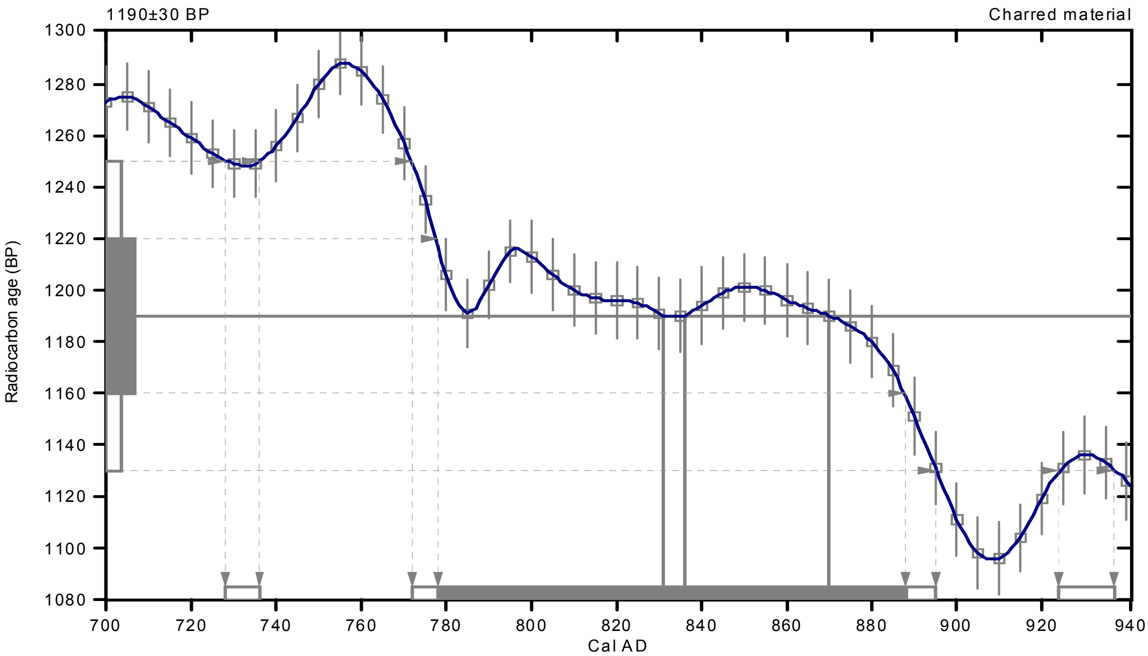
Conventional radiocarbon age: **1190±30 BP**

2 Sigma calibrated results: (95% probability) **Cal AD 730 to 740 (Cal BP 1220 to 1210) and Cal AD 770 to 900 (Cal BP 1180 to 1060) and Cal AD 920 to 940 (Cal BP 1030 to 1010)**

Intercept data

Intercepts of radiocarbon age with calibration curve: Cal AD 830 (Cal BP 1120) and Cal AD 840 (Cal BP 1110) and Cal AD 870 (Cal BP 1080)

1 Sigma calibrated result: (68% probability) Cal AD 780 to 890 (Cal BP 1170 to 1060)



References:

Database used

INTCAL09

References to INTCAL09 database

Heaton,et.al.,2009, Radiocarbon 51(4):1151-1164, Reimer,et.al, 2009, Radiocarbon 51(4):1111-1150, Stuiver,et.al,1993, Radiocarbon 35(1):137-189, Oeschger,et.al.,1975,Tellus 27:168-192

Mathematics used for calibration scenario

A Simplified Approach to Calibrating C14 Dates

Talma, A. S., Vogel, J. C., 1993, Radiocarbon 35(2):317-322

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CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-24.2:lab. mult=1)

Laboratory number: **Beta-317569**

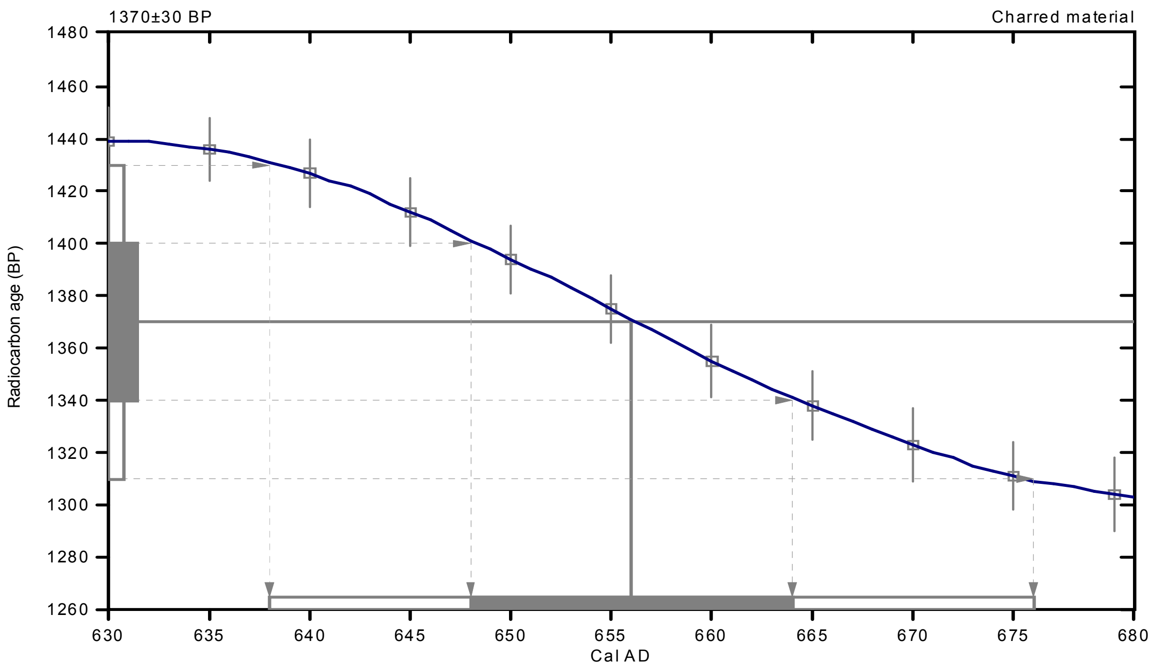
Conventional radiocarbon age: **1370±30 BP**

2 Sigma calibrated result: (95% probability) **Cal AD 640 to 680 (Cal BP 1310 to 1270)**

Intercept data

Intercept of radiocarbon age with calibration curve: Cal AD 660 (Cal BP 1290)

1 Sigma calibrated result: (68% probability) Cal AD 650 to 660 (Cal BP 1300 to 1290)



References:

Database used
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References to INTCAL09 database
Heaton,et.al.,2009, Radiocarbon 51(4):1151-1164, Reimer,et.al, 2009, Radiocarbon 51(4):1111-1150, Stuiver,et.al,1993, Radiocarbon 35(1):137-189, Oeschger,et.al.,1975,Tellus 27:168-192
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CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-11.6:lab. mult=1)

Laboratory number: **Beta-317570**

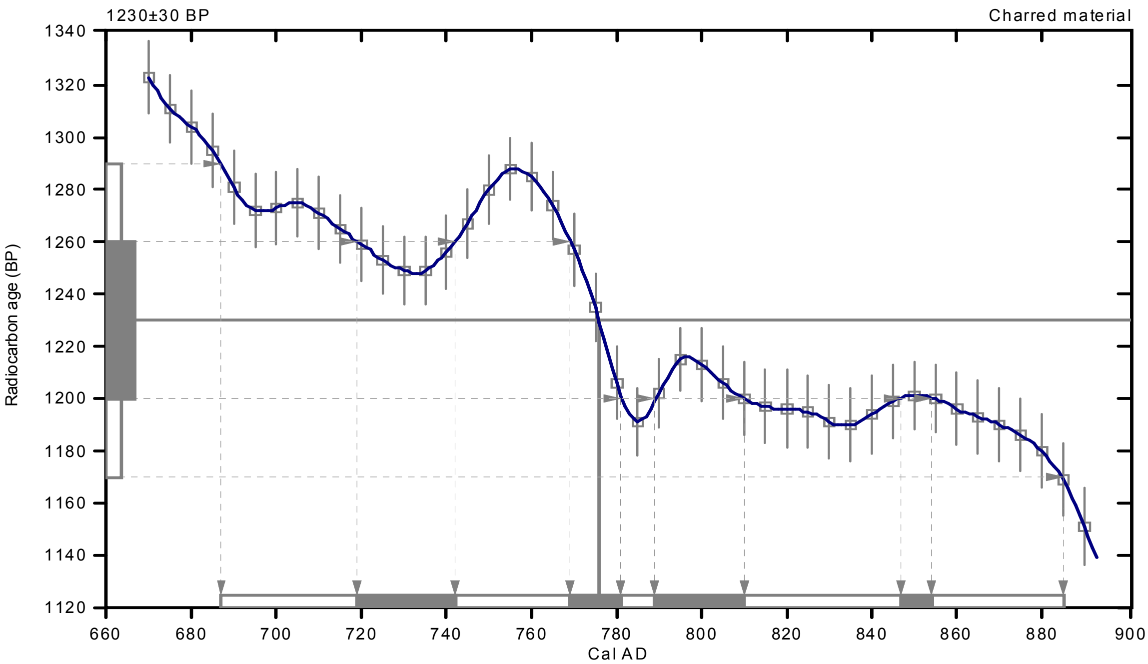
Conventional radiocarbon age: **1230±30 BP**

2 Sigma calibrated result: **Cal AD 690 to 880 (Cal BP 1260 to 1060)**
(95% probability)

Intercept data

Intercept of radiocarbon age
with calibration curve: Cal AD 780 (Cal BP 1170)

1 Sigma calibrated results: Cal AD 720 to 740 (Cal BP 1230 to 1210) and
(68% probability) Cal AD 770 to 780 (Cal BP 1180 to 1170) and
Cal AD 790 to 810 (Cal BP 1160 to 1140) and
Cal AD 850 to 850 (Cal BP 1100 to 1100)



References:

Database used
INTCAL09
References to INTCAL09 database
Heaton,et.al.,2009, Radiocarbon 51(4):1151-1164, Reimer,et.al, 2009, Radiocarbon 51(4):1111-1150, Stuiver,et.al,1993, Radiocarbon 35(1):137-189, Oeschger,et.al.,1975,Tellus 27:168-192
Mathematics used for calibration scenario
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CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-22.6:lab. mult=1)

Laboratory number: **Beta-317571**

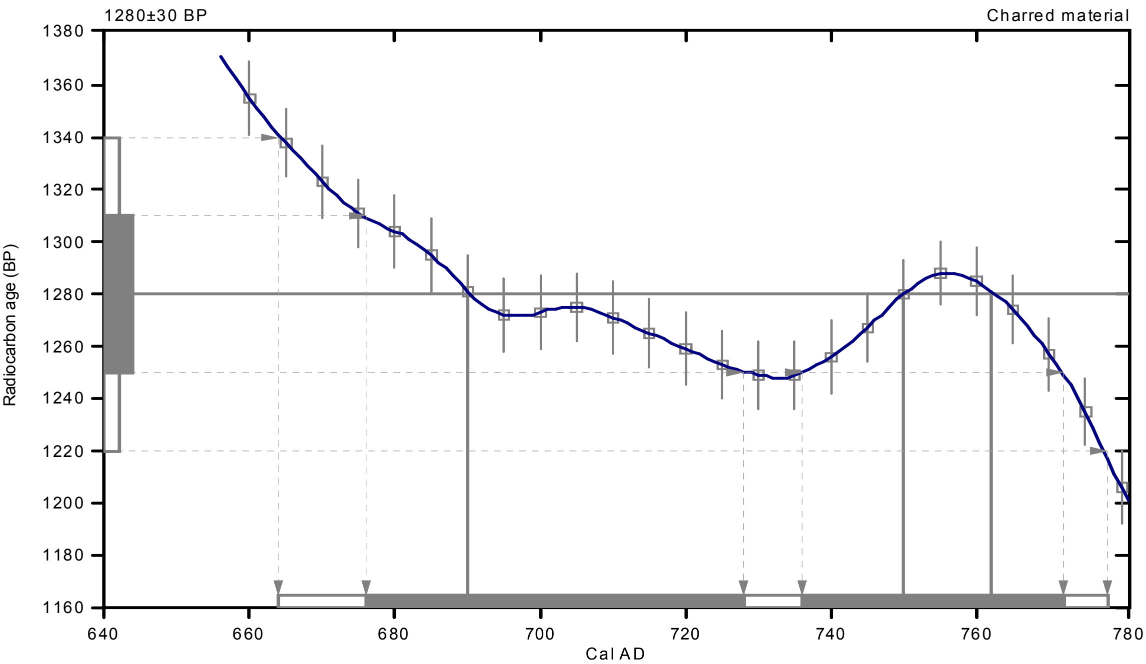
Conventional radiocarbon age: **1280±30 BP**

2 Sigma calibrated result: (95% probability) **Cal AD 660 to 780 (Cal BP 1290 to 1170)**

Intercept data

Intercepts of radiocarbon age with calibration curve: Cal AD 690 (Cal BP 1260) and
Cal AD 750 (Cal BP 1200) and
Cal AD 760 (Cal BP 1190)

1 Sigma calibrated results: (68% probability) Cal AD 680 to 730 (Cal BP 1270 to 1220) and
Cal AD 740 to 770 (Cal BP 1210 to 1180)



References:

Database used

INTCAL09

References to INTCAL09 database

Heaton,et.al.,2009, Radiocarbon 51(4):1151-1164, Reimer,et.al, 2009, Radiocarbon 51(4):1111-1150, Stuiver,et.al,1993, Radiocarbon 35(1):137-189, Oeschger,et.al.,1975,Tellus 27:168-192

Mathematics used for calibration scenario

A Simplified Approach to Calibrating C14 Dates

Talma, A. S., Vogel, J. C., 1993, Radiocarbon 35(2):317-322

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CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-22.8:lab. mult=1)

Laboratory number: **Beta-317572**

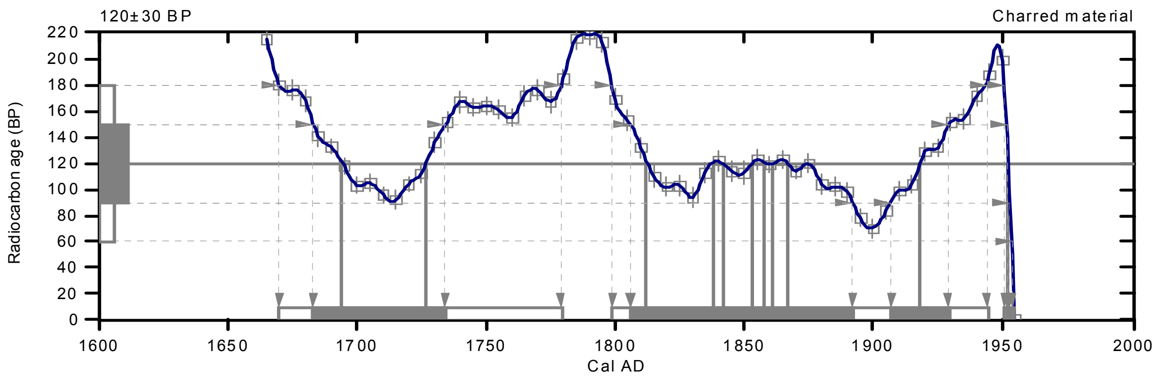
Conventional radiocarbon age: **120±30 BP**

2 Sigma calibrated results: **Cal AD 1670 to 1780 (Cal BP 280 to 170) and**
(95% probability) **Cal AD 1800 to 1940 (Cal BP 150 to 10) and**
Cal AD Post 1950

Intercept data

Intercepts of radiocarbon age
with calibration curve: Cal AD 1690 (Cal BP 260) and
Cal AD 1730 (Cal BP 220) and
Cal AD 1810 (Cal BP 140) and
Cal AD 1840 (Cal BP 110) and
Cal AD 1840 (Cal BP 110) and
Cal AD 1850 (Cal BP 100) and
Cal AD 1860 (Cal BP 90) and
Cal AD 1860 (Cal BP 90) and
Cal AD 1870 (Cal BP 80) and
Cal AD 1920 (Cal BP 30) and
Cal AD Post 1950

1 Sigma calibrated results: Cal AD 1680 to 1730 (Cal BP 270 to 220) and
(68% probability) Cal AD 1810 to 1890 (Cal BP 140 to 60) and
Cal AD 1910 to 1930 (Cal BP 40 to 20) and
Cal AD Post 1950



References:

Database used
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References to INTCAL09 database
Heaton,et.al.,2009, Radiocarbon 51(4):1151-1164, Reimer,et.al, 2009, Radiocarbon 51(4):1111-1150, Stuiver,et.al,1993, Radiocarbon 35(1):137-189, Oeschger,et.al.,1975,Tellus 27:168-192
Mathematics used for calibration scenario
A Simplified Approach to Calibrating C14 Dates
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CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-10.8:lab. mult=1)

Laboratory number: **Beta-317573**

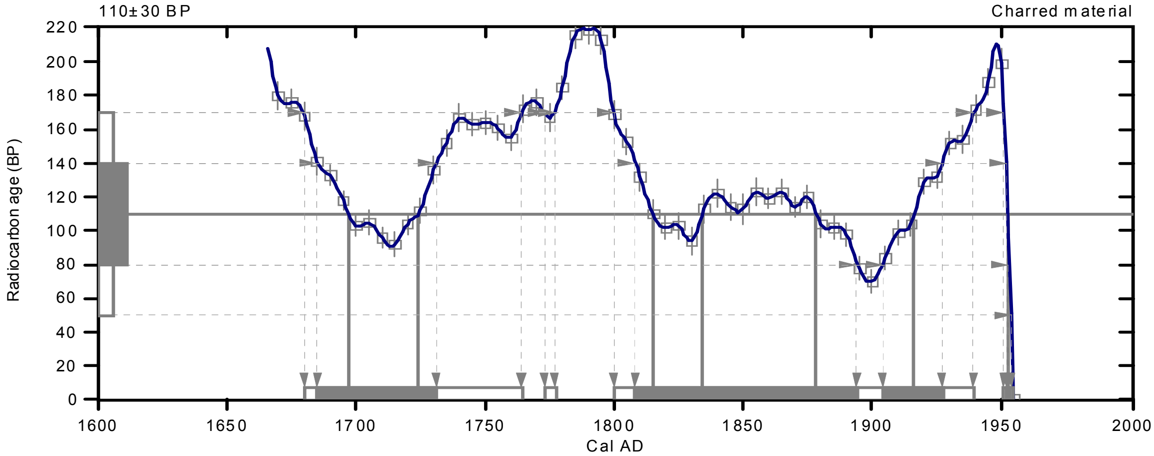
Conventional radiocarbon age: **110±30 BP**

2 Sigma calibrated results: (95% probability)
Cal AD 1680 to 1760 (Cal BP 270 to 190) and
Cal AD 1770 to 1780 (Cal BP 180 to 170) and
Cal AD 1800 to 1940 (Cal BP 150 to 10) and
Cal AD Post 1950

Intercept data

Intercepts of radiocarbon age with calibration curve:
Cal AD 1700 (Cal BP 250) and
Cal AD 1720 (Cal BP 230) and
Cal AD 1820 (Cal BP 140) and
Cal AD 1830 (Cal BP 120) and
Cal AD 1880 (Cal BP 70) and
Cal AD 1920 (Cal BP 30) and
Cal AD Post 1950

1 Sigma calibrated results: (68% probability)
Cal AD 1680 to 1730 (Cal BP 260 to 220) and
Cal AD 1810 to 1890 (Cal BP 140 to 60) and
Cal AD 1900 to 1930 (Cal BP 50 to 20) and
Cal AD Post 1950



References:

Database used
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References to INTCAL09 database
Heaton,et.al.,2009, Radiocarbon 51(4):1151-1164, Reimer,et.al, 2009, Radiocarbon 51(4):1111-1150, Stuiver,et.al,1993, Radiocarbon 35(1):137-189, Oeschger,et.al.,1975,Tellus 27:168-192
Mathematics used for calibration scenario
A Simplified Approach to Calibrating C14 Dates
Talma, A. S., Vogel, J. C., 1993, Radiocarbon 35(2):317-322

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CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-23.4:lab. mult=1)

Laboratory number: **Beta-317574**

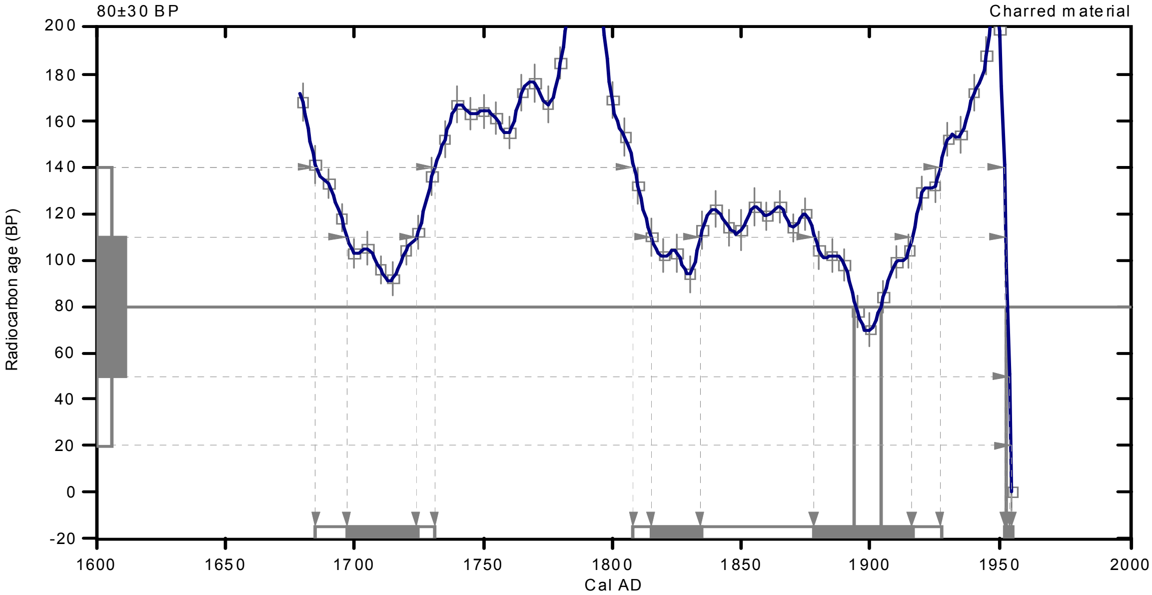
Conventional radiocarbon age: **80±30 BP**

2 Sigma calibrated results: (95% probability) **Cal AD 1680 to 1730 (Cal BP 260 to 220) and Cal AD 1810 to 1930 (Cal BP 140 to 20) and Cal AD Post 1950**

Intercept data

Intercepts of radiocarbon age with calibration curve: Cal AD 1890 (Cal BP 60) and Cal AD 1900 (Cal BP 50) and Cal AD Post 1950

1 Sigma calibrated results: (68% probability) Cal AD 1700 to 1720 (Cal BP 250 to 230) and Cal AD 1820 to 1830 (Cal BP 140 to 120) and Cal AD 1880 to 1920 (Cal BP 70 to 30) and Cal AD Post 1950



References:

Database used
INTCAL09
References to INTCAL09 database
Heaton,et.al.,2009, Radiocarbon 51(4):1151-1164, Reimer,et.al, 2009, Radiocarbon 51(4):1111-1150, Stuiver,et.al,1993, Radiocarbon 35(1):137-189, Oeschger,et.al.,1975,Tellus 27:168-192
Mathematics used for calibration scenario
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CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-21.2:lab. mult=1)

Laboratory number: **Beta-317575**

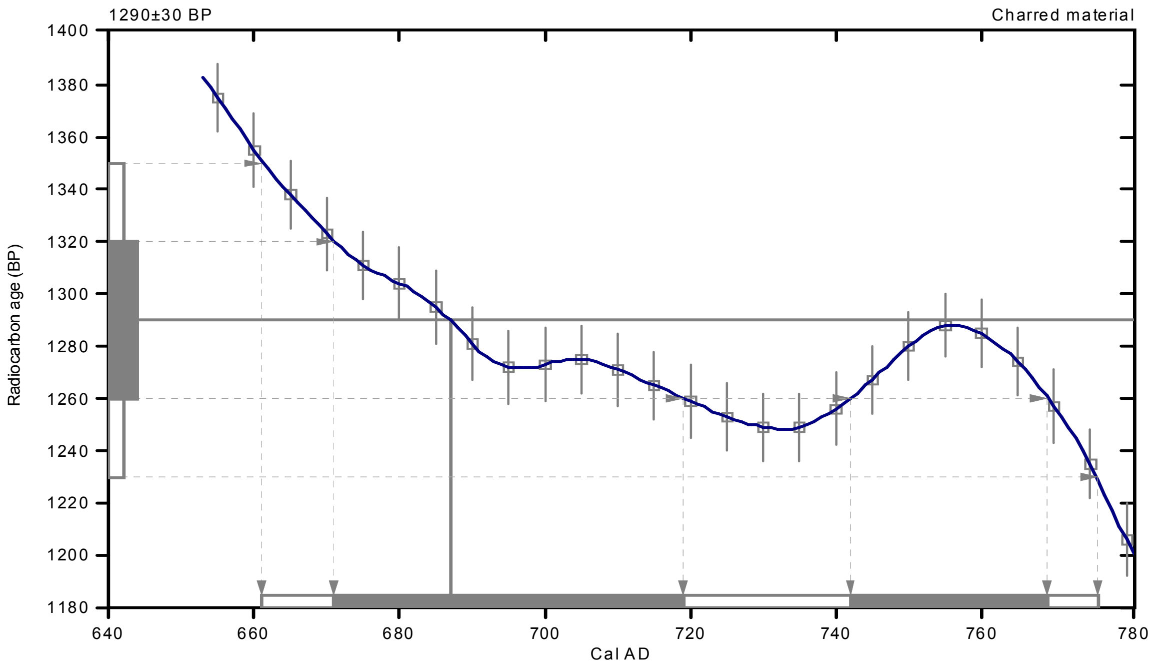
Conventional radiocarbon age: **1290±30 BP**

2 Sigma calibrated result: (95% probability) **Cal AD 660 to 780 (Cal BP 1290 to 1170)**

Intercept data

Intercept of radiocarbon age with calibration curve: Cal AD 690 (Cal BP 1260)

1 Sigma calibrated results: (68% probability) Cal AD 670 to 720 (Cal BP 1280 to 1230) and Cal AD 740 to 770 (Cal BP 1210 to 1180)



References:

Database used
INTCAL09
References to INTCAL09 database
Heaton,et.al.,2009, Radiocarbon 51(4):1151-1164, Reimer,et.al, 2009, Radiocarbon 51(4):1111-1150, Stuiver,et.al,1993, Radiocarbon 35(1):137-189, Oeschger,et.al.,1975,Tellus 27:168-192
Mathematics used for calibration scenario
A Simplified Approach to Calibrating C14 Dates
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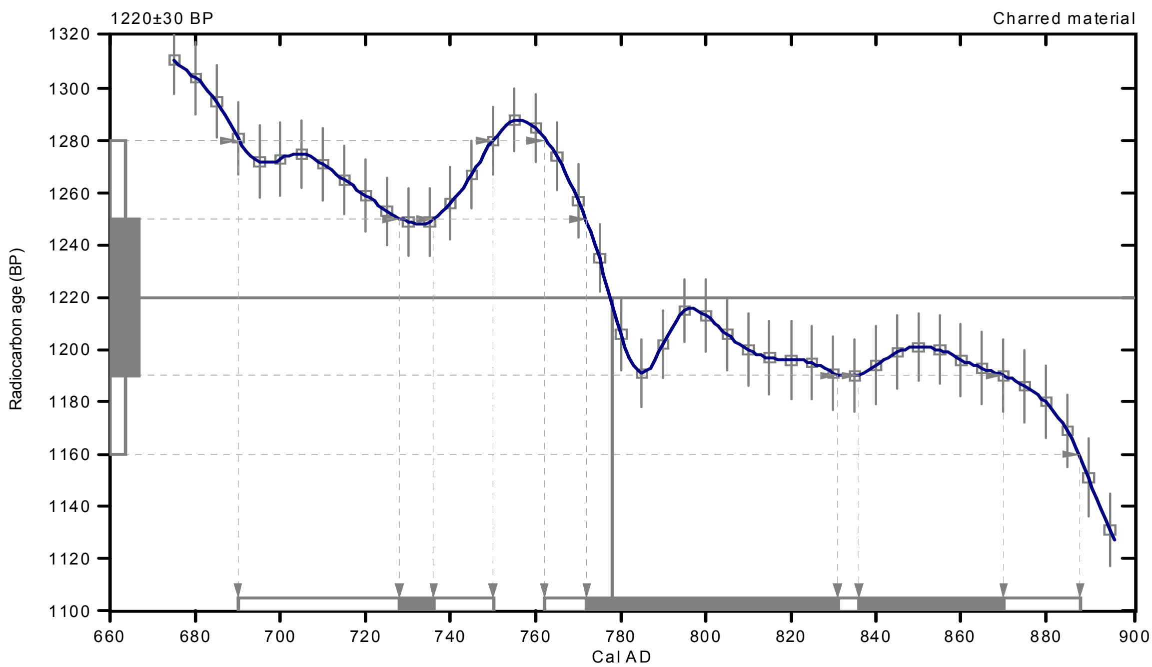
CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-23.5:lab. mult=1)

Laboratory number:	**Beta-317576**
Conventional radiocarbon age:	**1220±30 BP**
2 Sigma calibrated results: **(95% probability)**	**Cal AD 690 to 750 (Cal BP 1260 to 1200) and** **Cal AD 760 to 890 (Cal BP 1190 to 1060)**

Intercept data

Intercept of radiocarbon age with calibration curve:	Cal AD 780 (Cal BP 1170)
1 Sigma calibrated results: (68% probability)	Cal AD 730 to 740 (Cal BP 1220 to 1210) and Cal AD 770 to 830 (Cal BP 1180 to 1120) and Cal AD 840 to 870 (Cal BP 1110 to 1080)



References:

Database used

INTCAL09

References to INTCAL09 database

Heaton,et.al.,2009, Radiocarbon 51(4):1151-1164, Reimer,et.al, 2009, Radiocarbon 51(4):1111-1150, Stuiver,et.al,1993, Radiocarbon 35(1):137-189, Oeschger,et.al.,1975,Tellus 27:168-192

Mathematics used for calibration scenario

A Simplified Approach to Calibrating C14 Dates

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CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-21.2:lab. mult=1)

Laboratory number: **Beta-317577**

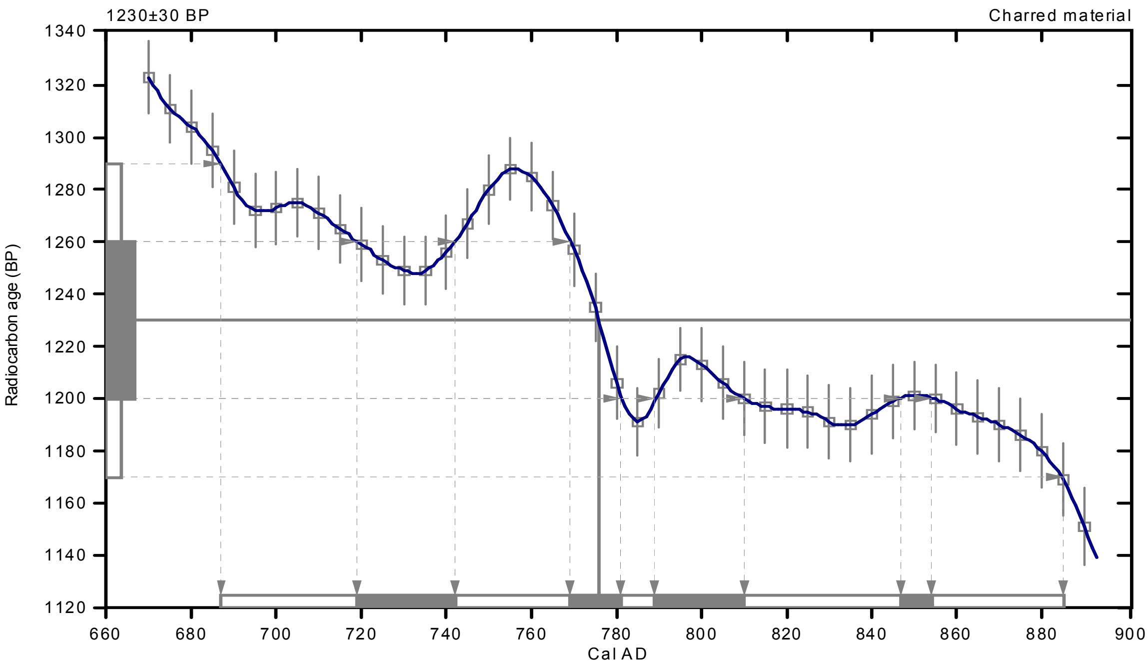
Conventional radiocarbon age: **1230±30 BP**

2 Sigma calibrated result: (95% probability) **Cal AD 690 to 880 (Cal BP 1260 to 1060)**

Intercept data

Intercept of radiocarbon age with calibration curve: Cal AD 780 (Cal BP 1170)

1 Sigma calibrated results: (68% probability)
Cal AD 720 to 740 (Cal BP 1230 to 1210) and
Cal AD 770 to 780 (Cal BP 1180 to 1170) and
Cal AD 790 to 810 (Cal BP 1160 to 1140) and
Cal AD 850 to 850 (Cal BP 1100 to 1100)



References:

Database used
INTCAL09

References to INTCAL09 database
Heaton,et.al.,2009, Radiocarbon 51(4):1151-1164, Reimer,et.al, 2009, Radiocarbon 51(4):1111-1150, Stuiver,et.al,1993, Radiocarbon 35(1):137-189, Oeschger,et.al.,1975,Tellus 27:168-192

Mathematics used for calibration scenario
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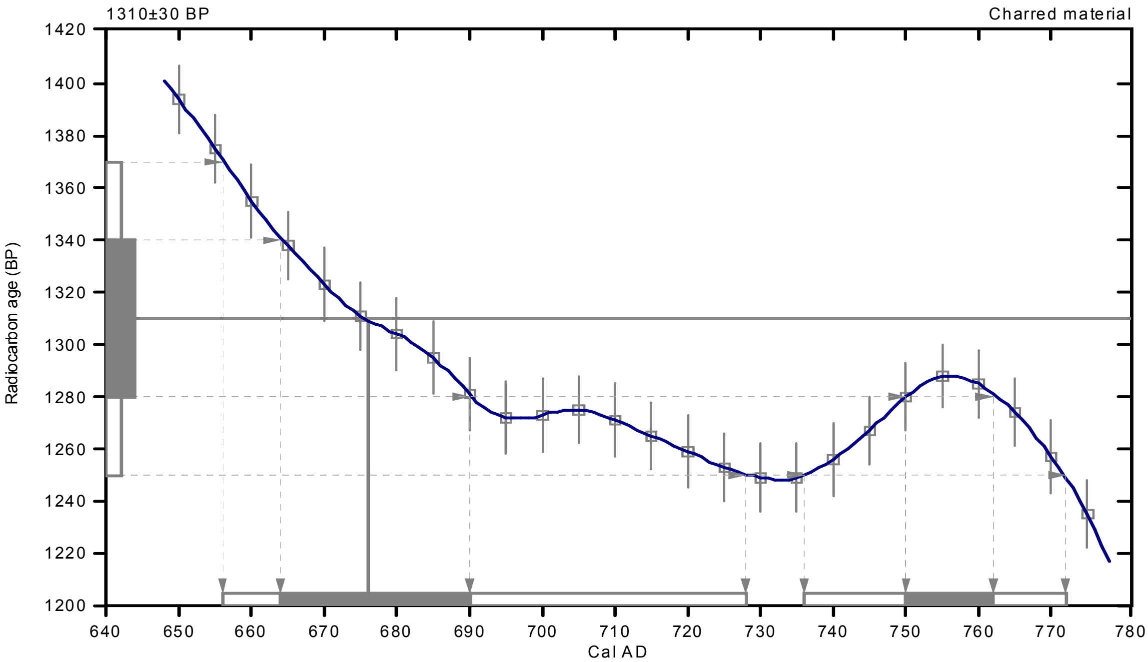
CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-12.3:lab. mult=1)

Laboratory number:	**Beta-317578**
Conventional radiocarbon age:	**1310±30 BP**
2 Sigma calibrated results: (95% probability)	**Cal AD 660 to 730 (Cal BP 1290 to 1220) and Cal AD 740 to 770 (Cal BP 1210 to 1180)**

Intercept data

Intercept of radiocarbon age with calibration curve:	Cal AD 680 (Cal BP 1270)
1 Sigma calibrated results: (68% probability)	Cal AD 660 to 690 (Cal BP 1290 to 1260) and Cal AD 750 to 760 (Cal BP 1200 to 1190)



References:

Database used

INTCAL09

References to INTCAL09 database

Heaton,et.al.,2009, Radiocarbon 51(4):1151-1164, Reimer,et.al, 2009, Radiocarbon 51(4):1111-1150, Stuiver,et.al,1993, Radiocarbon 35(1):137-189, Oeschger,et.al.,1975,Tellus 27:168-192

Mathematics used for calibration scenario

A Simplified Approach to Calibrating C14 Dates

Talma, A. S., Vogel, J. C., 1993, Radiocarbon 35(2):317-322

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CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

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

Laboratory number: **Beta-317579**

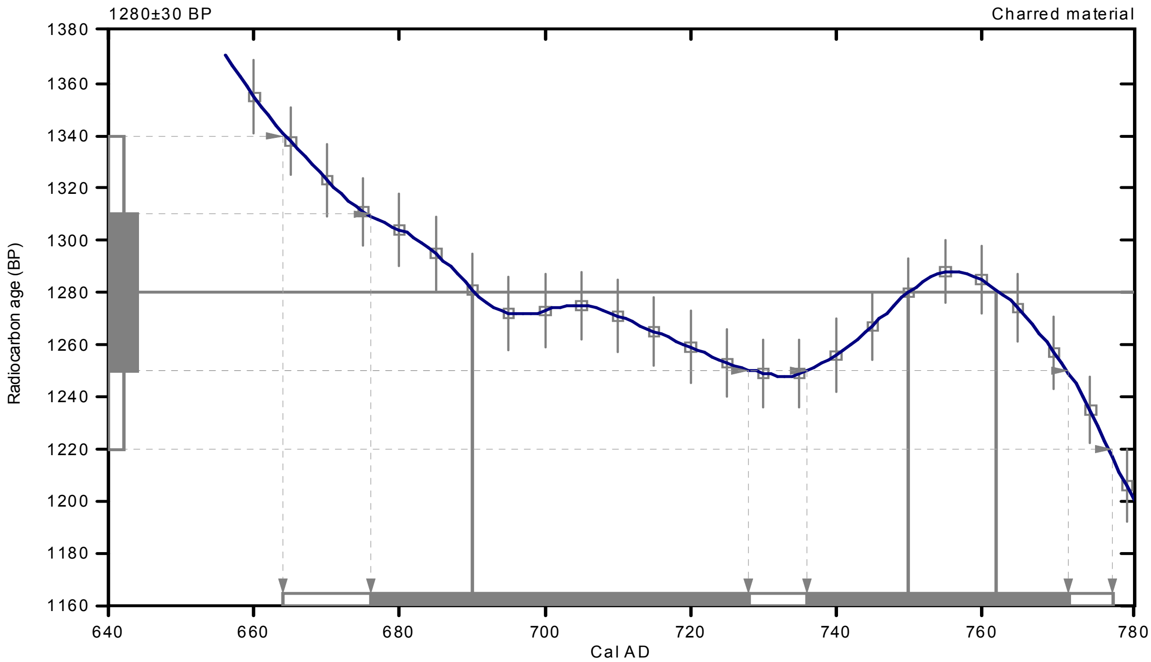
Conventional radiocarbon age: **1280±30 BP**

2 Sigma calibrated result: **Cal AD 660 to 780 (Cal BP 1290 to 1170)**
(95% probability)

Intercept data

Intercepts of radiocarbon age with calibration curve: Cal AD 690 (Cal BP 1260) and
Cal AD 750 (Cal BP 1200) and
Cal AD 760 (Cal BP 1190)

1 Sigma calibrated results: Cal AD 680 to 730 (Cal BP 1270 to 1220) and
(68% probability) Cal AD 740 to 770 (Cal BP 1210 to 1180)



References:
Database used
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References to INTCAL09 database
Heaton,et.al.,2009, Radiocarbon 51(4):1151-1164, Reimer,et.al, 2009, Radiocarbon 51(4):1111-1150, Stuiver,et.al,1993, Radiocarbon 35(1):137-189, Oeschger,et.al.,1975,Tellus 27:168-192
Mathematics used for calibration scenario
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CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-23.4:lab. mult=1)

Laboratory number: **Beta-317582**

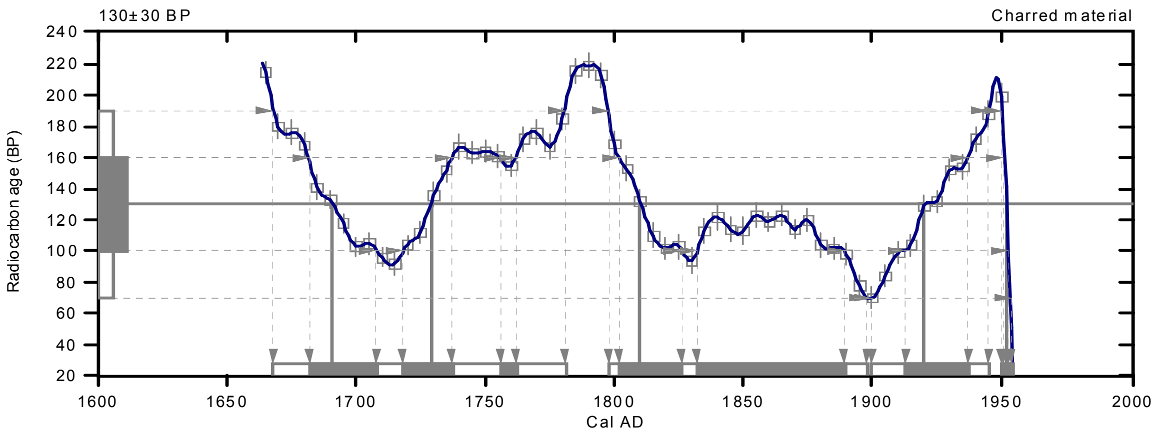
Conventional radiocarbon age: **130±30 BP**

2 Sigma calibrated results: (95% probability)
Cal AD 1670 to 1780 (Cal BP 280 to 170) and
Cal AD 1800 to 1900 (Cal BP 150 to 50) and
Cal AD 1900 to 1940 (Cal BP 50 to 0) and
Cal AD 1950 to post 1950 (Cal BP 0 to post 1950)

Intercept data

Intercepts of radiocarbon age with calibration curve:
Cal AD 1690 (Cal BP 260) and
Cal AD 1730 (Cal BP 220) and
Cal AD 1810 (Cal BP 140) and
Cal AD 1920 (Cal BP 30) and
Cal AD Post 1950

1 Sigma calibrated results: (68% probability)
Cal AD 1680 to 1710 (Cal BP 270 to 240) and
Cal AD 1720 to 1740 (Cal BP 230 to 210) and
Cal AD 1760 to 1760 (Cal BP 190 to 190) and
Cal AD 1800 to 1830 (Cal BP 150 to 120) and
Cal AD 1830 to 1890 (Cal BP 120 to 60) and
Cal AD 1910 to 1940 (Cal BP 40 to 10) and
Cal AD Post 1950



References:

Database used
INTCAL09
References to INTCAL09 database
Heaton,et.al.,2009, Radiocarbon 51(4):1151-1164, Reimer,et.al, 2009, Radiocarbon 51(4):1111-1150, Stuiver,et.al,1993, Radiocarbon 35(1):137-189, Oeschger,et.al.,1975,Tellus 27:168-192
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REPORT OF RADIOCARBON DATING ANALYSES

Dr. Robert Dello-Russo — Report Date: 3/19/2012

Office of Archaeological Studies — Material Received: 3/1/2012

Sample Data	Measured Radiocarbon Age	13C/12C Ratio	Conventional Radiocarbon Age(*)
Beta - 317580	1600 +/- 30 BP	-12.6 o/oo	1800 +/- 30 BP

SAMPLE : 429-F3-300-s
ANALYSIS : RadiometricPLUS-Standard delivery
MATERIAL/PRETREATMENT : (charred material): acid/alkali/acid
2 SIGMA CALIBRATION : Cal AD 130 to 260 (Cal BP 1820 to 1690) AND Cal AD 300 to 320 (Cal BP 1660 to 1630)

Sample Data	Measured Radiocarbon Age	13C/12C Ratio	Conventional Radiocarbon Age(*)
Beta - 317581	270 +/- 30 BP	-23.3 o/oo	300 +/- 30 BP

SAMPLE : 429-F11-297-m
ANALYSIS : RadiometricPLUS-Standard delivery
MATERIAL/PRETREATMENT : (charred material): acid/alkali/acid
2 SIGMA CALIBRATION : Cal AD 1490 to 1600 (Cal BP 460 to 350) AND Cal AD 1610 to 1650 (Cal BP 340 to 300)

Sample Data	Measured Radiocarbon Age	13C/12C Ratio	Conventional Radiocarbon Age(*)
Beta - 317583	100 +/- 30 BP	-23.6 o/oo	120 +/- 30 BP

SAMPLE : 964-F1-45-m
ANALYSIS : RadiometricPLUS-Standard delivery
MATERIAL/PRETREATMENT : (charred material): acid/alkali/acid
2 SIGMA CALIBRATION : Cal AD 1670 to 1780 (Cal BP 280 to 170) AND Cal AD 1800 to 1940 (Cal BP 150 to 10)
Cal AD Post 1950

Dates are reported as RCYBP (radiocarbon years before present, "present" = AD 1950). By international convention, the modern reference standard was 95% the 14C activity of the National Institute of Standards and Technology (NIST) Oxalic Acid (SRM 4990C) and calculated using the Libby 14C half-life (5568 years). Quoted errors represent 1 relative standard deviation statistics (68% probability) counting errors based on the combined measurements of the sample, background, and modern reference standards. Measured 13C/12C ratios (delta 13C) were calculated relative to the PDB-1 standard.

The Conventional Radiocarbon Age represents the Measured Radiocarbon Age corrected for isotopic fractionation, calculated using the delta 13C. On rare occasion where the Conventional Radiocarbon Age was calculated using an assumed delta 13C, the ratio and the Conventional Radiocarbon Age will be followed by "*". The Conventional Radiocarbon Age is not calendar calibrated. When available, the Calendar Calibrated result is calculated from the Conventional Radiocarbon Age and is listed as the "Two Sigma Calibrated Result" for each sample.

CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-12.6:lab. mult=1)

Laboratory number: **Beta-317580**

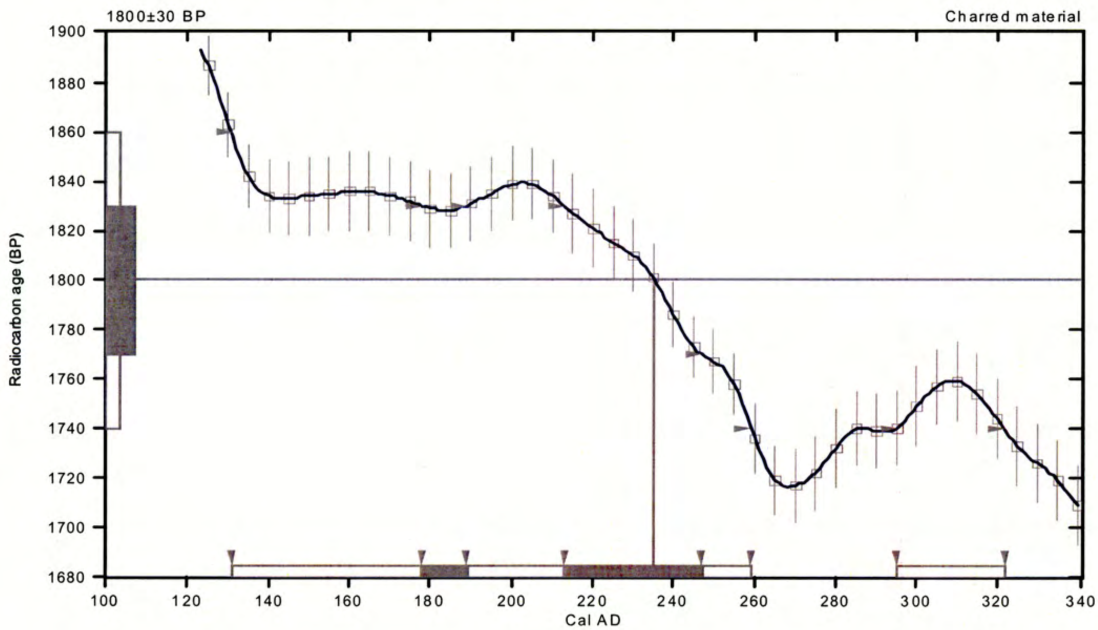
Conventional radiocarbon age: **1800±30 BP**

2 Sigma calibrated results: (95% probability) **Cal AD 130 to 260 (Cal BP 1820 to 1690) and Cal AD 300 to 320 (Cal BP 1660 to 1630)**

Intercept data

Intercept of radiocarbon age with calibration curve: Cal AD 240 (Cal BP 1720)

1 Sigma calibrated results: (68% probability) Cal AD 180 to 190 (Cal BP 1770 to 1760) and Cal AD 210 to 250 (Cal BP 1740 to 1700)



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CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-23.3:lab. mult=1)

Laboratory number: **Beta-317581**

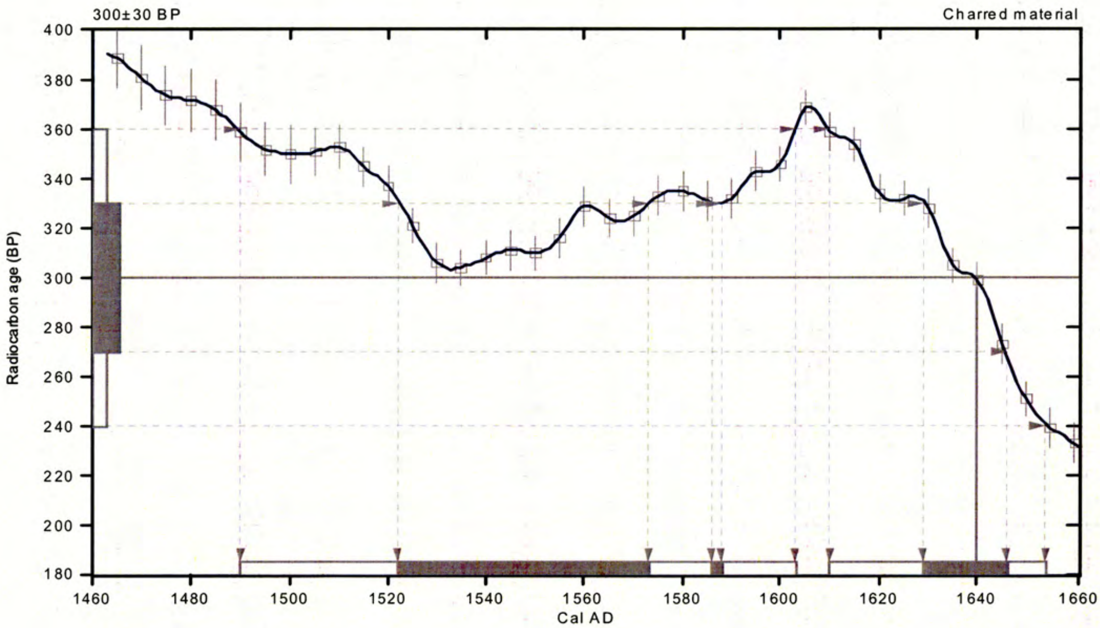
Conventional radiocarbon age: **300±30 BP**

2 Sigma calibrated results: (95% probability) **Cal AD 1490 to 1600 (Cal BP 460 to 350) and Cal AD 1610 to 1650 (Cal BP 340 to 300)**

Intercept data

Intercept of radiocarbon age with calibration curve: Cal AD 1640 (Cal BP 310)

1 Sigma calibrated results: (68% probability) Cal AD 1520 to 1570 (Cal BP 430 to 380) and Cal AD 1590 to 1590 (Cal BP 360 to 360) and Cal AD 1630 to 1650 (Cal BP 320 to 300)



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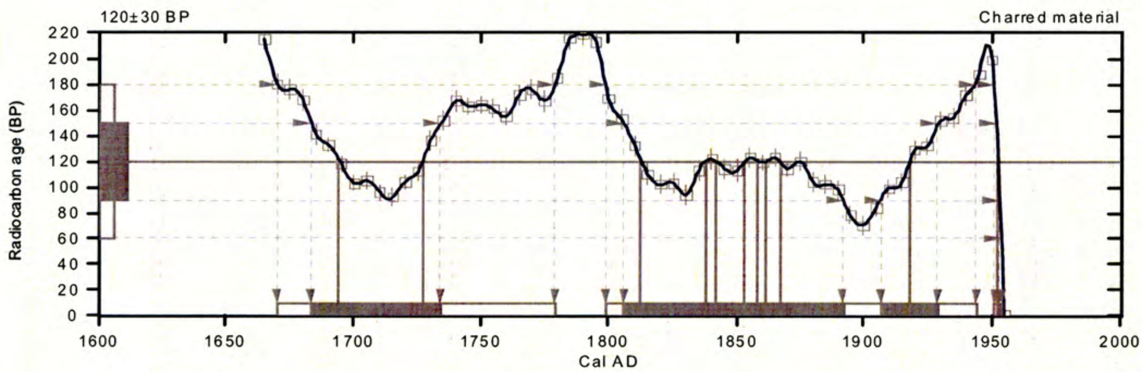
CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

(Variables: C13/C12=-23.6:lab. mult=1)

Laboratory number:	**Beta-317583**
Conventional radiocarbon age:	**120±30 BP**
2 Sigma calibrated results: (95% probability)	**Cal AD 1670 to 1780 (Cal BP 280 to 170) and Cal AD 1800 to 1940 (Cal BP 150 to 10) and Cal AD Post 1950**

Intercept data

Intercepts of radiocarbon age with calibration curve:	Cal AD 1690 (Cal BP 260) and Cal AD 1730 (Cal BP 220) and Cal AD 1810 (Cal BP 140) and Cal AD 1840 (Cal BP 110) and Cal AD 1840 (Cal BP 110) and Cal AD 1850 (Cal BP 100) and Cal AD 1860 (Cal BP 90) and Cal AD 1860 (Cal BP 90) and Cal AD 1870 (Cal BP 80) and Cal AD 1920 (Cal BP 30) and Cal AD Post 1950
1 Sigma calibrated results: (68% probability)	Cal AD 1680 to 1730 (Cal BP 270 to 220) and Cal AD 1810 to 1890 (Cal BP 140 to 60) and Cal AD 1910 to 1930 (Cal BP 40 to 20) and Cal AD Post 1950



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Darden Hood
President

Ronald Hatfield
Christopher Patrick
Deputy Directors

March 13, 2012

Dr. Robert Dello-Russo
Office of Archaeological Studies
P.O. Box 2087
Santa Fe, NM 87504
USA

RE: Radiocarbon Dating Result For Sample 422-F4-68-y

Dear Dr. Dello-Russo:

Enclosed is the radiocarbon dating result for one sample recently sent to us. It provided plenty of carbon for an accurate measurement and the analysis proceeded normally. As usual, the method of analysis is listed on the report sheet and calibration data is provided where applicable.

As always, no students or intern researchers who would necessarily be distracted with other obligations and priorities were used in the analysis. It was analyzed with the combined attention of our entire professional staff.

If you have specific questions about the analyses, please contact us. We are always available to answer your questions.

Our invoice has been sent separately. Thank you for your prior efforts in arranging payment. As always, if you have any questions or would like to discuss the results, don't hesitate to contact me.

Sincerely,

Darden Hood
Digital signature on file

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REPORT OF RADIOCARBON DATING ANALYSES

Dr. Robert Dello-Russo — Report Date: 3/13/2012

Office of Archaeological Studies — Material Received: 3/9/2012

Sample Data	Measured Radiocarbon Age	13C/12C Ratio	Conventional Radiocarbon Age(*)
Beta - 318168	1420 +/- 30 BP	-23.7 o/oo	1440 +/- 30 BP

SAMPLE : 422-F4-68-y
ANALYSIS : AMS-Standard delivery
MATERIAL/PRETREATMENT : (charred material): acid/alkali/acid
2 SIGMA CALIBRATION : Cal AD 570 to 650 (Cal BP 1380 to 1300)

Dates are reported as RCYBP (radiocarbon years before present, "present" = AD 1950). By international convention, the modern reference standard was 95% the 14C activity of the National Institute of Standards and Technology (NIST) Oxalic Acid (SRM 4990C) and calculated using the Libby 14C half-life (5568 years). Quoted errors represent 1 relative standard deviation statistics (68% probability) counting errors based on the combined measurements of the sample, background, and modern reference standards. Measured 13C/12C ratios (delta 13C) were calculated relative to the PDB-1 standard.

The Conventional Radiocarbon Age represents the Measured Radiocarbon Age corrected for isotopic fractionation, calculated using the delta 13C. On rare occasion where the Conventional Radiocarbon Age was calculated using an assumed delta 13C, the ratio and the Conventional Radiocarbon Age will be followed by "*". The Conventional Radiocarbon Age is not calendar calibrated. When available, the Calendar Calibrated result is calculated from the Conventional Radiocarbon Age and is listed as the "Two Sigma Calibrated Result" for each sample.

CALIBRATION OF RADIOCARBON AGE TO CALENDAR YEARS

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

Laboratory number: **Beta-318168**

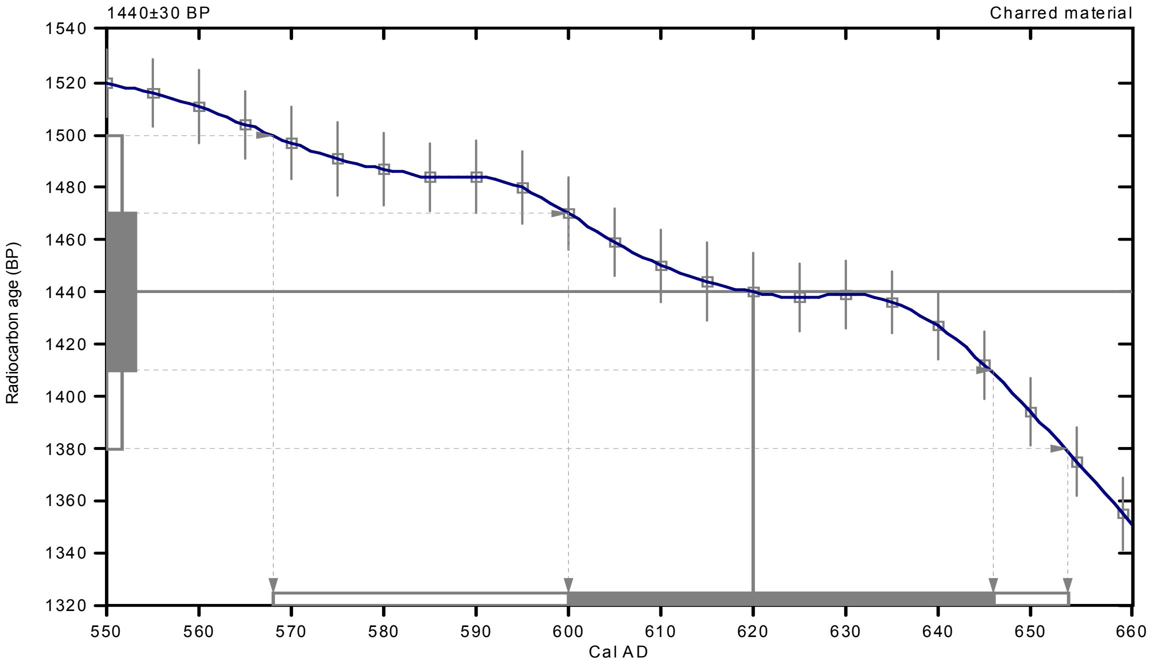
Conventional radiocarbon age: **1440±30 BP**

2 Sigma calibrated result: **Cal AD 570 to 650 (Cal BP 1380 to 1300)**
(95% probability)

Intercept data

Intercept of radiocarbon age with calibration curve: Cal AD 620 (Cal BP 1330)

1 Sigma calibrated result: Cal AD 600 to 650 (Cal BP 1350 to 1300)
(68% probability)



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