PUEBLO ON THE PLAINS: THE SECOND SEASON OF INVESTIGATIONS AT THE MERCHANT SITE IN SOUTHEASTERN NEW MEXICO Volume 2

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Volume 2

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Chapter 13

Pollen Results from the Merchant Site

Susan J. Smith

In this chapter, the pollen results from 48 samples collected over two field seasons (2014–2015 and 2019) are integrated with emphasis on the 35 samples analyzed from the 2019 field season (Table 13.1). Pollen and macrobotanical samples from the 2015 excavation of Pit Structure 1 contained high frequencies of maize (Dering and Smith 2016:253-263), providing strong evidence that people living at the Merchant site were farmers as well as hunters (Miller et al. 2016:389). Confirming cultigen presence in potential agricultural contexts is the key research theme for the pollen investigation. However, until the 2019 fieldwork, sampling schemes of possible field areas had produced negative results.

North of Pit Structure 1 and the cluster of residential features is a possible gridded field (Feature 82) defined by surface rock alignments and cross-walls comparable to grid garden patterns seen throughout the Southwest. The Feature 82 grids are located in a sandy area that slopes gently east and southeast into a dry drainage that contains several rock check dams. During the 2019 field season, the gridded field Feature 82 and the check dams of Feature 65 were intensively sampled for pollen to expand efforts to recover evidence of farming.

The 2019 archaeobotanical research included July field visits by Phil Dering and the author to see features first-hand and to assist sampling in addition to a survey of the plant resources growing on site. It is a rare archaeological project that provides for site visits for archaeobotanists, but the analyses of specialists are refined by perspectives that can only come from field observation. The July plant list is included as Appendix B.1.

Agricultural Pollen Studies: Assumptions and Techniques

Thirty-three of the 48 Merchant site pollen samples were collected from possible agricultural features or as controls near agricultural areas. Pollen can be an effective tool to reconstruct prehistoric farming systems, but this specialized niche in archaeological palynology requires different conceptual models and laboratory techniques from the more conventional studies of residential features (Fish 1994). Cultigen pollen and other ethnobotanical markers become concentrated in habitation and intramural processing features, whereas cultigen pollen in field samples is elusive (Dean 1995). Gardens and fields are open-air sites where environmental pollen rain dilutes cultural expressions and physical and biological soil processes degrade pollen, causing agricultural signatures to fade over time.

Table 13.1. Merchant site pollen samples from field seasons 2014, 2015, and 2019

Category	2019 CN Number	2014-2019 Field Collection Numbers	Feature	Level	Context	Sample Depth (cmbs)
Residential Features		2015-1.12	1.12	3	Pit Structure 1 fill	
		2015-1.3	1.3	3	Pit Structure 1 floor pit	
		2015-1.4	1.4	3	Pit Structure 1 floor hearth	
	189		110	6	Base of Refuse Pile B. Sample from base of deep midden	80
	280		6	3	Room 6 floor	28
	381		6.4	4	Room 6. Sample from base large, caliche-capped pit	49
	313		404	5	Room 25 floor beneath mano	26
	314		404	5	Room 25 floor beneath metate fragment	26
	315		404	5	Room 25 floor	38
	369		410.1	4	Room 29 hearth	29
Bedrock Mortars	457		441.2	1	Bedrock mortar complex, Mortar 2	5-14.4
	458		441.3	1	Bedrock mortar complex, Mortar 3	23-28
	459		441.4	1	Bedrock mortar complex, Mortar 4	5-11.3
	460		441.5	1	Bedrock mortar complex, Mortar 5	15-22.7
	461		442.9	1	Bedrock mortar complex, Mortar 9	10-16.3
Possible Agricultural Features	454			1	Outside Feature 65. Control	35
	452		65	1	Check dam	45-50
	453		65	1	Check dam	40-45
		2019-2	65		Check dam	7.5
		2019-4			Check dam	10-15
		2019-3			Possible field area west edge of Feature 65	0-5
		2019-7			Possible field area west edge Feature 65. Composite sample from along top of Tr 19-2	8-10
	401		82	2	Grid garden, NE	6-11
	402		82	3	Grid garden, NE	11-16
	403		82	2	Grid garden, SE	7-12
	404		82	3	Grid garden, SE	12-17
	405		82	2	Grid garden, SW	9-14
	406		82	3	Grid garden, SW	14-19
	407		82	2	Grid garden, NW	11-16
	408		82	3	Grid garden, NW	16-21
	409		82	2	Grid garden, Central	5-10
	410		82	3	Grid garden. Central	10-15
		2019-8	82		Grid garden, surface composite from several cells	0-5
		2019-5	82		Grid garden, N of TR 19-2	8-10
		2019-6	82		Grid garden, N of TR 19-2	8-10
		2019-9	82		NE portion grid garden	5-7
		2015-108-1	108	1	Possible field area	
		2015-108-2	108	1	Possible field area	

Category	2019 CN Number	2014-2019 Field Collection Numbers	Feature	Level	Context	Sample Depth (cmbs)
		2015-108-3	108	1	Possible field area	
		2015-108-4	108	1	Possible field area	
		2015-108-5	108	1	Possible field area	
		2014-BHT 2-1		1	Possible field area, Backhoe Tr 2	
		2014-BHT2-2		2	Possible field area, Backhoe Tr 2	
		2014-BHT3-1		1	Possible field area, Backhoe Tr 3	
		2014-BHT3-2		2	Possible field area, Backhoe Tr 3	
		2014 BHT Control			Control for 2015 Backhoe Trenches	
Rock Clusters		2019-1			Rock cluster, W of Tr 19-1	0-5
		2019-10			Rock cluster, W edge site near boundary road	5-8

Fields, gardens, and other agricultural features are optimal environments for camp-follower weeds that thrive in disturbed ground. Palynologists have predicted that a unique signature would tag such contexts composed of cultigens and inflated expressions of weed pollen (Fish 1994:56; Gish 1985). However, agricultural studies have not produced consistent evidence of farming; instead, the most important drivers of a sensible signature are field history and productivity (Gish 1985:346). Generally, there is less cultigen pollen in soils from dry-farmed fields that might have been used for only a few years compared with irrigated fields tilled over centuries. Understanding soil development in fields is another important factor that can guide pollen studies (Camilli et al. 2019). Even in regions that were farmed for thousands of years, pollen evidence can be ambiguous if farming horizons were missed during sampling or if the soil density of cultigen pollen is too low to register in samples. At the Merchant site, active modern eolian and sheetwash processes add a layer of complexity to understanding soils, as migrating sand has undoubtedly moved surface sediments. Furthermore, intermittent storm flows have blown out channels in the drainages and dispersed sediment from possible farmed surfaces. Historic livestock grazing across the site has also probably contributed to churned sediment and mixed soil horizons in addition to changes in vegetation composition and abundance.

Palynologists are well aware that field soil samples preserve a low level of crop pollen, and various procedures have been invented to optimize recovery (Dean 1998; Gish and Delanois 1993). In this analysis, two advanced techniques were used on 23 of the 2019 samples collected from suspected agricultural features – Intensive Systematic Microscopy (ISM) and Large Fraction Scanning (LFS), described below.

Methods

Laboratory

All of the project pollen samples were processed at the Palynology Laboratory, Texas A&M University, College Station, Texas, using protocols developed and tested by Dr. Vaughn Bryant, Jr. Using the same laboratory for extraction is ideal for a multi-year project and limits bias that might be introduced from different chemical procedures. The Texas A&M procedure is summarized below.

Subsamples (10 grams) were taken from the sample bags and spiked with a known concentration of club moss spores (Lycopodium) to monitor degradation from laboratory chemicals and to enable pollen concentration calculations. Pretreatment steps included sieving to remove coarse material (rocks, roots, and charcoal) and hydrochloric acid to dissolve carbonates. Next, samples were treated with hydrofluoric acid to reduce silicates, followed by a density separation in zinc bromide. Lignin and other organic plant material were oxidized by a chemical technique called acetolysis and the rinsed residues transferred to vials and stored in glycerol.

Pollen Identification

Pollen was identified to the lowest taxonomic level possible based on published keys (Fægri et al. 2000; Kapp et al. 2000). Grass family pollen was divided into three types (Fægri et al. 2000:284–286): maize grains are greater than 60 microns diameter with a large ringed pore; grains with diameters between 30 and 60 microns were counted as large grass; and grains smaller than approximately 30 microns were classified as grass family, which encompasses the majority of native species. The large grass type could represent introduced cereal grains — for example, oat (*Avena*) or rye (*Secale*), and a few native grasses, such as Indian ricegrass (*Achnatherum hymenoides*).

Sunflower family is a broad pollen category, but five distinct types are documented in the project samples: sunflower family or hi-spine type (Asteraceae), low-spine bursage/ragweed (*Ambrosia*), a long spine type that matches sunflower (*Helianthus*), chicory tribe (Liguliflorae) characterized by ornate grain sculpturing, and sagebrush (*Artemisia*), which can represent the iconic big sagebrush (*Artemisia tridentata*), as well as several herbaceous sages.

Spectacle pod (*Dimorphocarpa*) pollen is common in the project samples. Spectacle pod is a member of the mustard family (Brassicaceae), and this grain type is separated from other mustard grains by five or more equatorial colpi (stephanocolpate) and a tectate, coarse-reticulate exine. This morphology is similar to the mint family (Lamiaceae) and pepperweed (*Lesquerella*), another mustard, except the majority of mint and pepperweed grains display fine-reticulate exines. Another unique taxon is honeysuckle (Caprifoliaceae Family, *Lonicera*) identified in one sample from Pit Structure 1 (Dering and Smith 2016:254).

The lily family label is used to describe relatively large (30 to 40 microns) monocolpate, finely reticulate pollen grains, and in the project area, yucca is the most likely plant represented. Plant taxonomists have recently changed the yucca botanical family name to Asparagaceae; however, the lily family name is retained in this analysis for pollen grains of similar morphology. This category encompasses several other taxa, for example wild onion (*Allium* sp.), sego lily (*Calochortus* spp.), and sotol (*Dasylirion* spp.) with different botanical family names (Amaryllidaceae, Liliaceae, and Asparagaceae) based on current taxonomy.

Three exotic or introduced taxa are part of the Merchant site pollen record: two wind-pollinated trees, elm (*Ulmus*) and pecan (*Carya*), and the insect-pollinated herb, crane's bill (*Erodium*). These taxa represent historic imported species that are now common and widespread, and in the case of crane's bill, largely naturalized. There are native *Erodium* species, but the pollen type recovered from shallow soils is generally attributed to *Erodium cicutarium*, a species that may have been introduced by early Spanish explorers. There are no native elms in New Mexico, and the presence of elm pollen in just two Merchant samples is attributed to long-distance, wind dispersal from the popular shade tree, Siberian elm (*Ulmus pumila*), or the closely related Chinese elm (*Ulmus parviflora*). Wind transport is also a reasonable explanation for pecan pollen, a wind-pollinated nut tree planted in regional to local orchards and gardens.

Standard Microscopy

Drops from the extracted samples were spread and sealed onto microscope slides and analyzed on a Reichert Microstar compound microscope at 400x magnification. If possible, pollen grains for each sample were counted to a sum of 100 to 200 grains and then the entire slide was scanned at 100x magnification to record additional taxa. Pollen grains larger than approximately 30 microns can be identified at 100x magnification, which includes maize, cotton, squash, and agave as well as cacti, pines, and some herbs. Clumps of grains of the same taxon referred to as aggregates are added to the pollen sum as one grain per occurrence and the size of the largest clump documented. For example, in a sample containing two aggregates of grass pollen, one of four grains and the second of eight grains, the data would be entered as "Grass Aggregates 2(8)." The interpretive convention for aggregates is that they represent on-site plants because clumps are heavier than single grains and less likely to be dispersed by wind (Gish 1991).

Intensive Systematic Scanning (ISM) of 10 Field Samples

Following the standard microscopy, a set of 10 field samples collected in July 2019 were analyzed using the Intensive Systematic Microscopy (ISM) method. ISM was developed by Glenna Dean (1995, 1998) as a technique to increase the probability of finding rare pollen by scanning more than one microscope slide. The advantages of ISM are that the level of analysis is standardized and the abundance (or absence) of cultigen pollen relative to the amount of soil sampled is quantified. The resulting estimate of cultigen density within field soils may correlate to crop yields, thereby providing an objective basis to compare different sites and environments.

The ISM method is made possible by introduction of a known concentration of exotic tracer grains (Lycopodium) into each weighed sample. The number of tracer grains relative to the sample weight is determined to observe cultigen pollen occurring at a defined concentration, generally 1.0 grains/gram. Successive microscope slides prepared from each sample are scanned until the target analysis level is reached, while the number of tracers and any observed cultigens are documented. Calculation of the soil density of recovered cultigen pollen is expressed as the number of grains relative to the tracer spike and the sample weight, abbreviated as gr/gm.

Large Fraction Scanning (LFS) of 23 Samples

The results of the ISM scans were disappointing with no cultigen pollen found. One last technique was applied to 23 of the 2019 samples (Table 13.2) –LFS invented by Jan Gish (Gish and Delanois 1993). LFS is based on sieving processed samples through a fine, 45 micron-mesh sieve to separate larger pollen grains from smaller sized material. The material remaining on the screen is transferred back into sample vials and prepared as usual for scanning at 100x magnification and the smaller material that passed through the sieve is discarded. The majority of cultigens (maize, squash, cotton, and agave) are larger than 45 microns, which makes LFS an effective procedure for concentrating all of the larger grains in a processed sample.

Table 13.2. Samples from agricultural fields, lab analysis methods, and maize presence (yellow highlight)

2019 CN Number	2014-2019 Field Collection Numbers	Feature	Level	Context	Notes. Yellow highlight marks maize identifications	Sample Depth (cm)	Additional Lab Procedures [a]	
							ISM	LFS
454			1	Outside Feature 65	Collected outside check dam	35		X
452		65	1	Check dam	Base of Feature 65, dip between two rock check dams	45-50		X
453		65	1	Check dam	Base of Feature 65, southern dip	40-45		X
	2019-2	65		Check dam	Western edge first upstream check dam; interface between upper loose sand and deeper, indurated surface	7.5	X	X
	2019-4			Check dam	Check dam in side-rill W-SW of Feature 65; S side of dam, 50 cm from dam edge	10-15	X	X
	2019-3			Possible field area near Feature 65	Possible field area along western edge Feature 65	0-5	X	X
	2019-7			Possible field area near Feature 65	Composite sample from top of trench 3 sidewalls at interface between loose sand and compacted surface	8-10	X	X
401		82	2	Gridded field	NE portion	6-11		X
402		82	3	Gridded field	NE portion	11-16		X
403		82	2	Gridded field	SE portion	7-12		X
404		82	3	Gridded field	SE portion	12-17		X
405		82	2	Gridded field	SW portion	9-14		X
406		82	3	Gridded field	SW portion	14-19		X
407		82	2	Gridded field	NW portion	11-16		X
408		82	3	Gridded field	NW portion	16-21		X
409		82	2	Gridded field	Central portion	5-10		X

2019 CN Number	2014-2019 Field Collection Numbers	Feature	Level	Context	Notes. Yellow highlight marks maize identifications	Sample Depth (cm)	Additional Lab Procedures [a]	
							ISM	LFS
410		82	3	Gridded field	Central portion	10-15		X
	2019-8	82		Gridded field	Composite of surface pinches throughout gridded field cells	0-5	X	X
	2019-5	82		Gridded field	Field N of Tr 19-2, NE corner of W cell	8-10	X	X
	2019-6	82		Gridded field	Gridded field N of Tr 19-2, along rock alignment	8-10	X	X
	2019-9	82		NE portion gridded field	Gridded field NE corner grid cell	5-7	X	X
	2019-1			Rock cluster	Rock cluster west of Tr 19-1	0-5		X
	2019-10			Rock cluster	Rock cluster near boundary road; sample from between & under surface rock	5-8		X
	2015-108-1	108	1	Series of check dams				
	2015-108-2	108	1	Series of check dams				
	2015-108-3	108	1	Series of check dams				
	2015-108-4	108	1	Series of check dams				
	2015-108-5	108	1	Series of check dams				
	2014-BHT2		1	Possible field near Feature 95	Backhoe Trench 2			
	2014-BHT2		2	Possible field near Feature 95	Backhoe Trench 2			
	2014-BHT3		1	Possible field near Feature 90	Backhoe Trench 3			
	2014-BHT3		2	Possible field near Feature 90	Backhoe Trench 3			
	2014 BHT Control			Control for 2015 Backhoe Trenches				

a. Additional laboratory and microscopy methods applied after standard analysis. ISM = Intensive Systematic Microscopy, LFS = Large Fraction Scanning.

Results

The project samples are productive and yielded significant counts. Fifty-two pollen types were identified, although the majority are rare, occurring in one to a few samples at low counts. An overview of the pollen results is presented in Figure 13.1 as a series of graphs for samples ordered by context. All of the project pollen data are documented in Appendix B.2 in four tables: detailed sample descriptions, sample raw counts with scientific and common pollen names, extended microscopy results from field samples, and the July 2019 plant species list. Discussion of botanical names can be confusing when scientific and common names are mixed with other pollen identification terms. The Merchant site pollen data are discussed using common names, and both scientific and common names are listed in Appendix B.1.

Vegetation in the project region may appear sparse and monotonous, but this southeastern corner of New Mexico lies within a broad ecological transition characterized by a surprising variety of plants. The diversity of resources would have provided practical materials and food for native people. To the south, the dominant ecosystems are the Chihuahuan semi-desert grassland and mesquite upland scrub that intermix to the north with the vast Great Plains short-grass prairie of Texas (Whitehead and Flynn 2016:3–7). The 2019 field survey emphasized a subtle mosaic of plant resources surrounding the Merchant site that reflects the different local substrates and physiography from mesa to basin. It is important to note that the 2019 July plant survey catches just one season during a summer-drought year and the species list would expand significantly if other seasons were represented, especially early spring.

Creosote is the dominant plant at the southern end of the Merchant site ridge but is replaced by mesquite and then shinnery oak to the north following increasing depth of surface sand to active dunes north of the site. The basin and playa west of the mesa top appear to hold seasonal water and periods of wet mud. Surrounding the playa and in local areas of the site ridge, grasses are the dominant plant cover. The availability of native grasses undoubtedly attracted grazing wildlife and human hunters. Modern ranchers recognized the forage potential around the site and brought in livestock. Across the region, historic overstocking of range land has altered vegetation, causing an expansion of mesquite that has replaced other desert shrubs and trees (Whitehead and Flynn 2016:15). Broom snakeweed is a prominent sub-shrub in grassy hollows and flats at the Merchant site and is interpreted to reflect nineteenth and twentieth century grazing impacts. Doveweed (Croton) is abundant in portions of the site and is another possible marker of over-grazing.

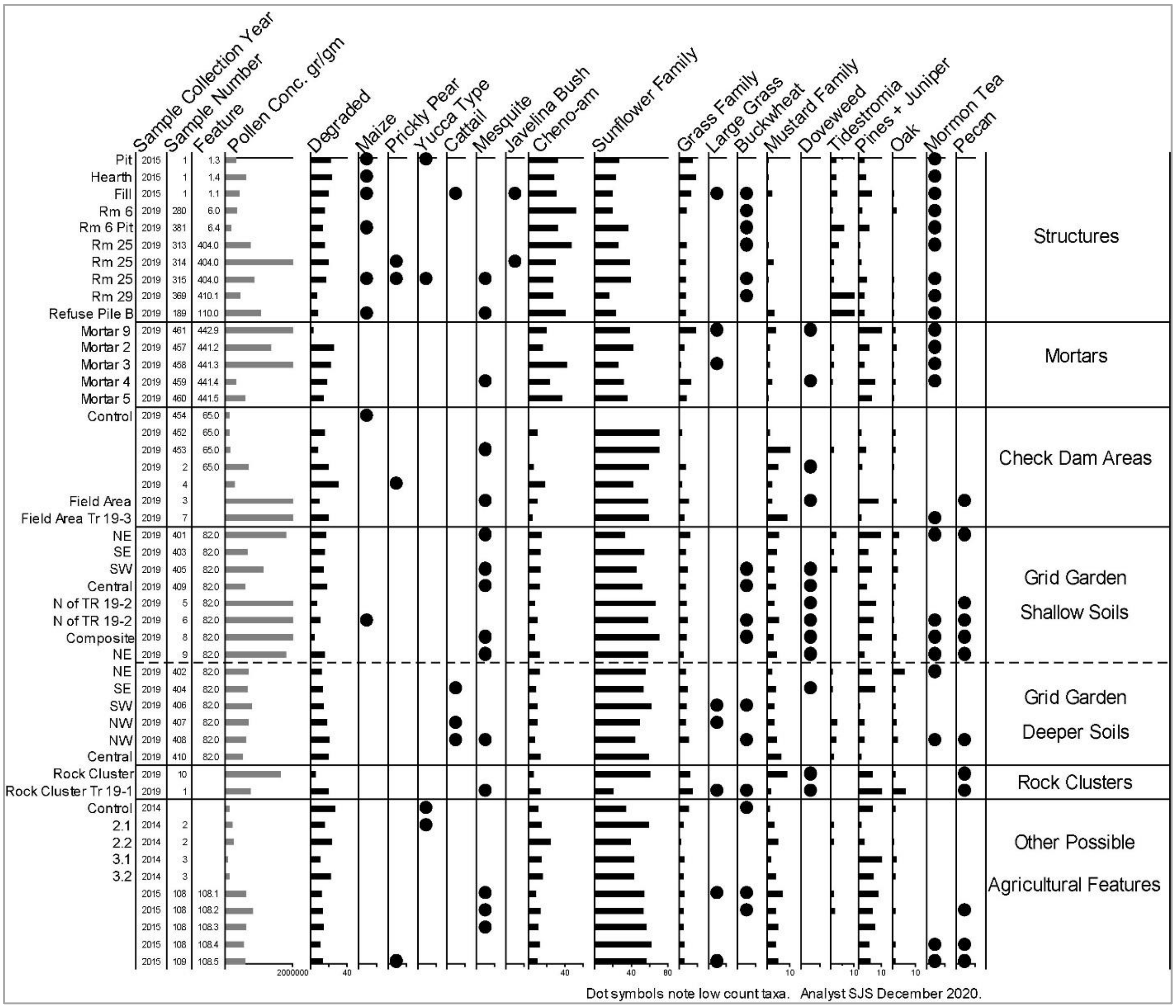

Figure 13.1. Summary pollen results from the Merchant site.

In the following sections, the pollen results are organized and discussed by context with an emphasis on the potential agricultural features that form the core of the sample set. From the pollen perspective, context is a major architect of archaeological assemblages because how people used different features and activity loci influence pollen deposition and preservation in addition to the history of post-occupation processes (Adams and Smith 2011). The analytical approach used here is to mine the pollen data for statistical patterns within and between context categories.

In Table 13.3, a comparison by context of the 2019 samples and the three 2015 Pit Structure 1 samples is presented based on parameters tailored by taxon to mediate the effects of over or under-representation. The most abundant pollen type is the insect-pollinated sunflower family, followed by wind-pollinated Cheno-am and grasses. Average values by context categories were calculated for these abundant taxa and sample summary measures (sample pollen concentration and taxon richness). Simple presence is adequate for low-count types occurring in only a few samples and groups of sorted samples can be compared by ubiquity, which is the percentage of samples within a defined group recording a specific taxon.

Table 13.3. Comparison by context of 2019 pollen results. Maize is highlighted in red text.

Context Category	Gridded Field Fea. 82		Check Dam Fea. 65 & Side-Rill Check Dam		Possible Field Area Adjacent Fea. 65	Rock Clusters	Six Residential Features (includes Pit Structure 1)	Five Bedrock Mortars
Depth cm below ground surface	0-14	11-21	7.5-50		0-10	0-8		0-8
Number of samples	8	6	5		2	2	10	5
	Average by Category							
Sample Concentration average gr/gm	24,389	6,599	2,708		30,552	11,987	8,032	15,007
Richness	15	12.5	8		13.5	14	12.6	11.8
Degraded%	12	16	20		14	12	13	16
Cheno-am %	10	9	9		6	9	34	27
Sunflower %	54	53	57		59	41	26	34
Grass %	8	7	3		8	13	9	9
Mustard Family %	4	3	5		5	5	1	2
Mormon Tea %	<1	<1			<1		2	<1
Combined Pine & Juniper	6	3	2		5	9	3	6
	Ubiquity: % of Taxon per Number of Samples by Category							
Maize	13		20				60	
Prickly Pear			20				20	
Yucca type							20	
Large Grass	13				50	50	10	60
Doveweed	75	17	20		50	100		40
Tidestromia	38	83	20		50		100	60
Pecan	63	17			50	100		40
Other Notable Pollen Types		Cattail present in 3 samples					*Tidestromia* 13% Refuse Pile B & 36% Room 29 floor hearth; Mormon Tea 6% Room 6 large pit; prickly pear & Hog Potato Room 25 only; cattail one sample from deep Pit Str. 1	3% large grass & 18% grass Mortar 9; pea family 1% Mortar 9; 13% grass Mortar 4

Pollen from Potential Field Areas and Check Dams

Backhoe Trenches/ Rock Alignments

Five pollen samples were collected from two backhoe trenches dug to expose suspected rock alignments in the northwest portion of the site near Features 90 and 95 (Frederick et al. 2016:197–204). The five assemblages are characterized by low pollen concentrations, which can result from rapid deposition, for example aeolian processes, or degradation over time in older sediments. No cultigen pollen was recovered from the backhoe trenches, but there were interesting results from Trench 3. Two samples included birch, alder, and elevated conifer frequencies that suggest mixed sediment with possibly an older Pleistocene component,

Feature 108

In 2015, five pollen samples were analyzed from Feature 108, which is described as a series of possible check dams in a shallow drainage east of Features 90, 95, and 82 (Frederick et al. 2016). Four of the five samples contained one or more of three introduced taxa (elm, pecan, and crane's bill), indicating samples were collected in modern horizons or from churned contexts with mixed levels. No cultigen pollen was recovered.

Rock Clusters

Two rock clusters were sampled in 2019. The clusters appear to have been constructed and may have functioned as rock pile gardens, boundary markers, or shrines. One of the clusters is located east of Feature 82 near the 2019 Trench 1 and the second was at the west end of Feature 82 near the boundary road. No cultigen pollen or other obvious cultural indicators were recovered. Grass percentages are higher in rock piles (11 and 14 percent) compared with other features (Table 13.3), which is interpreted as a micro-habitat effect that favored grasses.

Feature 82, Check Dam Feature 65, and Possible Field Area

Pollen sampling during 2019 was concentrated in the gridded complex of Feature 82 and near Feature 65 in the drainage southeast of Feature 82. Fourteen pollen samples from Feature 82 were collected from two depth ranges, shallow sand at 0 to 14 cm below ground surface (n=8) and deeper, generally compacted sand at 11 to 21 cm below ground surface (n=6). Seven samples were collected around a Feature 65 check dam plus a smaller check dam in a side-drainage to the west. Feature 65 is a series of check dams through a relatively straight reach of the drainage. Along the west edge and downstream of the first check dam is a flat area where grasses may once have been dominant but where, today, snakeweed shrubs are the principal cover. The flat looks like a field and two samples were collected from the area.

The different categories of agricultural contexts preserved similar pollen spectra characterized by sunflower family dominant followed by Cheno-am, grasses, and mustard family, and low percentages of conifer pollen interpreted as blown in from regional mountain woodlands and forests. There is no evidence for an enhanced weed signature that might reflect farming practices, and the recovered assemblages are inferred to represent environmental pollen from local plants.

The two depth categories in the Feature 82 grid garden capture a pattern often documented in vertical profiles from terrestrial sites. Upper, younger levels are characterized by a greater variety and abundance of pollen, lower percentages of degraded pollen, and higher representation of regional wind-pollinated conifer and the introduced pecan (Table 13.3). These traits define a preservation gradient whereby pollen is differentially degraded and lost with increasing depth (Hall 1991). Maize pollen was identified in one of the shallow grid garden samples (sample number 2019-6) collected at 8 to 10 cm below ground surface and this sample also preserved pecan, indicating some degree of sediment mixing. A low frequency of pecan is present even in the deeper grid garden samples, again indicating mixed levels, which is not surprising given the mobile sands and churn of modern livestock hooves. One interesting contrast in the two depth categories from Feature 82 is a high ubiquity (75 percent) of doveweed in shallow samples but Tidestromia pollen is notable in deeper samples (83 percent ubiquity).

Cattail pollen was identified from Feature 82 in three of the deeper samples. This identification is solid based on the morphology of a grass-like grain with a single aperture that is a ragged thinned area lacking boundaries or edges versus the well-defined structural pore that characterizes the grass family. Two of the samples with cattail are from the same location described as the northwest portion of the grid garden (CN numbers 407 and 408), and the third is from the southeast portion (CN number 404). Cattail was also identified previously in the level 3 fill sample excavated from Pit Structure 1 (Dering and Smith 2016). One of the more probable theories for the cattail is that it was introduced by pot-watering garden plots using water from a source where cattail was growing. It is also possible cattail leaves and flowering spikes were somehow used within the grid garden. Given the size of the Merchant site and evidence for long settlement duration and intensive occupation by multiple family groups (Miller et al. 2016:384), accessible water was a necessity and cattail, as a specialized desert aquatic plant, would have been part of the landscape.

The second agricultural maize occurrence is in a sample collected from deep sand (35 cm below ground surface) and outside of the Feature 65 check dam. Evidence of modern water flows and sand movement through and across the check dams may have removed any signatures of past farming. However, outside the drainage, more stable surfaces could have caught and preserved maize pollen from a field area. The depth of the sample could also reflect recent sand that sealed and protected a prehistoric surface. A microphotograph of the well-preserved maize grain is shown in Figure 13.2.

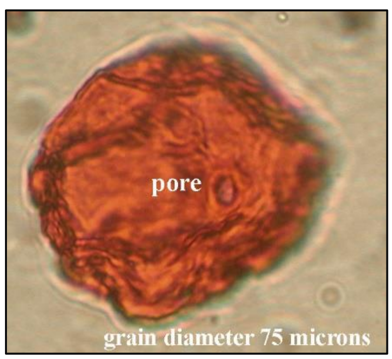

Figure 13.2. Maize in sample CN 454 adjacent the Feature 65 check dam.

Pollen from Residential Features

Results from three pollen samples from the deep Pit Structure 1 were reported in Dering and Smith (2016). The salient result from Pit Structure 1 is the presence of maize in all three samples and the presence of two rare types (cattail and honeysuckle) in the level 3 fill sample. Additionally, grass representation is high (average 15 percent, n=3) compared with other context groups at 3 to 9 percent (Table 13.3), which may relate to use of grass thatch. The 2019 samples include six samples from three rooms (Features 6, 404, and 410) and one sample from near the base of Refuse Pile B (Feature 110), which is a deep and extensive midden extending over a 98-square-meter area (Miller et al. 2016:134).

Summary pollen data presented in Table 13.3 emphasize the differences between residential features where cultural activities were concentrated and other contexts. First is the reversal of the dominant pollen types from sunflower family in agricultural samples to Cheno-am. The enriched

Cheno-am in structures is probably a mix of disturbance weeds, such as goosefoot (*Chenopodium*) and amaranth (*Amaranthus*) and could also include pollen from local saltbush (*Atriplex* spp.).

Maize was identified in three of the seven 2019 samples, the base of the refuse pile, the base of a large pit in Room 6 (Feature 6.4), and a floor sample from the west wall of Room 25 (Feature 404). Combining all residential samples (n=10), the maize ubiquity is high at 60 percent.

Contrasts between the residential and agricultural features point to two pollen types that were probably wild food resources. Prickly pear was identified in only one of the 2019 agricultural samples but is present in two of three Room 25 samples (Feature 404). Of the 2019 samples, Room 25 preserved the most evidence of ethnobotanical resources. In addition to prickly pear and maize, yucca type, buckthorn family (probably *Condalia*), and hog potato (*Hoffmannseggia*) were identified. Buckthorn family pollen was also identified from a Pit Structure 1 sample.

Hog potato is a native perennial species in the pea family (Fabaceae) that grows in deep, often disturbed soils and produces edible tubers that were prepared and eaten like modern potatoes (Moerman 1998). Hog potato plants were observed growing at the site in 2019. The buckthorn family shrub *Condalia*, common name javelina bush, is the likely plant represented. This spiny shrub was also observed at the site in 2019. Javelina bush produces edible berries that could be eaten raw or cooked into storable jellies. Whitehead and Flynn (2016:257) report that Rhamnaceae and by inference *Condalia* wood has been found in 81 sites across the CFO region (data on file, Carlsbad Field Office, BLM). It can be interpreted as an important supplementary wood from the Late Archaic to the Post Formative.

Two other pollen types are notable in structures, Mormon tea and *Tidestromia*. *Tidestromia* is what botanists call a "belly plant" because one needs to be at ground level to see it. It is an annual grey-green herb that grows and flowers after summer rains. In the project samples, Tidestromia occurs in all 10 of the residential samples and is notable in the deeper grid garden samples but is less frequent in other contexts. Aggregates of *Tidestromia* were documented only in structure samples (Pit Structure 1 and hearth Feature 410.2). This distribution hints at a different vegetation community in the past. Whereas modern disturbance plants are doveweed and probably some of the mustard and sunflower family plants, *Tidestromia* appears to have been the prehistoric weed and might also signal wetter summers during site occupation.

Mormon tea is present in 22 of the 48 project samples (41 percent ubiquity) at low percentages of less than 1 percent. In the residential contexts, Mormon tea occurs in 9 of 10 samples (90 percent ubiquity), and in four samples the percentage range is 1 to 6 percent. The maximum 6 percent value is from the sample from the base of a large pit in Room 6 (Feature 6.4), which may be significant. Mormon tea stems are full of tannins and were widely used by Southwest Indians for medicine (Moerman 1998). The high value in Feature 6.4 suggests cultural use, and one possibility is that Mormon tea was added to the pit as a fumigant to discourage insects and pests from stored materials.

Pollen from Bedrock Mortars

Clusters of bedrock mortars are found on the western slope of the Merchant site ridge. Five samples were analyzed from individual mortars. There is no evidence for plant processing in the mortar samples except for possibly the high grass values from Mortars 4 and 9 (13 and 18 percent). Grasses have a long history of use in the American Southwest (Moerman 1998) for food and practical products, and different grass species are relatively abundant in the local grassland ecosystems. Geib and Smith (2008) demonstrated that grass grain ground on metates is one of the few resources to leave a pollen imprint that could be recovered in artifact pollen washes. It is likely several seed and grain resources were processed in the mortars. It is worth noting that maize pollen is not transferred to ground stone through grinding of raw kernels (Geib and Smith 2008).

Conclusions

Pollen studies from southeastern New Mexico are relatively sparse and there is a bias within the scientific and archaeological community that pollen is not reliable for investigating past subsistence in this region. Hall and Goble (2016:103) writing about the Mescalero Plain state "Pollen is simply not present in our eolian deposits because of post depositional pollen grain deterioration." In their review of paleoethnobotanical data from southeastern New Mexico, Whitehead and Flynn (2016:72) summarize the archaeological pollen record, stating that pollen counts and species diversity are low and that there is no firm identification of maize pollen. Eolian deposits are challenging for pollen recovery (Bryant et al. 1994), but the results from the Merchant site demonstrate that pollen can contribute significantly to reconstructing past subsistence. Maize pollen occurs in nine samples, and a total of 52 pollen types were identified (Appendix B.2). Pollen is a successful tool at the Merchant site in part because there was a substantial residential occupation, but another factor is improved palynology techniques in the laboratory and at the microscope have increased pollen recovery.

The pollen research emphasis for the project is to test possible agricultural features for evidence of cultigens. Thirty-three pollen samples were analyzed from four possible agricultural features (Table 13.2). Maize pollen was identified in two samples, but only after using the extended LFS procedure on 23 of the 2019 samples. In one of the positive samples, 2019-6 from the Feature 82 grid garden, LFS was the third level of microscopy employed after standard microscopy and Intensive Systematic Scanning. This recovery of maize is extremely low even for prehistoric fields. A comparison of pollen data from dry-farmed fields and gardens in northern New Mexico analyzed by the ISM method documented maize in an average of 18 percent of 78 field samples (Camilli et al. 2019:Table 3.2). Maize ubiquity from the 23 LFS Merchant samples is less than 1 percent. If only the grid garden samples are considered, maize is present in one out of 14 samples or 7 percent ubiquity.

This low expression may not accurately reflect the productivity or the extent of farming efforts at the Merchant site. The project area geology is characterized by a mantle of Recent Eolian Sand that may be Historic in age (less than 150 years) (Graves et al. 2016:18). The mobile sands combined with historic churning of sediment by livestock have probably disturbed farming surfaces and mixed the stratigraphy. The recovery of cattail pollen in three of the grid garden samples indicates there was accessible water, as there had to be to support the Merchant community. The basin playa is a likely water source, perhaps even augmented by shallow wells dug during the dry season. Pot-watering garden plots with water containing pollen from cattail growing around the water source is a possible explanation for the pollen in Feature 82. If the pollen is a marker of irrigation, it indicates a significant investment in support of farming.

The evidence for farming is reinforced by the results from residential features where maize occurs in six of 10 samples and at counts ranging from one to three pollen grains. Contrasts in pollen assemblages between residential and suspected agricultural features highlight the presence of wild native resources in structures that include yucca type, prickly pear, grasses, buckthorn family (probably javelina bush), cattail, and possibly hog potato (*Hoffmannseggia*) and, in the deep intramural pit sample from Room 6, Mormon tea. Patterns of pollen representation between the residential features and other contexts also suggest a different plant community during occupation characterized by the weedy annual *Tidestromia*, which could reflect wetter summers because it a summer monsoon plant. The variety of 52 identified pollen types is an index of the diverse foodscape that supported Merchant people including the high value food and fuel resources of mesquite and oak.

Chapter 14

Phytolith Analysis and Ceramic Microfossil and Residue Analysis

Crystal A. Dozier, Jennifer Banks, Savannah A. Gann, Elayne V. Howard, and John G. Jones

In this chapter, the results of analysis of ceramic residues from Ochoa ware ceramics and phytolith analysis of soil samples collected from rooms, artifacts, and gridded fields is presented. Ten Ochoa ware sherds with evidence of burning and or sooting were selected from rooms and midden deposits and submitted to the Archaeology of Food Laboratory of Wichita State University for extraction of residues adhering to sherd surfaces. The samples were examined for the presence of pollen and phytoliths and were then sent to the Texas A&M University Chemistry Mass Spectrometry Facility to assess whether compounds were present indicating the use of Ochoa ware vessels for preparation, transport, or serving of ritual drinks such as Black Drink or cacao.

Phytoliths were analyzed from 25 soil samples. The analysis of phytoliths mirrors the pollen analysis reviewed in the preceding chapter. Ten paired phytolith and pollen samples were submitted from Feature 82, the gridded field selected for excavation and three paired samples were submitted from the Feature 62 check dams. Additional samples were extracted from grinding tools and two groups of bedrock mortars.

Pollen and macrobotanical studies identified numerous examples of maize and mesquite in samples collected from rooms, ceremonial structures, middens, and agricultural features (see Chapters 12 and 13). The primary goals of the residue and phytolith analyses was to confirm the presence of cultigens and non-domesticated foods from a similar range of features with the addition of ceramics and bedrock mortars.

Analysis of Ceramic Microfossils and Residues

Microfossil and residue analysis were conducted on a sample of 10 Ochoa ware sherds collected from the Merchant site (Table 14.1). Sherds with evidence of burning and sooting were selected since those specimens derived from vessels that were most likely used for cooking. The lower and central portions of jar vessels were preferred, but two sherds from the necks of jar vessels were submitted to provide a more thorough sample of vessel parts.

Table 14.1. Ochoa ware ceramic residue samples from the Merchant site

Lab Sample#	CN#	Feature#	Context	Vessel Notes	Note	Approx. Surface Area (cm^2)
V1	153-1	110	Midden	Large textured body	Sooted	6.4
V2	380-1	416	Room	Mid-body, smoothed corrugations	Burned, sooted	7.0
V3	226-1	407	Room	Neck, rough corrugations	Burned, sooted	5.6
V4	141-1	6	Room	Textured body	Sooted	6.0
V5	197-1	412	Room	Mid-body, smoothed corrugations	Sooted	8.0
V6	166-1	110	Midden	Lower body, spalled	Sooted, 2 sherds	17.0
V7	153-2	110	Midden	Lower body	Exterior soot	10.5
V8	172-1	110	Midden	Mid-body, smoothed corrugations	Some sooting	6.0
V9	192-1	402	Room	Neck	Burned	4.0
V10	155-1	110	Midden	Mid-body, smoothed corrugations	Sooted, 2 sherds	15.0

Methods

Sample preparation and extraction methods followed the procedures outlined in Dozier et al. (2020) and Dozier (in press).

Microfossil Extraction: Each sample was characterized and photographed on a Kim-wipe, starch-free paper. Using a small vise and Dremel, both sanitized with 5 percent NaOH solution between samples, approximately 0.5 mm of the exposed sherd edges were removed and discarded. The exterior 0.5 mm of each side of each sherd was removed and collected into separate sterile 15 milliliter (ml) test tubes. The interior samples are indicated by sample letter I; exterior (outside) portions are indicated by sample letter O. The interior core was then pulverized in a sterile plastic bag and transferred to a third sterile 15 ml test tube for organic chemical residue analysis.

A dissolved lycopodium tablet (19855 spores/tablet) was added to both the interior and exterior microfossil samples. To improve microfossil recovery from clay particles, 10 ml of a 5 percent weight-by-volume (wbv) Calgon solution (sodium hexametaphosphate [(NaPO3)6]) was mixed well into the samples and left to sit for one hour. The sample was mixed and left to settle for an additional 5 minutes. The light fraction of small clay particles was decanted, checked for lycopodium, and discarded. Since deflocculants, including Calgon, are known to harm starch in longer processes and stronger concentrations (Cuthrell and Murch 2016; Torrence and Therin 2006; Awad and Dozier 2021), all samples were rinsed with water two or three times until the supernatant liquid ran clear.

Microfossil slides were prepared with a 50 percent mixture of the light sample in water with glycerin to achieve a proper refraction index for starch analysis (Field 2006:112–113). All slides were completely examined under brightfield and polarized light microscopy at 200-400x power; multiple slides were created with a goal lycopodium count of 100 to provide proper sampling. The interior components of the sherds were examined first for possible economic taxa. If recovery was very low and no economic taxa were identified, the exteriors were only superficially examined and not analyzed.

Chemical Extraction: After the removal of sherd exteriors for microfossil analysis, the interior sherd was pulverized in a sterile plastic bag and transferred to a sterile 15 ml test tube. Samples then sat in a dry heating bath at 80° C for 20 minutes with sterile de-ionized water. After cooling to room temperature, the samples were centrifuged at 3300 rpm for 10 minutes. The supernatant liquid (water) was decanted into another sterile 15 ml test tube. To the residue of the pulverized samples, 1.5 ml of ammonium hydroxide and 1.5 ml of methylene chloride were added. After vortexing to mix well, samples were processed at 3300 rpm for 10 minutes. The supernatant liquid (ammonium hydroxide and methylene chloride) was decanted into the same 15 ml test tube with the residue water. Samples were then sent to the Texas A&M Chemistry Mass Spectrometry Facility.

Mass Spectrometry: Following TAMU Chemistry Mass Spectrometry Facility standards, samples were centrifuged at 4000 rpm and 1 (nanoliter) nL of the supernatant removed. That sub-sample was dried under nitrogen air and resuspended in methanol and water. The samples were run under two different column procedures in both positive and negative electrospray ionization (ESI) mode to assess the retention time and fractionization patterns of 4 compounds: caffeine, theobromine, theophylline, and atropine.

Contamination Controls: Protocols to avoid or monitor contamination of samples included use of a water trap for 300 minutes during removal of the exterior sherd surfaces for microfossil analysis to assess probably airborne starch contamination (Laurence et al. 2011). A single starch grain of unknown species was recovered in the trap (Figure 14.3). The specimen did not match any of the starch grains identified on samples. No pollen grains were found in the water trap, indicating a secure sample preparation environment. All equipment was sanitized with a 5 percent wbc sodium hydroxide (NaOH) solution between each side of each sample. NaOH removes starch from surfaces (Crowther et al. 2014).

Results

Microfossil recovery was sparse and pollen grains were mostly degraded, but several economic taxa were identified (Table 14.2).

Table 14.2. Microfossil results

Lab Sample#	Inside/ Outside	# Tracer Spores	# Slides	Pollen Concentration (grains/cm^3)	Starch Concentration (granules/cm^3)	Other Microfossil Concentration (per/cm^3)
V1	I	576	1	59.20	0.0	16.2
	O	102	2	91.00	0.0	0.0
V2	I	201	1	0.10	0.0	0.0
V3	I	510	1	13.90	0.0	7.0
V4	I	23	8	143.00 ~	0.0	429.0 ~
V5	I	120	1	41.40	0.0	0.0
V6	I	858	1	2.72	2.72 3 *Zea*	0.0
	O	140	1	0.00	8.34 ~	0.0
V7	I	141	1	53.60 2 *Zea*	0.0	0.0
	O	93	3	467.00 1 *Morus*	0.0	0.0
V8	I	280	1	0.00	0.0	0.0
V9	I	101	1	0.00	49.0 ~ 1 *Prosopis*	40.0 ~
	O	132	1	0.00	0.0	0.0
V10	I	102	8	116.00 1 *Zea*	0 .0	26.0 1 *Zea*?
	O	79	13	50.30 1 *Celtis*	67.0 1 *Zea*. 1 Unk	0.0

~ considered inaccurate due to low slide density or single counts of microfossils
Lycopodium tracer spores were added to each sample to assess microfossil recovery rates

All economic taxa were recovered on sherds from midden contexts that appear to be more conducive to preservation of residues and microfossils. Pollen and starch microfossils of *Zea mays* were recovered on three sherds (Table 14.2; Figures 14.1 and 14.2), representing a respectable 30 percent of the sherd samples submitted for analysis. These findings corroborate the results of the macrobotanical and pollen analyses, as well as establishing that Ochoa ware jars were used to process or store maize.

Other taxa identified among the pollen and starch grains include mesquite (*Prosopis* spp.), hackberry (*Celtis* spp.), and mulberry (*Morus* spp). Mesquite was identified in several flotation samples and hackberry phytoliths (see below) were identified in several samples from bedrock mortars. Morus is likely the Texas mulberry (*Morus microphylla*), a non-local tree species that was prized for its edible berries and for wood for making bows (Basehart 1960:47–48).

Two unidentified starch grains were found, one in sample V10 and the second from the laboratory air trap (Figure 14.3). The sample from the air trap does not compare with any of the granules recovered from the archaeological samples.

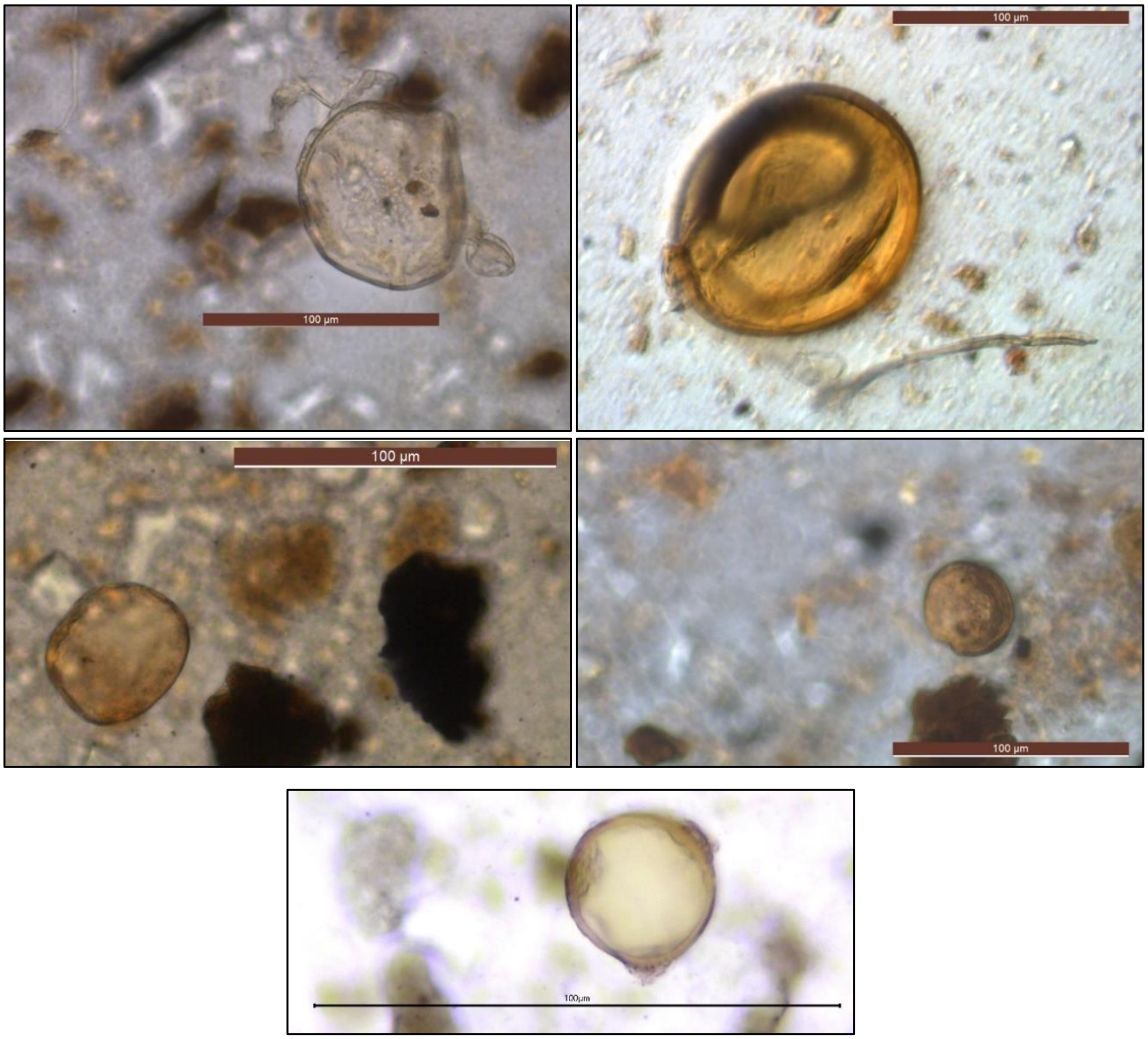

Figure 14.1. Pollen taxa identified in ceramic samples: (upper left) *Zea mays* from Sample V10-Interior; (upper right) *Zea mays* from Sample V7-Interior; (center left), *Morus* spp. from Sample V7-Exterior, (center right) control *Lycopodium clavatum* spore from Sample V6-Interior; (bottom center) *Celtis* spp. from Sample V10-Exterior.

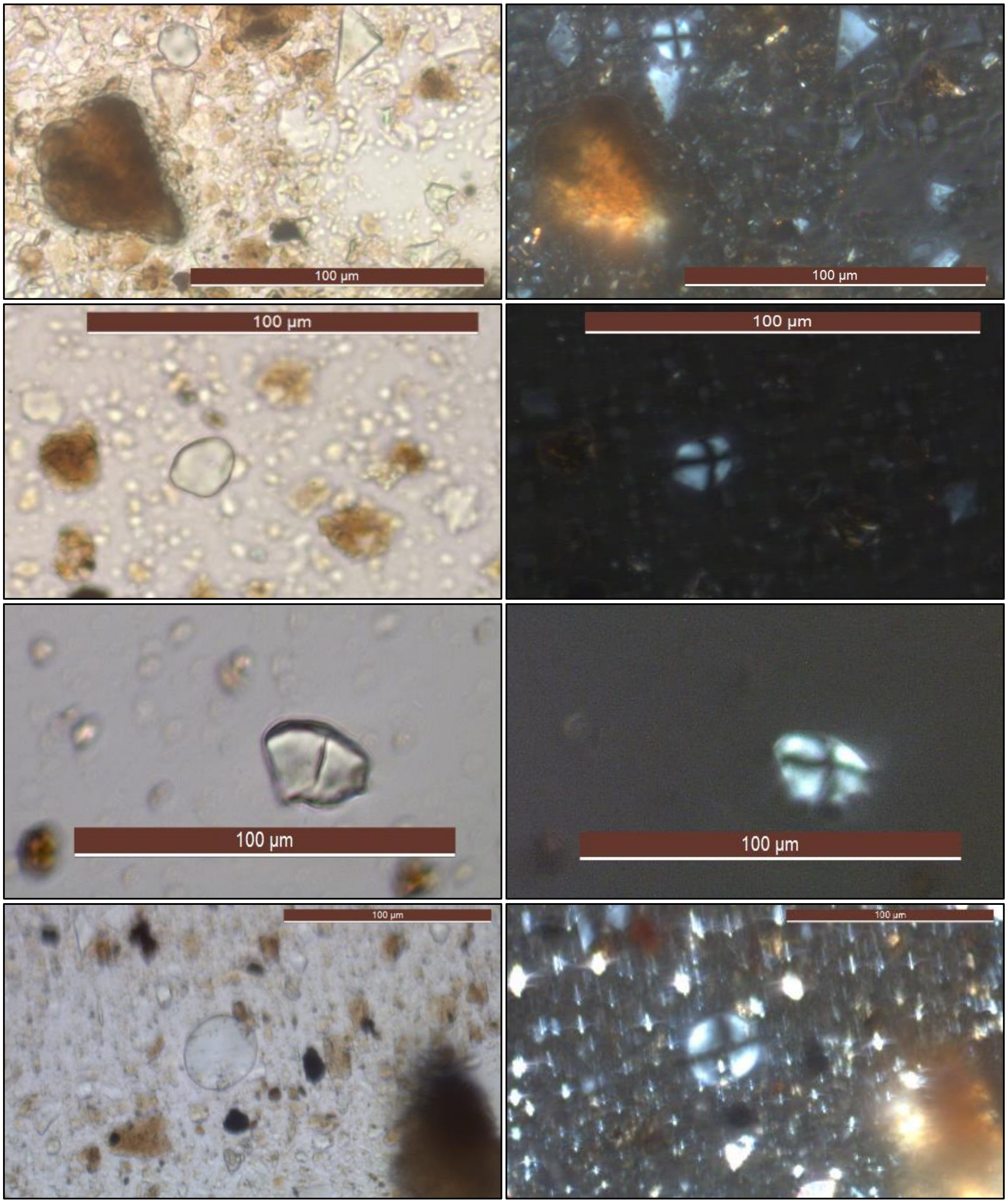

Figure 14.2. Starch grain taxa identified in ceramic samples as viewed under brightfield and polarized light: (upper row) Type A starch under brightfield and polarized light. Sample V6-I. Morphology is consistent with *Zea mays*; (second row) Type A starch under brightfield and polarized light. Sample V6-I. Morphology is consistent with *Zea mays*; (third row) Type B starch, linear hilum scar with angular shape. Compares positively with published images of *Prosopis* spp., (Giovannetti et al. 2008); (fourth row) Type C starch under brightfield and polarized light. Sample V10-I. Morphology compares positively with some varieties of maize (Cagnato 2020) but too general for positive identification.

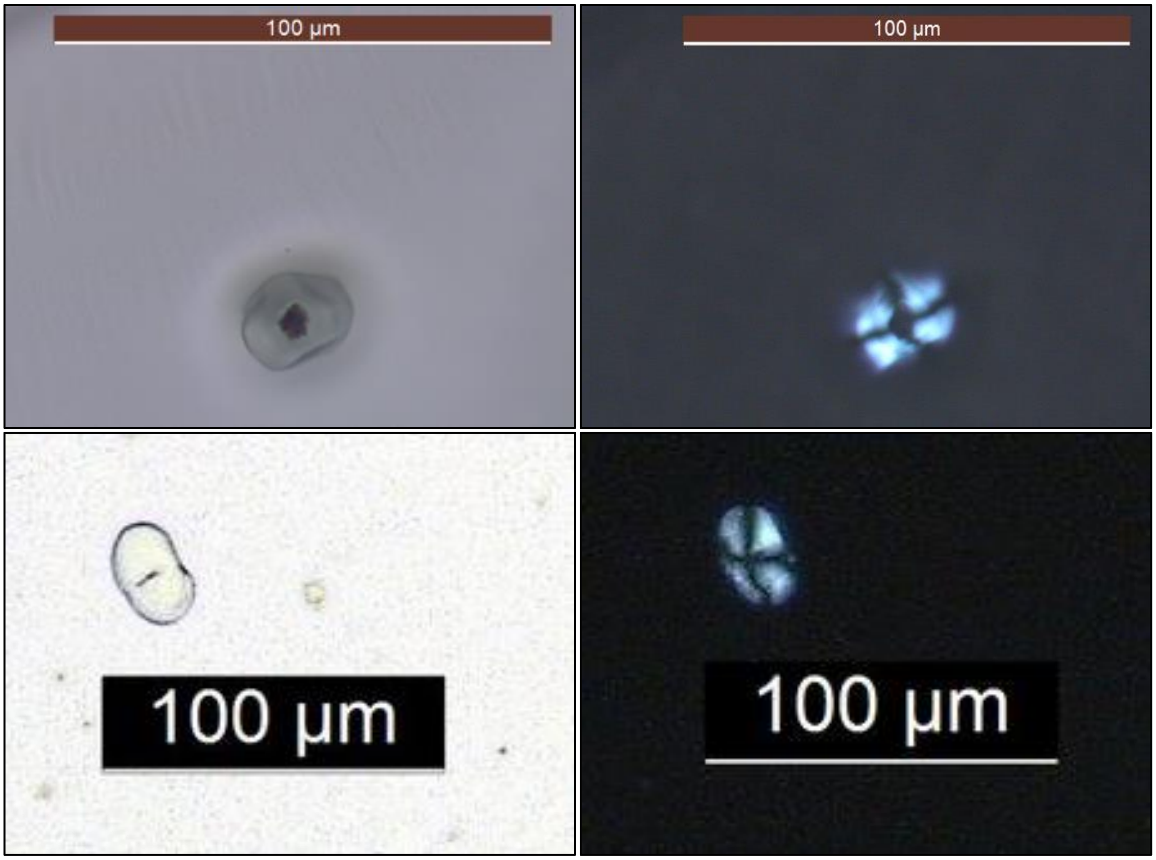

Figure 14.3. Unidentified starch grains viewed under brightfield and polarized light: (upper row) Type D starch with pronounced dimpled hilum (V10) under brightfield and polarized light. Unclear taxonomic classification; (lower row) single starch granule recovered in air trap. Hilum visible, legume-shaped, unclear taxonomic association but does not match starches recovered in samples.

The 10 sherds were also investigated for chemical residues through gas chromatography and mass spectroscopy. The focus of this analysis to identify biomarkers of caffeine, theobromine, theophylline, and atropine that would indicate the use of ceramics to process, store, transport, or serve ritual drinks such as Black Drink (Yaupon holly) or cacao (Dozier et al. 2020). None of those compounds were identified in any of the samples.

Phytolith Analysis

Phytoliths were analyzed from 25 samples as part of an evaluation of archaeological features at the Merchant site, LA 43414. These samples were collected from a variety of features (Table 14.3), though mostly from agricultural features, in an effort to identify maize remains as well as other resources cultivated or utilized at the site. LA 43414, located in Lea County in the far southeastern corner of New Mexico, is a pueblo settlement dating from A.D. 1300 to 1450, and consists of jacal pueblos with kivas and agricultural gridded fields, along with distinctive corrugated ceramics typically associated with settlements of central and western New Mexico. Large numbers of bison and other bones were found in the site's middens, along with a significant number of projectile points indicating a hunting economy.

Six samples were collected from bedrock mortars at LA 121668, a large site in the Custer Mountain survey area (see Graves et al. 2021b). Here, it was thought that samples from these bedrock mortars might prove illuminating compared to the mortars found at the Merchant site (Castañeda and Willis 2021).

Table 14.3. Proveniences of the LA43414 and LA 121668 phytolith samples

Lab #	Site	CN	Feature	Level	Depth	Description	Context
1	LA43414	189	110	2	25-30	Midden	Upper fill of midden deposit
2	LA43414	280	6	2	30	Room 6	Sediment from palette from floor
3	LA43414	313	404	5	26	Room 25	Sediment from mano on floor
4	LA43414	314	404	5	26	Room 25	Sediment from metate on floor
5	LA43414	315	404	5	29	Room 25	Sediment from palette from floor
6	LA43414	369	410.1	4	29-34	Room 29	Sediment from mano from floor hearth
7	LA43414	381	6.4	4	46-50	Room 6	Sediment from subfloor ash pit
8	LA43414	401	82	2	5-10	Gridded field	Paired with pollen sample
9	LA43414	402	82	3	10-15	Gridded field	Paired with pollen sample
10	LA43414	403	82	2	5-10	Gridded field	Paired with pollen sample
11	LA43414	404	82	3	10-15	Gridded field	Paired with pollen sample
12	LA43414	405	82	2	5-10	Gridded field	Paired with pollen sample
13	LA43414	406	82	3	10-15	Gridded field	Paired with pollen sample
14	LA43414	407	82	2	5-10	Gridded field	Paired with pollen sample
15	LA43414	408	82	3	10-15	Gridded field	Paired with pollen sample
16	LA43414	409	82	2	5-10	Gridded field	Paired with pollen sample
17	LA43414	410	82	3	10-15	Gridded field	Paired with pollen sample
18	LA43414	452	65	1	44-54	Check dams	Trench 2019-3 near check dams
19	LA43414	453	65	1	40-46	Check dams	Trench 2019-3 near check dams
20	LA43414	454	65	1	22-28	Check dams	Trench 2019-3 near check dams
21	LA43414	457	441.2	1	5-14.5	Bedrock mortar	Merchant site vicinity
22	LA43414	458	441.3	1	23-28	Bedrock mortar	Merchant site vicinity
23	LA43414	459	441.4	1	5-11.3	Bedrock mortar	Merchant site vicinity
24	LA43414	460	441.5	1	15-22.7	Bedrock mortar	Merchant site vicinity
25	LA43414	461	442.9	1	10-16.3	Bedrock mortar	Merchant site vicinity
26	LA121668		23.29		0–24.5	Bedrock mortar	Custer Mountain, 20 km SE
27	LA121668		23.35		0–27	Bedrock mortar	Custer Mountain, 20 km SE
28	LA121668		23.42		0–38	Bedrock mortar	Custer Mountain, 20 km SE
29	LA121668		23.61		0–25	Bedrock mortar	Custer Mountain, 20 km SE
30	LA121668		23.88		0–24	Bedrock mortar	Custer Mountain, 20 km SE
31	LA121668		23.91		0–25	Bedrock mortar	Custer Mountain, 20 km SE

It was anticipated that the phytolith data would provide insights into past site or feature use, augmenting previously conducted macrobotanical and palynological investigations. The 25 phytolith samples examined for the Merchant site study consisted of three suites of samples collected from ground stone artifacts, gridded fields, check dams, and bedrock mortars.

The region near the Merchant site is characterized as desert grassland/Chihuahuan desert thorn scrub, dominated by mesquite (*Prosopis glandulosa*), snakeweed (*Gutierrezia* sp.) and other members of the Asteraceae family, creosotebush (*Larrea tridentata*), various members of the cactus family, and grasses, particularly dropseed (*Sporobolus* sp.), three-awn (*Aristida* sp.), and grama grass (*Bouteloua* sp.) (Whitehead and Flynn 2016). Local vegetation and resources may have differed significantly in the past.

Previous Research

A study of samples collected from the nearby Permian Basin area (Cummings and Kováčik 2013) identified a suite of fuel and plant subsistence resources for the region. Woods used for fuel consisted primarily of mesquite, with oak, cholla, juniper, creosotebush, pine, sumac, and members of the sunflower and rose families, whereas potential plant foods included charred sumac, sunflower, cacti, Cheno-Am, saltbush, mesquite, acorns, and dropseed, which can be collected from the summer to fall. At these sites, which ranged in age from 2901 to 435 B.P., spanning the late Archaic and Formative periods, maize was observed to be generally rare, present only in village sites, where it made up only 2 percent of the 500 samples examined for the project. Maize has also been reported from village sites such as Fox Place, Henderson Pueblo, and Bloom Mound, which date to the thirteenth and fourteenth centuries (Kelley 1984; Miller et al. 2016; Speth 2017; Wiseman 2002).

The southeastern New Mexico area is under-represented in local phytolith studies, perhaps largely because of the shallow or deflated nature of the sediments found in area sites. This study attempts to address this under-representation. In particular, bedrock mortars in the region, though common, have been poorly studied. A strategy for collecting phytolith residues from these features was developed and it was anticipated that insights into plant processing and utilization could be gained.

Theoretical Background

Phytoliths are biogenically produced opal structures formed within and between plant cells. Many, but not all, plants produce phytoliths, and these biosilicates are frequently recognizable and diagnostic; thus, they are a valuable tool in paleoenvironmental and archaeological reconstructions. Phytoliths are small, and diagnostic forms generally fall in the range of 8 to 100 microns. Because they are composed of silica, their recovery from soils necessitates they be extracted in a manner separate from pollen, because chemicals used to extract pollen are destructive to phytoliths. Similarly, all organic traces, including pollen, must be removed from the sediments to successfully extract phytoliths.

Many plants produce phytoliths, but they are particularly well-represented in the Monocot group; palms, sedges, and grasses are prolific phytolith producers. The reason plants produce phytoliths is not fully understood, but some factors in their production include the prevention of herbivory, particularly from insects, and to mitigate the effects of wilting in grasses. Phytoliths are formed when dissolved silica in ground water is taken up by plants and is precipitated within and sometimes between plant cells. Fortunately, these phytoliths can take on diagnostic shapes and sizes allowing for their identification (Piperno 1988).

Phytolith analysis is a perfect complement to pollen studies for a number of reasons. First, phytolith production and recognition is often well-represented in groups that have limited diagnosticity in pollen studies. For example, all grasses produce pollen, but nearly all grass pollen grains are morphologically identical, with the exception of maize and domesticated cereal grains. The identification of grasses from pollen, therefore, is generally limited to the family level. However, all grasses produce phytoliths, and more than 10 different types of phytoliths have been observed in a single grass species. These forms can often be classified into grass tribes or subfamilies based on their morphological characteristics. As these tribes of grasses each favor distinctive environmental conditions, the presence of a specific grass phytolith type might signal specific environmental conditions.

North American grass tribes include the Festucoideae (Pooideae), mostly cool climate C3 grasses; the Chloridoideae, mostly warm and dry-favoring C4 bunch grasses; the Panicoideae, warm and moist favoring subtropical C4 grasses; and the Bambusoideae (bamboos); other grass phytolith subdivisions are also recognized. Similar types of subdivisions are recognized in the sedge family and among the palms, whereas these groups' pollen grains are often of limited value for identification and interpretation. Fortunately for archaeologists, phytoliths are also well-represented among the native cultigens. Maize, beans, and squash, along with many other domesticates, are all known to produce diagnostic phytolith forms. For example, beans can produce distinctive hook-shaped silicified hairs (Bozarth 1990), while beans are virtually invisible in the pollen record. Since beans are cleistogamous (self-pollinating), they produce very few pollen grains which tend to remain with the flower; further, domesticated bean pollen grains are moderately fragile, and they are largely non-diagnostic.

Phytoliths, however, have some important limitations. First, most plants do not produce diagnostic phytoliths; thus, the range of types encountered in archaeological sediments is limited. Further, preservation of phytoliths is imperfectly understood. Phytoliths often exhibit poor or variable preservation in calcareous environments, although they have often been recovered in perfect condition from shell middens. Conditions leading to phytolith dissolution are also not well known. Still, in silica-rich settings, phytoliths can usually be extracted from most sediment types, particularly when the phytolith-sized silt fraction is well represented.

Phytoliths also can be composed of calcium-based materials, particularly calcium oxalate. These phytoliths are common in many succulents, including all members of the cactus family, along with agave, yucca, and the Araceae family. Calcium oxalate phytolith shapes are governed by chemistry; thus, these forms take on crystalline shapes and usually have limited taxonomic value. Additionally, calcium oxalate phytoliths tend to break apart and ultimately dissolve in many environmental settings, so the likelihood of these forms being recovered is usually low. Nevertheless, the potential for species identification exists under certain circumstances. For example, a 7,000 year old fragment of dried cactus pad from a cave in west Texas was identified to the species level through the types and proportions of calcium oxalate phytoliths present in the ancient pad (Jones and Bryant 1992), and many genera of cactus appear to produce distinctive calcium oxalate phytoliths. Thus, in dry caves, where edaphic alterations have been minimal, the potential for calcium oxalate phytolith recovery is high.

Most phytolith studies have centered upon their occurrence in either tropical environments or grasslands, where their value is most apparent (Piperno 1988). In contrast, there are limitations of phytolith studies in New Mexico and the southwest. First, the number of useful phytolith-producing plants in the region is not known but appears to be moderately low. Significant phytolith producers in the project area include grasses and sedges, many of which are of limited taxonomic value in terms of identification potential. Further, while other locally available plants are likely to produce diagnostic phytoliths, baseline studies for this region are limited; thus, the number of known phytolith types in the region is not high. While finding any identifiable phytoliths in a sample is noteworthy and useful, assessment of differential preservation must also be addressed. Did one particularly durable phytolith type survive at the expense of other, more fragile types? Despite these challenges, phytolith analysis has a tremendous potential for providing information on past environmental conditions and human/plant interactions. The combined strengths of pollen and phytolith studies conducted in tandem greatly augment our knowledge of the past in ways unobtainable from the use of just one of these techniques.

Phytolith Types

Phytolith types do not necessarily follow taxonomic lines, and one form may be found in several different plants. Nonetheless, patterns are present, particularly among the grasses, allowing for the discussion of these types.

Festuceae: Festucoid or Pooid (Pooideae) grasses are generally cooler climate grasses in the C3 carbon pathway group. These types are abundant in North America and throughout the temperate world, becoming less frequent as the climate becomes hotter and drier. For the most part, the only occurrence of Festucoid grasses in the tropics is at higher elevations (Twiss 1992). The introduced Old World domesticated cereal grains wheat (*Triticum*), barley (*Hordeum*), rye (*Secale*), and oats (*Avena*) are all members of the Festucoid tribe. Common phytolith types in this category include a variety of short cells, elongate plates, and irregular echinate rods or plates (Festucoid irregular) that are particularly well represented in wheat but might also be found in some other Festucoid grass. *Hordeum pusillum* (little barley), *Oryzopsis hymenoides* (Indian ricegrass), and *Phalaris* (canary grass), important native cultivars throughout much of the United States (Moerman 1998), are all members of this subfamily.

Paniceae: Panicoid grasses are C4 grasses favoring warmer and moister climates; maize (*Zea maize*) is an important domesticated member of this group. Common Panicoid phytoliths include distinctive bilobate forms possessing a recognizable three-dimensional morphology, and cross forms. Maize produces distinctive phytoliths allowing for the positive identification of this plant; bilobate crosses in maize are often notably large, while wavy-top rondel forms, especially common in maize cobs but also occurring in other parts of the plant, are recognized as distinct and representative of maize (Piperno et al. 2009).

Chlorideae: The Chloridoid grasses are C4 bunch grasses or short grasses, generally favoring warmer and drier climates. Chloridoid grasses are particularly well-represented in the western United States. Chloridoid grasses are notable for producing saddle-shaped forms absent or rare in other grass tribes. Common members of this tribe include *Distichlis* (saltgrass), and *Sporobolus* (dropseed), both of which genera were important in prehistoric times, the former in the manufacture of salt (Hallock 2015) and the latter as a food (Reinhard 1992).

Other Poaceae Types: Poaceae bulliform or "keystone" type cells are produced in many grasses and are rarely distinctive. Non-diagnostic grass hair cells, non-specific bilobates, and elongated crenate forms also fall within this category, and these types are known to occur in many North American grasses.

Cucurbitaceae: Domesticated squash (*Cucurbita*) produce distinctive large, scalloped spheres in their pericarp and stems. These forms are produced in wild squash as well, but in non-domesticated forms, the phytoliths are significantly smaller. Gourd (*Lagenaria siceraria*) phytoliths are similar to squash types, but the bodies are often irregularly shaped rather than consistently spherical. Only one small squash body was noted in the Merchant site samples, likely derived from wild squash naturally found in the area.

Beans: Bean phytoliths take the form of thin-hooked hairs, found in the pod and stems of the bean fruit. These lightly silicified forms are fragile and are likely to be easily lost from many phytolith assemblages through dissolution and mechanical breakage. These hooked hairs have been observed in many types of domesticated beans, including common kidney bean (*Phaseolus vulgaris*), tepary bean (*P. acutifolius*), lima bean (*P. lunatus*), and others (Bozarth 1990), and in some wild members of the Fabaceae family.

Celtis: Hackberries produce distinctive rugulose plates within their stony seeds. These phytoliths appear to be particularly durable, and will likely, after further study, prove to be diagnostic to the species level.

Asteraceae: Distinctive silicified cells representing hair cell bases from the Asteraceae were also noted, though this type is known to occur in a number of genera so an identification below the family level is not possible.

Cyperaceae: All members of the sedge family produce phytoliths, many of which forms are distinctive to the family, or even genus level. Phytoliths are produced in all parts of the plant, including the roots, stems, and leaves, and the shapes produced in the inflorescences are often the most diagnostic. Sedges prefer moist meadow, stream side, and wetland environments. Phytolith plate types bearing distinctive edge crenulations and rugulose surfaces along with a dome-shaped centric appendage are diagnostic to the genus *Cyperus* (flatsedge). Sedges are unlikely to have been common in the area of the sites, and their presence in the phytolith samples might signal residue from food preparation, basketry, matting, or screening.

Wood and Bark Forms: Small sub-spherical bodies, blocky cells, and spinulose types are frequently produced in tree wood and bark as are rare silicified tracheid cells. Members of the Fabaceae, Pinaceae, and other families are known to produce these phytolith types, though they cannot safely be assigned to any taxon, as their positive sources are not known. Echinate irregular forms likely originate in juniper wood or bark, though these forms may also have originated in other taxa. Ultimately, a detailed study of North American wood phytoliths will resolve the sources of these important phytoliths.

Other phytolith forms of limited interpretive value are produced by many plants, or in some cases, by unknown plants. These types include bulliform cells, spherical forms, plain and echinate rods, and lunate forms and spinulose sculpted types are also of note. Unidentified hair cells, echinate oval types, and unknown types M and S, likely derived from a monocot plant, were also noted in the assemblage. Dicot plates likely derive from dicot leaves, though this phytolith type is produced by many plants. *Sabal* palm type phytoliths found in desert environments probably originated in geologic-age sediments representative of an age when palms were present on the landscape. Small dodecahedral crystals likely to be composed of calcium oxalate were noted in a few samples; these phytoliths have been observed in wood and bark of mesquite trees and other members of the Fabaceae family. Diatoms were noted in the samples but were excluded from the counts. Forms were mostly pennate types, usually representing a freshwater origin. A large number of *Nitzschia* diatoms were noted; many diatoms in this genus thrive in moist soil and their presence in the samples is thought to signal the past presence of semi-permanent water.

Methods

The Phytolith Research Laboratory at ACS processed the phytolith samples, using a protocol favored by ACS (Jones 2013). First, a 3–5 gram sample of sediment was placed in a beaker where it was washed with 10 percent hydrochloric acid to remove unwanted carbonates. The samples were next screened through 150-micron mesh, effectively removing all unwanted larger materials, washed in 10 percent potassium hydroxide to remove alkaline-soluble humates, and rinsed clean. Repeated short spins removed colloidal material smaller than 3 microns. Next, the samples were oxidized in 35 percent hydrogen peroxide (Jones 2013), resulting in the removal of organics—a step necessary before phytoliths can be isolated from all other silicates. Finally, the phytoliths were isolated from the remaining silts through a heavy density separation using sodium polytungstate (Sp. G. 2.35). Phytoliths were removed by pipette, rinsed thoroughly, and dehydrated in absolute alcohol for curation in 1 dram vials. A slide was prepared at ACS using Meltmount mounting media, and the phytoliths were identified on a Nikon E200 binocular microscope at 400 and 625x magnification. Identifications were confirmed using published keys and the ACS reference collection.

Phytolith residue samples were fractionated in the laboratory into coarse (25–150 micron), and fine (3–25 micron) samples. There is usually little overlap between phytolith category groups within these size fractions. Separation into fractions facilitates counting through a standardization of phytolith size in the visual search image. Coarse samples tend to contain large amounts of bulliform cells as well as rods, plates, and grass elongates. The fine fraction usually contains short cells from grasses, sedges, and spheroids common in some tree barks. Most diagnostic forms come from the fine fraction and thus more effort is expended counting these forms.

Although there is no standard agreement among researchers on how many phytoliths should be counted for each sample, the current analysis was based on counting at least 100 coarse-sized phytoliths, and at least 200 fine-sized phytoliths per sample, a standard substantially more rigorous than most current methodologies. Percentage occurrences were calculated within their size division; thus, for each sample, two separate counts and sets of percentages were obtained. As phytolith categories within the size fractions are usually mutually exclusive, the data can be interpreted collectively.

Phytolith Samples: Well-preserved phytoliths were present in all of the phytolith samples from LA 43414 and LA 121668, and although erosion and degradation of individual phytoliths was sometimes apparent in the sample assemblages, full counts were made for all samples. Phytoliths at both sites exhibited fairly comparable states of preservation, with only a few phytoliths showing any significant degree of erosion and degradation. Results of the phytolith analysis are presented in Tables 14.4, 14.5, and 14.6.

Many plants likely to have been roasted or otherwise prepared in these various features are not phytolith producers and would not be represented in the phytolith assemblages. Some of these locally important economic plants that are invisible in the phytolith record might include onions and other bulbs, cacti, agave, sotol, and yucca. Calcium oxalate phytoliths are rarely preserved in open-air sites; thus, they are not likely to be found in these contexts. Calcium oxalate phytoliths may have been represented by dodecahedral phytoliths from the Fabaceae family, possibly from mesquite (*Prosopis* sp.), though these may have been intrusive modern phytoliths.

The phytolith assemblages in all samples were dominated by grass phytoliths, predominantly bunch grasses in the Chloridoideae sub-family, Festucoid short cell forms, and by spherical and spinulose forms presumably representing bark or wood phytoliths, as well as by rare irregular echinate forms probably originating from juniper bark or wood.

Cultigen phytoliths were absent from the assemblages from both LA 43414 and LA 121668, though a single small squash-like phytolith was present in Sample 408 collected within the gridded field, and a hook hair similar to those found in bean pods was noted in Sample 13, also from a gridded field sample.

Table 14.4. Phytolith samples from rooms, artifacts, and agricultural fields at LA 43414

	Rooms and Artifacts							Agricultural Fields									
Catalog Number	**189**	**280**	**313**	**314**	**315**	**369**	**381**	**401**	**402**	**403**	**404**	**405**	**406**	**407**	**408**	**409**	**410**
Feature	**110**	**6**	**404**	**404**	**404**	**410.1**	**6.4**	**82**	**82**	**82**	**82**	**82**	**82**	**82**	**82**	**82**	**82**
Specimen Number	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**
Coarse Fraction																	
Bulliform	75	72	80	79	72	73	83	84	87	83	76	79	80	80	86	92	91
Rod	14	10	6	4	12	17	12	11	11	15	16	14	19	11	6	1	6
Echinate Rod	2	6	3	3	2				1								
Lunate														1			
Tracheid			1	2								1					
Poaceae Bulliform	3	3	2	4	2			2		2	5	4		6	2	3	2
Poaceae Hair	5	8	8	8	12	10	5	3	1		3	2	1	2	6	4	1
Dicot Plate	1	1															
Total Coarse Sum	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**
Fine Fraction																	
Festucoid Short Cell	16	11	10	12	12	17	16.5	7.5	13	9	15	12.5	15	6.5	6	10	5
Festucoid Irregular	0.4		1.5	3		1.5		1	0.5	1	1	2	1		0.5	0.5	
Panicoid Cross	0.4		1			0.5		0.5		0.5	1.5	2.5		0.5		0.5	
Panicoid Bilobate	3.5	5	5.5	4.5	1	8	4	1.5	2.5	2.5	4	3.5	1				2.5
Chloridoid Saddle	35.8	35.5	37	37.5	35	31.5	33	33	34.5	53.5	40	42.5	39.5	58.5	53	46.5	42.
Bilobate	16.5	22.5	24.5	19.5	18.5	20	17.5	25	23.5	18.5	20	18.5	17.5	5.5	8	13.5	8
Crenate	8	5.5	5	7.5	10.5	6.5	6.5	3.5	2.5	4.5	1.5	2.5	3.5	7.5	9.5	8	8
Hooked Hair													0.5				
Solid Hair																	
Cyperaceae		0.5			1							0.5					
Cyperus		0.5	0.5					0.5				0.5	0.5	1	1.5	2	
Aster Hair base																	0.5
Celtis																	
Juniperus					0.5		0.5		0.5						0.5		2
Cucurbitaceae															0.5		
Unknown M				0.5		1.5								0.5			
Unknown S											0.5		0.5				
Echinate oval												0.5					

	Rooms and Artifacts							Agricultural Fields									
Catalog Number	**189**	**280**	**313**	**314**	**315**	**369**	**381**	**401**	**402**	**403**	**404**	**405**	**406**	**407**	**408**	**409**	**410**
Feature	**110**	**6**	**404**	**404**	**404**	**410.1**	**6.4**	**82**	**82**	**82**	**82**	**82**	**82**	**82**	**82**	**82**	**82**
Specimen Number	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**
Spinulose sculpted																	1
Blocky Bark	1.3	1.5	0.5	0.5	1		0.5						1.5			0.5	5
Sub-Spherical Bark	18.1	18	14.5	15	20.5	13.5	21.5	27.5	23	10.5	16.5	14.5	19.5	20	20.5	18.5	25.
Total Fine Sum	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**
Phytoliths counted	**226**	**200**	**200**	**200**	**200**	**200**	**200**	**200**	**200**	**200**	**200**	**200**	**200**	**200**	**200**	**200**	**200**
Fabaceae				1													
Arecaceae											1						
Diatom	2	6	3		2	11	4	83	74	16	24	30	36	10	30	11	
Nitzschia		10	1		6	5		53	43	4	19	24	18		5	3	

Table 14.5. Phytolith samples from check dams and bedrock mortars at LA 43414

	Check Dams			Bedrock Mortars				
Catalog Number	**452**	**453**	**454**	**457**	**458**	**459**	**460**	**461**
Feature				**441.2**	**441.3**	**441.4**	**441.5**	**442.9**
Specimen Number	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**
Coarse Fraction								
Bulliform	85	91	85	77	90	89	85	91
Rod	9	7	9	15	5	6	6	2
Echinate Rod								
Lunate		1			1			
Tracheid	1				1	1	3	
Poaceae Bulliform	1		2	6	3	1	2	4
Poaceae Hair	4	1	4	2		3	4	3
Dicot Plate								
Total Coarse Sum	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**
Fine Fraction								
Festucoid Short Cell	5	5.5	12	7	4	5	6	8.5
Festucoid Irregular		0.5		2.5				0.5
Panicoid Cross								
Panicoid Bilobate	2.5	1.5	1.5	1.5	3	0.5	1	1
Chloridoid Saddle	43	36	37	59	49	53.5	54.5	50
Bilobate	17	11.5	16	9.5	12.5	8	3.5	12
Crenate	4	8.5	9	6	3.5	6	9.5	10
Hooked Hair								
Solid Hair	0.5							
Cyperaceae		0.5	0.5				0.5	
Cyperus							0.5	
Aster Hair base								
Celtis								
Juniperus		2.5	3			2.5	1	2
Cucurbitaceae								
Unknown M	1	2	1.5					
Unknown S								
Echinate oval								
Spinulose sculpted	0.5	1						
Blocky Bark	4.5	7	1.5	1	1.5	2	2	1
Sub-Spherical Bark	22	23.5	18	13.5	26.5	22.5	21.5	15
Total Fine Sum	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**
Phytoliths counted	**200**	**200**	**200**	**200**	**200**	**200**	**200**	**200**
Fabaceae						1		
Arecaceae			1			1	1	
Diatom	6	127	2					4
Nitzschia	1	19						4

Table 14.6. Phytolith percentages from bedrock mortars at LA 121668

Feature	23.29	23.35	23.42	23.61	23.88	23.91
Specimen Number	**26**	**27**	**28**	**29**	**30**	**31**
Coarse Fraction						
Bulliform	68	84	87	86	85	82
Rod	20	10	3	9	8	12
Echinate Rod						
Lunate						
Tracheid						
Poaceae Bulliform	1		1		2	1
Poaceae Hair	11	6	9	5	5	5
Dicot Plate						
Total Coarse Sum	**100**	**100**	**100**	**100**	**100**	**100**
Fine Fraction						
Festucoid Short Cell	5.5	5.5	3.5	1.5	4	6
Festucoid Irregular			0.5			
Panicoid Cross	0.5					
Panicoid Bilobate	1.5	6	3	7.5	2.5	1.5
Chloridoid Saddle	39.5	35	38.5	45	43	44.5
Bilobate	12.5	21	13	19.5	10	15.5
Crenate	15.5	13.5	9.5	9.5	12	7
Hooked Hair						
Solid Hair		0.5	1			0.5
Cyperaceae					0.5	
Cyperus			0.5			
Aster Hair base						
Celtis	3.5	0.5	0.5		1	0.5
Juniperus	3		2	1	5	5
Cucurbitaceae						
Unknown M	0.5		0.5			
Unknown S						
Echinate oval						
Spinulose sculpted						
Blocky Bark	1		0.5	1		
Sub-Spherical Bark	17	18	27	15	22	19.5
Total Fine Sum	**100**	**100**	**100**	**100**	**100**	**100**
Phytoliths counted	**200**	**200**	**200**	**200**	**200**	**200**
Fabaceae						
Arecaceae						
Diatom	2	4		1	1	1
Nitzschia	1	1				

Results

Three suites of samples from LA 43414 were examined, including seven phytolith samples collected from ground stone tool surfaces and feature fill, 10 samples collected from gridded field Feature 82, three samples representing check dams associated with the gridded field samples, and five bedrock mortar samples. These samples collectively provide a better picture of plants growing in the site area. Each suite of samples will be discussed individually.

Ground Stone Artifacts: Seven ground stone artifacts from LA 43414 were examined for this study. Sediments on the surface of the artifacts were brushed into collection bags, and phytoliths were extracted from these materials. Preservation was generally good in these samples, and full counts were achieved in all samples.

<u>Sample 189</u>: Sample 189 represents the upper fill of a midden, Feature 110, and the phytolith preservation was mostly good. Phytoliths in this sample probably largely represent typical background types from the site area. Echinate rod types of unknown affiliation were rare or non-existent in most of the LA 43414 and LA 121668 samples but were noted in five of the seven ground stone/sediment samples. Coarse fraction phytoliths show a slightly above-average number of grass types (Poaceae bulliform and edge hair cells), probable associated with slightly increased numbers of fine fraction Festucoid and Panicoid grasses. Chloridoid grasses, representing probable background short or bunch grasses characteristic of this region, are reduced in number, suggesting that grasses discarded in this midden might represent economically useful Festucoids and Panicoids. These potentially economically significant types were likely to have been present in the area but were probably much less common than Chloridoid forms. Bark type phytoliths were present in fairly low numbers. These types are small, are readily dispersed by the wind, and were likely introduced into the sediments from natural woody plant decomposition, and from woody fuel usage.

<u>Sample 280</u>: Sample 280 was a sediment sample collected from a palette from Feature 6, the floor of Room 6. The coarse fraction in this sample showed a high occurrence of echinate rod types of unknown origin. Economically notable types were mostly absent from the assemblage, though Festucoid and Panicoid type grasses were slightly elevated again, possibly representing edible or otherwise useful grasses. Both the sedge family (Cyperaceae), and flatsedge (*Cyperus*) were represented by single phytoliths. These plants prefer streamside settings, where sediments are perennially moist, though single phytoliths may also represent the transport of a phytolith through wind or water. Bark phytolith types were again fairly low in number in this sample.

<u>Sample 313:</u> Sample 313 represents a mano from Feature 404, the floor of Room 25. Three ground stone artifacts were collected from this context, representing Samples 313, 314, and 315. The coarse fraction contained a slightly elevated number of grass phytoliths, along with three echinate rods. In the fine phytolith fraction, Festucoid grasses were slightly more common, and the presence of three Festucoid irregular forms might indicate that little barley (*Hordeum pusillum*) was associated with this mano. Little barley is a native grass known to have been widely utilized throughout North America as a food (Moerman 1988; Yanofsky 1936), is known to produce this type of phytolith, although this form is known from other grasses, as well. Panicoid grass phytoliths are also elevated. Bark phytoliths are present in fairly low numbers in this sample.

<u>Sample 314</u>: Sample 314 represents sediment collected from a metate from Feature 404, the floor of Room 25. Phytoliths from this metate bear a strong resemblance to the assemblage noted in Sample 313. The coarse fraction contains three echinate rods and 12 coarse phytoliths, nearly identical to Sample 313. The fine fraction, like Sample 313 shows elevated numbers of Festucoid phytoliths including 3 percent Festucoid irregular types, again possibly representing little barley. Panicoid grasses are also present in elevated numbers hinting at the use of some member of this sub-family. Bark phytoliths are represented in numbers nearly identical to Sample 313. It is

possible, considering both the context and phytolith samples, that these grinding stones were associated in their use.

<u>Sample 315</u>: Sample 315 is sediment from a palette collected from Feature 404, the floor of Room 25. Phytoliths were generally well preserved in this sample, and the assemblage was consistent with other samples from the structure. Two echinate rods were noted in the coarse fraction reflecting an unknown plant, while grasses were reflected by 14 phytoliths. The fine fraction of Sample 315 showed a decrease in grass phytolith forms with an increase in bark types. The phytolith assemblage from this palette likely reflects background environmental types, rather than forms associated with the use of this artifact. The increased number of bark types may be associated with ash disposal from nearby thermal features, and the presence of a single juniper-type phytolith in a site area lacking junipers, might support this idea.

<u>Sample 369</u>: This sample is sediment collected from a mano associated with a hearth (Feature 410.1) in Room 29. Echinate rods were absent from this sample. In the fine fraction of Sample 369, Festucoid grass types were present at 18.5 percent, with Panicoid forms occurring at 8.5 percent. These elevated numbers indicate the mano had been used to grind Festucoid and Panicoid type grasses, and the slightly elevated number of grass edge hair cells in the coarse fraction are likely associated with these elevated fine fraction types. Bark forms are reduced in this sample.

<u>Sample 381</u>: Sample 381 represents sediments collected from Feature 6.4, a sub-floor ash pit located in Room 6. Echinate rods were absent from this sample, and grass forms in the coarse fraction were low. The fine fraction shows an elevated number of Festucoid grass types at 16.5 percent, and a reduction in the number of Panicoid grass forms. Consistent with this feature's use as a hearth, there is an increased number of bark forms in the assemblage, with 22 percent sub-spherical and blocky forms, and a single juniper phytolith.

Ground Stone and Sediment Sample Summary: As a whole, the phytolith assemblages reflect the use of specific tools in the preparation of grasses, specifically Festucoid and Panicoid types, for use as food. Panicoid grass phytoliths in the ground stone samples averaged 14.4 percent compared to the average of 8.6 percent in all other samples from the site. Panicoid grasses had an average occurrence of 4.8 percent in the ground stone samples, compared to a 2 percent average in other samples from the site, indicating that both Festucoid and Panicoid grasses were being ground or otherwise processed on these tool surfaces. Chloridoid grass phytoliths were represented by an average of 35.0 percent in the ground stone assemblage, compared to an average of 45.9 percent in other samples from the site. Chloridoids were probably background phytoliths, representing the dominant subfamily of grasses in the site area; their occurrence in lesser numbers on the ground stone samples reflects the fact that Chloridoid grasses were not processed on the tools. Echinate rods of unknown origin were present in five of the seven ground stone and sediment samples, though this type was absent from all other samples from Sites LA 43414 and LA 121668, with the exception of a single echinate rod type found in a gridded field sample. The origin of this phytolith is not known, but it may have been produced by an economically significant plant.

Gridded Field Samples: Ten samples were examined from Feature 82, a series of gridded field plots. These samples were collected from Levels 2 and 3 throughout the feature, and it was anticipated that a reflection of plants grown in the gridded fields might be identified in the phytolith samples. A comparison of Level 2 and Level 3 samples across the feature revealed no patterning, though both a possible bean and squash type phytolith were identified, both originating in Level 3 samples.

A comparison of the grass phytoliths from the gridded field fine samples reveals that Festucoid forms averaged 10.7 percent, while all other samples from this site averaged a nearly identical 10.5 percent occurrence. Panicoid grasses, present in the grid samples at an average of 2.35 percent, likewise were similar to the average occurrence of 3.1 percent, and Chloridoid phytoliths were represented by an average of 44.35 percent in the grid samples, with the non-grid samples averaging a comparable 41.8 percent occurrence. The similarity of grass phytolith assemblages in the gridded field and non-agricultural samples suggests that grasses were not cultivated in these features, but rather that plants cultivated in this feature were either scant, or non-phytolith producers. It was initially thought that maize might have been cultivated in the gridded field; however, no maize phytoliths were present in the samples. Further, Panicoid grass types representing, in part, non-diagnostic maize phytoliths were present in percentages below the average for this site. Other phytolith types in the gridded field samples were present in numbers comparable to other samples collected from the site.

Interestingly, the only occurrences of phytolith type Unknown S were single phytolith occurrences in two gridded field samples. This type likely represents *Commelina* (dayflower), a moderately common weed, some species of which are found in the site area. Phytoliths of a type consistent with Unknown S are produced in the seeds/fruit of the plant. A single hooked phytolith was also noted in one sample from the gridded field. This phytolith type is known to occur in several species of bean pod, including common bean (*Phaseolus vulgaris*), tepary bean (*P. acutifolius*), and lima bean (*P. lunatus*). Hooked hair cells are also produced in other poorly studied members of the Fabaceae family, including *Robinia* (locust); thus, a positive association with domesticated beans cannot be made.

A single small squash type phytolith was also noted in one gridded field sample. This type is produced in both wild and domesticated squash pericarp and stems, and in lesser numbers in gourd pericarp; thus, an identification below the family level is not possible. The lack of distinctive large squash phytoliths in any of the samples from this site suggests that this phytolith represents a wild *Cucurbita foetidissima* (buffalo gourd) rather than a cultivated variety of squash.

Backhoe Trench/Check Dams: Three samples were collected from Level 1 from backhoe trenches associated with check dams in the vicinity of the gridded field area. Phytolith preservation in the check dam samples was generally very good, and full counts were made in all samples. Coarse fraction assemblages were largely unremarkable, and all samples were dominated by non-diagnostic bulliforms and rods, along with a few grass hair edge cells. Grasses made up a significant percentage of the fine fraction in all of the samples, though specific sub- family occurrences were generally low. Unknown M type phytolith was present in all of the samples, though always represented by a 2 percent occurrence or less. The source of this phytolith is not known, though it likely represents a monocot type. Blocky type bark phytoliths are polygonal-shaped plates of unknown origin; the three highest occurrences of this type are in the check dam samples, likely representing some species of plant once found in the area. Interestingly, unidentified diatoms, along with Nitzschia pennate forms, were abundant in Catalog Number 453, signaling the retention of perennial or semi-perennial water around the check dam. The check dam samples are all consistent with the environment portrayed in the adjacent gridded field samples, reflecting the presence of water in this otherwise xeric landscape.

Bedrock Mortar Samples: Five undated bedrock mortar samples were examined from the Merchant site, LA 43414. These mortar samples were assumed to be associated with at the occupation of the site, though they were located some distance away from the central activity area. These features are undated, though presumed to have been contemporaneous with the Puebloan settlement. Phytolith samples collected from all of the bedrock mortars exhibited generally good preservation.

The phytolith sample from the mortar features reflect mostly natural phytoliths in the area, rather than economically useful species likely to have been processed within the features. The coarse fractions from the bedrock mortars reflects only typical phytolith types, present in unremarkable quantities. Notable phytolith types identified in the coarse fractions include unidentified bulliform cells and rods, and lesser numbers of grass phytoliths represented by edge hair cells and grass bulliforms. Silicified tracheid cells, found in woods and bark, were noted in three of the five mortar samples. This phytolith type was scarce in the Merchant site where they were noted in only four other samples and were absent from samples from LA 121668. These likely represent phytoliths produced in wood, twigs, or bark that washed into these features or decayed in place.

Grass phytoliths were largely present in typical quantities in these sample, although there was a slight increase in the number of Festucoid forms in the sample from Feature 441.2. Here, Festucoid short cells and Festucoid irregular types made up 9.5 percent of the assemblage, similar to the Festucoid grass numbers found in the gridded field samples. Elevated numbers of Festucoid grasses were also noted in Feature 442.9, where they made up 9 percent of the sample. Panicoid bilobate types were low in all of the mortar samples, and Panicoid cross forms were absent in all samples, suggesting that maize or other Panicoid grass preparation was not taking place in these mortar features. Chloridoid grass saddle-shaped phytoliths were elevated in all of the mortar samples; this type is thought to represent background type phytoliths, rather than economically notable forms, and the Chloridoid grass Sporobolus was a dominant grass in the site area.

Bedrock Mortar Samples from Site LA 121668: Six sediment samples from Site LA 121668 were analyzed as a supplement to the project. These samples were collected from bedrock mortars at LA 121668, a site located in the Custer Mountain area, about 20 km southeast of LA 43414. It was anticipated that an examination of phytoliths in the mortar features would generate information on plant processing within these features.

Phytolith samples were collected from within the mortar features, and these basally derived materials were thought to represent, in part, residues from the actual use of the features, though materials blown or washed into the bedrock mortars after their period of uses may have served to dilute the assemblages associated with their uses. Phytoliths in all bedrock mortar samples were generally well preserved, and full counts were achieved in all samples.

Feature 23.29: Phytoliths from bedrock mortar Feature 23.29 were generally well preserved, and the assemblage was dominated by Chloridoid and Festucoid grass types and sub-spherical bark type phytoliths. These types dominate the fine fraction assemblages in all of the bedrock mortar samples, and probably represent background phytolith types found throughout the site area. Interestingly, grass hair edge cells present in the coarse fraction are generally more common in the suite of samples from LA 121668, perhaps corresponding to the overall increase in grasses at this site. Phytolith types positively attributable to maize were absent from all bedrock mortar samples, though overall, these samples contained slightly elevated numbers of Panicoid grass types represented by cross types and Panicoid bilobates. It is possible that some of these Panicoid forms may represent some of the non-diagnostic phytolith types produced by maize, possibly signaling that maize, either traded or grown locally, may have been utilized in these features. Native Panicoid grasses include plants that have a documented economic value, including *Panicum* (panic grass), *Paspalum* (paspalum), and *Setaria* (foxtail) (Moerman 1998; Yanofsky 1936).

Celtis (hackberry) phytoliths were absent from all of the sediment samples from LA 43414 but were present in five of the six bedrock mortar samples from LA 121668, indicating that these important seasonal fruits were processed in the bedrock mortar features. Hackberry phytoliths are produced within the stony seeds of the hackberry fruit and are usually a rare component of archaeological samples. A total of seven hackberry seed phytoliths (3.5 percent) were identified in the Feature 23.29 sample, a value considered to be very high. These phytoliths indicate that hackberry seeds/fruits were likely to have been processed in this bedrock mortar feature. Hackberry fruits, consisting of a thin dried fruit surrounding the relatively large stony seed, are very nutritious, and were often pulverized into a paste used by native populations to flavor dried meat (Elias 1980; Moerman 1998; Yanofsky 1936).

Feature 23.35: Feature 23.35 exhibited a similar assemblage to other bedrock mortar features. Again, grasses and bark types, probably representing background phytolith types, were dominant in this sample. Panicoid grass bilobate types were represented by a 6 percent occurrence, higher than nearly all of the LA 43414 sediment samples, hinting that Panicoid grasses may have been processed in this feature. A single hackberry phytolith was identified in this sample, again suggesting that this fruit was processed in the mortar feature. A single solid hair phytolith was also noted in this sample. The origin of this phytolith is not known, but the occurrence of this rare phytolith type in three of the bedrock mortars, while it was found in only one sample from LA 43414, suggests that it may represent a potentially significant plant.

Feature 23.42: A similar pattern of phytolith distribution was noted in bedrock mortar Feature 23.42, where a slight elevation in Panicoid grass bilobates hints at the past use of these grasses within the feature. Hackberry was represented by a single phytolith occurrence, and two solid grass hairs of unknown origin were also present in the feature fill.

Feature 23.61: Bedrock mortar Feature 23.61 differed from other mortar features in the absence of solid hair and hackberry seed phytoliths, which were present in the assemblages from most other features. Panicoid bilobate phytoliths were represented by 7.5 percent, the highest value in any of the samples from these sites. This number likely indicated the processing of Panicoid grasses in this feature.

Feature 23.88: Mortar Feature 23.88 was similar in composition to the other bedrock mortar samples from LA 121668, where the phytolith assemblage was dominated by grasses and bark types. Panicoid grasses, represented by bilobate types only, made up 2.5 percent of the sample. Two hackberry phytoliths were noted in this sample, while juniper-type echinate forms, normally scarce in the samples, were represented by a 5 percent occurrence.

Feature 23.91: Bedrock mortar feature 23.91 was similar in composition to Feature 23.88, with dominant numbers of background grasses and bark types. Panicoid grass types were scarce with only 1.5 percent bilobate types, and hackberry was represented by a single seed phytolith. A single solid hair of unknown affiliation was also noted in this sample, and juniper was represented by a 5 percent occurrence.

Discussion

Environment and Economic Plant Use at the Project Sites

The phytolith assemblages from the Merchant site indicate that the environment of the site at the time of occupation was likely to have been similar to that currently found in the region. Little evidence of arboreal phytoliths was noted, with the exception of possibly juniper wood represented by juniper-type phytoliths found in low numbers in 10 samples. These phytoliths may represent the use of juniper wood for fuel or for construction. Hackberry phytoliths were absent from all of the Merchant site samples, indicating that this small tree was not exploited at the site, possibly because of its absence from the area. Dicot plate phytoliths were noted in two samples; the source of these phytoliths is not known but *Quercus* (oak) is known to produce this type of phytolith in its leaves. As oak or other leaves are usually not selectively collected, these phytoliths are usually uncommon components of most phytolith assemblages.

Calcium-based mesquite phytoliths may have been represented by dodecahedral phytoliths produced in the wood and bark of mesquite, and possibly in other members of the Fabaceae family. These distinctive crystals were noted in only two samples, and rather than indicating the rarity of mesquite trees on the landscape, likely reflect an uneven dissolution of calcium oxalate phytoliths. Other calcium oxalate phytoliths, including raphides from *Yucca* and *Agave*, and druse forms from cacti, were completely absent from the Merchant site assemblages, indicating that calcium phytoliths had been removed from the samples. *Sabal*-type palm phytoliths were noted in four samples and almost certainly represent re-worked Tertiary age phytoliths from a time when southeastern New Mexico was a wetter sub-tropical location. Phytoliths of this type are commonly found in this area, as well as parts of south and central Texas where palms flourished during Paleocene through Miocene times.

Grasses were a dominant vegetation at the Merchant site, as well as a dominant phytolith producer. An examination of the three major subfamilies of grasses revealed that Festucoid grasses were present in the Merchant site samples at an average of 10.6 percent, while Panicoids were present at 2.7 percent, and Chloridoids were noted at an average 42.8 percent occurrence per sample. These numbers reflect the general composition of grasses in the vicinity of the site area, though Festucoids and possibly also Panicoid grass types were clearly being utilized on the ground stone artifacts for food preparation.

Other identifiable plants in the assemblages include rare sedge (present in six samples) and *Cyperus* (flatsedge) phytoliths, present in nine samples, mostly in the Feature 82 gridded field sample. Most species of sedge prefer a wetland, streamside, of moist meadow environment, and the slight increase in sedges in the gridded field samples may reflect the deliberate watering of these agricultural features, resulting in a more favorable environment in which these sedges could grow. Cultigens may have been represented by a single bean-type hooked hair phytolith, and a single small Cucurbitaceae sample.

A comparison with the six bedrock mortar samples from site LA 121668 reveals difference between the phytolith assemblages, likely to be a result of variations in local flora. Arboreal phytolith types were better represented at LA 121668, where juniper-type phytoliths were present in five of the six samples, suggesting juniper trees were more commonly used in the area and may have been locally common. Hackberry phytoliths were also noted in five of the six samples from LA 121668, indicating that these plants were utilized for food, and may also have been more abundant on the local landscape. The absence of palm phytoliths might suggest a geological difference between the sites, while the lack of mesquite-type phytoliths at LA 121668 may be a function of calcium oxalate preservation or the absence of this species. Grasses were represented by a low occurrence of Festucoid forms at 4.5 percent average (compared to 10.6 percent at the Merchant site), though Festucoid (3.75 percent) and Chloridoid (40.9 percent) averages were comparable to Merchant site percentage averages. Sedges were represented by a single phytolith identifiable only to the family level, and a single flatsedge type. Cultigens were wholly lacking in the LA 121668 bedrock mortar samples.

Comparison of Bedrock Mortars from LA 43414 and LA 121668

A comparison of the bedrock mortars from the Merchant site with those from site LA121668 reveals a number of significant differences. The mortars from the Merchant site are not particularly informative, containing phytoliths largely present in background type frequencies. Silicified tracheids, a generally rare phytolith type that are present in some woods and twigs, were noted in three of the mortar samples from LA 43414. While not necessarily suggesting that wood was macerated in these features, these tracheids probably indicate that wood or twigs accumulated in the mortars after their use and decayed in place resulting in the liberation of these phytoliths. In two of the mortars from this site, there was a slightly elevated number of Festucoid grass phytolith types, possibly reflecting the preparation of Festucoid grasses in these features. *Hordeum*, or possibly other grass genera in this subfamily, may have been cultivated or collected in the area as food for local populations, though the phytolith percentages from these features do not indicate these plants were of major importance. Chloridoid grasses were also somewhat elevated in the Merchant site samples. *Sporobolus* (dropseed), a plant that was widely utilized in its natural range as a food (Moerman 1998; Yanofsky 1936), was identified in the assemblage as a common grass type and may have been an important plant resource to the site's occupants, though this plant also represents a dominant genus in the site area.

An examination of the six bedrock mortar samples from LA 121668 showed a different suite of phytoliths in the samples. Five of the samples contained juniper-type phytoliths, in frequencies as high as 5 percent in two samples. Juniper phytoliths were less common in the Merchant site samples, and when present were represented by low percentage occurrences. These differences may be due to the presence of juniper trees in the environment of LA 121668, or an increased use of juniper wood as fuel or for construction at this site. Juniper seeds have been a significant food resource in the southwest and may also have been exploited at the Merchant site, though it is not known if these seeds produce phytoliths. Of significance is the presence of hackberry phytoliths in five of the six mortar samples from LA 121668, often in relatively high percentages. These phytoliths almost certainly represent the processing of hackberry seeds for food at LA 121668, a resource that was not identified in deposits at the Merchant site. While this resource was certainly used at LA 121668, its absence from the Merchant site may be due to differences in local vegetation, as hackberry was not identified in that area in a botanical survey, but it may have been a common local tree at LA 121668. Festucoid and Chloridoid grasses, in comparison with non-mortar samples from the Merchant site, are present in normal quantities; however, there is a slightly elevated number of Panicoid grass phytoliths in the LA 121668 mortar samples (3.75 percent), possibly suggesting that Panicoid grasses were prepared in the mortars.

Comparison of Gridded Field and other Merchant Site Phytolith Samples

Ten phytolith samples were examined from different locations within Levels 2 and 3 from Feature 82 at LA 43414. This gridded field feature was located north of the site and was thought to represent an organized semi-permanent agricultural feature. Phytolith preservation in this feature was generally good, consistent with phytolith preservation elsewhere at this site. An examination of grass phytoliths collectively found within the Feature 82 samples revealed that Festucoid and Chloridoid types were present in percentages very similar to those found in other samples from the site. Panicoid grasses in Feature 82 were present at an average of 2.35 percent, while Panicoid types elsewhere at the site were present at 3.1 percent. This lower percentage occurrence indicates that Panicoid grasses were likely not cultivated within this feature. Maize, a Panicoid grass, contains diagnostic phytoliths represented by both sinuous topped rondels and enlarged cross forms, neither of which were identified in any samples from the Merchant site. Most maize phytoliths produced by the plant are general non-diagnostic Panicoid forms; thus, if maize had been cultivated in or near the gridded field feature, an elevated number of these phytoliths would be expected. However, the number of Panicoid grass phytoliths is low in this feature, arguing that maize was not cultivated widely within this feature.

Diatoms were not analyzed for this study, though their occurrences were noted in the samples when encountered during phytolith counting. An examination of diatoms in the samples reveals that both *Nitzschia* and unidentified forms were more common in the Feature 82 samples. These increases are likely due to introducing water into the feature to irrigate whatever crops were being cultivated in this feature; many diatoms thrive in moist soils and do not require open water to live; thus, the presence of increased diatom numbers in a general sense suggests this feature represents an area where an increased amount of water was present. *Cyperus* (flatsedge) phytoliths were also present in slightly elevated percentages in the gridded field feature samples. As this genus favors moist soils, these phytoliths also suggest the feature received more water than elsewhere at the site.

While phytoliths representing cultigens or economically significant plants were absent from this site, a single bean-type hooked hair cell and a small squash pericarp cell were noted in the gridded field samples. These phytolith types were unrecorded elsewhere at the site, and though they probably represent wild plants, may be reflective of the deliberate cultivation of local plants within the feature. It is not known what plant may be represented by the Fabaceae hooked hair, but the squash pericarp phytolith may represent *Cucurbita foetidissima* (buffalo gourd). Buffalo gourd produces edible fruit that can also serve as useful containers. Phytolith type Unknown S likely represents *Commelina* (dayflower), a locally common weed that also would thrive in an area containing elevated amounts of water.

Summary

An examination of phytoliths from LA 43414/the Merchant site, and nearby LA 121668 revealed insights into past environmental conditions and feature use at these sites. Samples were collected from a variety of features, including ground stone artifacts, a gridded field system, check dam features identified in backhoe trenches, and bedrock mortar features from both sites. A total of 25 samples from LA 43414 were examined, along with an additional six samples from LA 121668. Phytolith preservation was generally good, and full counts were achieved for all samples.

Most samples from the sites contained the same general pattern of phytoliths, likely representing background phytolith types. A detailed examination of general phytolith types reveals patterns of significance. Cultigen phytoliths were absent from all of the samples, indicating that areas sampled were unlikely to have been associated with large-scale agriculture. All samples were dominated by Chloridoid grasses, the dominant grass type in the region. Lesser numbers of Festucoid and Panicoid grasses were also noted in the samples, while bark or wood types, including sub-spherical, blocky type, and juniper-type forms probably represent local vegetation and fuel-type resources.

An examination of the phytoliths recovered from seven ground stone artifacts and bedrock mortar features revealed an increase in both Festucoid and Panicoid grass forms, representing the processing of food plants. Echinate rods, an otherwise rare and unknown phytolith type, was common on the ground stone samples, occurring in five of the seven samples. This type was absent from all but one of the other samples examined from this study.

Three samples were examined from sediments associated with check dam features. Here, rare phytoliths labelled Unknown M were present in all of the samples, and blocky type bark or wood forms were elevated in all of the check dam samples. Diatom frequencies were also high, probably associated with increased moisture in the sediments associated with water retention.

The 10 samples from gridded field Feature 82 revealed possible cultigens, including a single hooked hair from the Fabaceae family, and a small squash form. Panicoid grass phytoliths, however, were present in low quantities, indicating that maize was unlikely to have been cultivated in these features. The presence of elevated numbers of diatoms, along with Unknown S phytoliths probably representing dayflower, indicated that this feature received more water than elsewhere at the site, probably representing irrigation of the crop feature.

Bedrock mortars from LA 43414 were largely uninformative, suggesting that whatever was ground in these features was not a phytolith producer. Two of the mortar samples did show elevated percentages of Festucoid grass-type phytoliths, hinting that a member of this sub-family had been processed in these features. The bedrock mortars from LA 121668 were more informative. Five of the six samples showed juniper-type phytoliths, while five samples also contained hackberry phytoliths. The presence of these phytoliths might hint at a different environment at this site; though juniper berries have been consumed throughout the southwestern region, it is not known if they produce phytoliths. Hackberry phytoliths are generally rare in sediment samples, and the occurrence of this type, produced in the fruit/seed, indicates that this food was processed in the bedrock mortars at LA 121668.

Chapter 15

Faunal Analysis

Jeremy Loven

Data recovery excavations conducted by Versar in 2019 at the Merchant site resulted in the recovery of 3,532 faunal specimens. The faunal assemblage was comprised predominantly of mammals, although a small quantity of reptile remains also were identified. The animal remains collected during the current investigation appear to be predominantly related to subsistence and domestic activities. All faunal specimens collected from Merchant during the current investigation were analyzed and are discussed in detail in this chapter.

Analytical Methods and Assemblage Characteristics

Identification

Identifications of the 3,532 faunal specimens collected during Versar's investigations at Merchant were made using the analyst's (Jeremy Loven) personal comparative collection. Prior to analysis, all bone items were carefully cleaned with a dry, soft brush to remove any attached sediment or organic debris.

The initial step in the analysis of the faunal specimens involved identifying the original specimen of each skeletal element. Specimens (complete bones or bone fragments, or complete teeth or tooth fragments) where the element could be identified were subsequently assigned to a particular taxonomic group. These groupings include the animal's order, genus, or species. When the element of a specimen could not be identified, an attempt was made to identify the taxonomic class and size of animal that the specimen originated from, such as large mammal or small mammal. For each identifiable specimen an attempt was made to classify it to the lowest taxonomic level possible.

General taxonomic class and size categories for unidentifiable specimens are as follows:

- Small mammal: jackrabbit or smaller
- Small to medium mammal: smaller than sheep
- Medium mammal: larger than jackrabbit, smaller than sheep
- Medium to large mammal: larger than sheep
- Large mammal: sheep to deer size
- Very large mammal: larger than deer
- Unidentified mammal: mammal bone from an uncertain size class

In addition to identifying the element and taxon, or the size and class, of each identifiable specimen, numerous other attributes and modifications were recorded when possible. These attributes included: provenience, condition, portion, side, fusion, burning, artifact type, animal alteration (gnawing), natural modification, butchering marks, and total specimen counts. For the purpose of identifying more discreet traits potentially present on the bones, such as gnaw marks and cut marks, a hand lens and/or magnifying lamp were used when necessary.

Quantification

For this faunal analysis, the primary method of calculation is the number of identified specimens (NISP). The NISP consists of total bone counts and is used to quantify the frequency of a particular taxa, or taxonomic category, contained within a faunal assemblage. Despite some flaws and problems with the NISP, it is the most widely used quantification method for calculating taxonomic abundance in current faunal analyses. Grayson (1984) clearly outlined the problems with the NISP, but the most significant issues with this method concern bone fragmentation. Excessive bone fragmentation can potentially inflate NISP values, sometimes greatly. This can particularly impact large mammal specimens, whose "bones tend to be broken into more pieces than those of smaller mammals, and thus over-exaggerate the importance of larger mammals" (Driver 1985:11). To partially alleviate the problem of bone fragmentation on NISP values, bone fragments were refit when possible.

In addition to the total bone counts, the NISP was used to calculate the Artiodactyl Index and Lagomorph Index for site faunal assemblage. These two indices are commonly used to compare the relative abundance of small and large-bodied mammals identified within faunal assemblages collected from archaeological sites in the American Southwest.

The Artiodactyl Index (AI), as developed by Bayham (1982), compares the relative abundance of artiodactyls and lagomorphs (Szuter and Bayham 1989:83); it is essentially an index used to determine the ratio of large mammals (usually antelope and deer, or other artiodactyls) to the two most abundant small mammals (cottontails and jackrabbits) most often collected from archaeological sites throughout the Southwest.

For the purposes of this study, the Artiodactyl Index has been modified to incorporate animals categorized as "large mammal" and "very large mammal" into the artiodactyl category. During the late Prehistoric period in this region of the Southwest, it is extremely unlikely that any animals identified as "large mammal" or "very large mammal" would belong to any order of animals other than Artiodactyla. Thus, the modification of the original AI formula in this instance is appropriate. The AI ranges from 0 (all lagomorphs, no artiodactyls) to 1 (all artiodactyls, no lagomorphs). The AI ranges from 0 (all lagomorphs, no artiodactyls) to 1 (all artiodactyls, no lagomorphs). The following formula is used to calculate the AI:

$$Artiodactyl\ Index\ (AI) = \frac{Artiodactyls + large\ mammals}{(Artiodactyls + large\ mammals) + \ Lagomorphs}$$

The Lagomorph Index (LI) is used to calculate the ratio of cottontails to total leporids (cottontails plus jackrabbits) within a sample and is useful for illustrating the relative abundance of cottontails and jackrabbits within a faunal assemblage (Driver and Woiderski 2007:7). It is scored on a scale of 0 to 1. A score of 1 is indicative of all cottontails, and a score of 0 is representative of all jackrabbits. The formula used for calculating the LI is:

$$Lagomorph\ Index\ (LI) = \frac{Cottontails}{(Cottontails + Jackrabbits)}$$

The LI can provide insight not only into the subsistence patterns of a local population with regard to the consumption of the two rabbit types, but it can also be used to illustrate certain ecological realities within a particular location. Cottontails and jackrabbits thrive in different ecological conditions. Cottontails avoid predation by hiding or occupying burrows (Bailey 1931:54, 55) and prefer habitats thick with brush and grasses; jackrabbits typically avoid predation by outrunning their predators (Driver and Woiderski 2007:5) and survive and reproduce most successfully on more open landscapes. Generally, cottontails are more successful than jackrabbits in lusher environments, such as riverine/floodplain environments (Dean 2007:15).

The LI can potentially help to provide a better understanding of the local paleoenvironment that surrounded an archaeological site during its occupation; additionally, the LI can provided insights into the relative abundance of cottontails and jackrabbits within that environment. Although important, factors other than local ecology must also be considered when interpreting the results. Lagomorph Index values can represent a direct correlation between lagomorph abundance and the natural environment, but the values are often influenced by cultural factors as well. Human behaviors and actions, such as communal hunting, alteration of the natural environment and vegetation through agriculture and irrigation, increases in human population density and long-term habitations, and prey choice, can all potentially affect LI values (Dean 2007; Driver and Woiderski 2007). Thus, when interpreting the results of the Lagomorph Index, all potential influencing factors must be considered.

Sampling and Sample Bias

Faunal specimens collected during the 2019 excavations were collected directly while excavating or through screening excavated sediment fill through wire mesh. Screened fill was passed through 1/4-inch mesh or 1/8-inch mesh.

Excavated fill from archaeological sites in the American Southwest is most commonly screened through 1/4-inch mesh. This method is significantly more efficient than screening though smaller mesh sizes and is completely satisfactory for recovering faunal specimens originating from larger animals, but it can produce a bias in faunal assemblages against small animal remains. Specimens from smaller animals, particularly those weighing less than 340 grams, or smaller than the size of a gray squirrel, will almost certainly be underrepresented (Shaffer 1992:131). This is primarily due to the small size of small animal bones that causes some bones and bone fragments from these animals to fall through the screen unnoticed. Controlled experiments by Shaffer and Sanchez (1994) produced results indicating that only "taxa larger than 4,500 grams (fox-size) will have the potential for nearly total recovery" (Shaffer and Sanchez 1994:525). Shaffer and Sanchez (1994) experiments were performed using complete bones predominantly from adult specimens. The collection of bones from small animals becomes even more problematic and limited as bone fragmentation increases.

Another form of sample bias is differential bone preservation. The bones from small mammals, such as rabbits and hares, were—particularly in times of food stress—occasionally ground into a bone paste or pounded into small pieces with meat still attached and consumed (Rea 1998:90; Tyler 1975:133). Carnivore activity can also differentially affect bone preservation. Dogs are known to completely consume the bones of small mammals, small birds, and fish and significantly alter or obliterate identifiable portions of medium-sized animals (Lyon 1970:214). In addition to dogs, other carnivores such as coyotes, bobcats, and skunks could have accessed fresh bones. Consequently, bone preservation at archaeological sites can be biased, and small mammal remains can be underrepresented relative to the initial deposited values.

Fragmentation

The animal remains collected from rooms and midden deposits generally exhibited a moderate degree of fragmentation caused primarily by post-depositional processes. Post-depositional processes that affected bone preservation included natural taphonomic processes such as weathering, erosion, and root etching; additional fragmentation also occurred during excavation. Despite the fragmentation, the skeletal elements of most of the bone fragments could be determined.

The animal remains collected from Merchant exhibit a high degree of fragmentation caused by both pre-depositional and post-depositional processes. The substantial fragmentation of bone and teeth made identification of the skeletal elements difficult, and in many instances impossible. Much of the pre-depositional fragmentation of large mammal bone was probably the result of marrow and grease extraction activities, but confirmation of this would require additional analyses of fragment sizes, fracturing types and patterns, and other assemblage attributes. Prehistorically, bones from large mammals were commonly fractured using various methods to obtain marrow (Binford 1981:148–162) or for grease extraction (Church and Lyman 2003:1083). Post-depositional processes that affect bone fragmentation include natural taphonomic processes, such as weathering and erosion, and trampling and recovery damage caused during excavation and looting activities that have occurred at the Merchant site.

Taxonomic Composition

Mammals and reptiles were the only taxonomic class of animals represented within the 2019 Merchant faunal assemblage (Table 15.1); no birds, amphibians, or fish were identified. Mammal remains dominated the assemblage, comprising approximately 99.8 percent (n=3,526) of all animal specimens; the remaining specimens were identified as reptile (n=3) or unidentified vertebrate (n=3). Animals from five separate genera were identified within the assemblage: Lepus sp. (jackrabbit), *Sylvilagus* sp. (cottontail), *Canis* sp. (dog/coyote/wolf), *Odocoileus* sp. (deer), and *Bison bison* (bison). The remaining faunal specimens could only be identified to the level of order (Artiodactyla, Rodentia) or to various class and size categories.

Similar taxa and frequencies of taxa were observed in the faunal assemblage recovered during the 2015 excavations (Loven and Speth 2016), although birds were present in the 2015 assemblage. Excavations conducted by LCAS during the 1950s and 1960s were documented by Leslie to have uncovered a substantial quantity of large ungulate remains, with many identified in the bone layer of Zone E of Pit Structure 1.

The faunal remains collected during the 2019 excavation were recovered from a variety of contexts, including pueblo rooms, intramural pueblo room features (hearths, pits, postholes), extramural pits, activity areas, and refuse areas. Skeletal element frequencies by provenience are summarized below in Table 15.2.

Mammals

Artiodactyls are the most ubiquitous and abundant of all taxa identified in the 2019 faunal assemblage. Noted among the artiodactyl remains were specimens originating from deer and bison; numerous additional artiodactyl bones and teeth were classified as medium to large artiodactyl, and likely include the remains of deer, pronghorn, and bison. The large and very large mammal remains also are probably composed—predominantly or entirely—of deer, pronghorn, or bison. Other large-bodied mammals that inhabit the greater region were elk (*Cervus canadensis*) black bears (*Ursus americanus*), and mountain lions (*Felis concolor*), which presently inhabit the Guadalupe and Sacramento mountains (Findley et al. 1975:293, 318) and did so prehistorically as well. Together, artiodactyl and large to very large mammal specimens account for 72 percent of remains in the 2019 faunal assemblage.

Table 15.1. Merchant site faunal assemblages

Common Name	Taxon / Class	2019	2015
Unidentified vertebrate	Unidentified vertebrate	3	1,917
Unidentified mammal	Unidentified mammal	173	—
Very small mammal	Very small mammal	—	3
Small mammal	Small mammal	113	116
Small to medium mammal	Small to medium mammal	4	—
Medium mammal	Medium mammal	1	335
Medium to large mammal	Medium to large mammal	412	—
Large mammal	Large mammal	2,219	2,084
Large to very large mammal	Large to very large mammal	197	—
Very large mammal	Very large mammal	139	796
Small rodent	Small rodent	1	—
Dipodomys sp.	Kangaroo rat	—	1
Geomys sp.	Pocket Gopher	—	1
Neotoma sp.	Woodrat	—	1
Neotoma albigula	White-throated Woodrat	—	3
Cottontail	*Sylvilagus* sp.	11	16
Jackrabbit	*Lepus* sp.	65	153
Lagomorph (indeterminate)	*Cottontail/jackrabbit*	—	1
Dog/Coyote/Wolf	*Canis* sp.	6	13
Red Fox	*Vulpes Vulpes*	—	1
Medium carnivore	Medium carnivore	—	6
Deer	Odocoileus sp.	19	31
Mule Deer	Odocoileus hemionus	—	1
Pronghorn	*Antilocapra americana*	—	48
Deer/Pronghorn	*Odocoileus* sp. / *Antilocapra americana*	—	179
Bison	*Bison bison*	43	59
Medium artiodactyl	Medium artiodactyl	83	32
Medium to large artiodactyl	Medium to large artiodactyl	12	—
Large artiodactyl	Large artiodactyl	28	192
Snake	Unidentified snake	1	—
Turtle/tortoise	*Testudinata* sp.	2	5
Western Box Turtle	*Terrapene ornata*	—	7
Turkey	*Meleagris gallopavo*	—	3
Small bird	Quail size	—	1
Total		**3,532**	**6,005**

Table 15.2. Skeletal element frequencies by provenience

Taxon / Class	Element	Age	Provenience	Count
Jackrabbit	Tibia	Mature	Feature 6 (Pueblo Room)	332
Deer	Phalanx (third)	Mature	Feature 6 (Pueblo Room)	1
Medium artiodactyl	Tooth fragment	Mature	Feature 6 (Pueblo Room)	10
Medium artiodactyl	Femur	Mature	Feature 6 (Pueblo Room)	1
Medium to large	Tooth fragment	Mature	Feature 6 (Pueblo Room)	2
Large artiodactyl	Tooth fragment	Mature	Feature 6 (Pueblo Room)	2
Medium to large	Bone fragment	Mature	Feature 6 (Pueblo Room)	25
Medium to large	Long bone fragment	Mature	Feature 6 (Pueblo Room)	1
Medium to large	Tooth fragment	Mature	Feature 6 (Pueblo Room)	2
Large mammal	Bone fragment	Mature	Feature 6 (Pueblo Room)	21
Large mammal	Long bone fragment	Mature	Feature 6 (Pueblo Room)	55
Large mammal	Cancellous fragment	Mature	Feature 6 (Pueblo Room)	2
Large mammal	Tooth fragment	Mature	Feature 6 (Pueblo Room)	3
Very large mammal	Tooth fragment	Mature	Feature 6 (Pueblo Room)	1
Turtle/tortoise	Carapace fragment	Mature	Feature 6 (Pueblo Room)	1
Large mammal	Tooth fragment	Mature	Feature 6.1 (Pueblo Room	1
Jackrabbit	Tibia	Mature	Feature 13 (Pueblo Room)	1
Medium artiodactyl	Tooth fragment	Mature	Feature 13 (Pueblo Room)	2
Medium artiodactyl	Femur	Mature	Feature 13 (Pueblo Room)	1
Medium artiodactyl	Tibia	Mature	Feature 13 (Pueblo Room)	1
Small mammal	Bone fragment	Mature	Feature 13 (Pueblo Room)	2
Small mammal	Long bone fragment	Mature	Feature 13 (Pueblo Room)	6
Medium to large	Bone fragment	Mature	Feature 13 (Pueblo Room)	24
Medium to large	Long bone fragment	Mature	Feature 13 (Pueblo Room)	11
Medium to large	Tooth fragment	Mature	Feature 13 (Pueblo Room)	2
Large mammal	Bone fragment	Mature	Feature 13 (Pueblo Room)	1
Large mammal	Long bone fragment	Mature	Feature 13 (Pueblo Room)	149
Large mammal	Cancellous fragment	Mature	Feature 13 (Pueblo Room)	1
Large mammal	Tooth fragment	Mature	Feature 13 (Pueblo Room)	2
Large mammal	Femur	Mature	Feature 13 (Pueblo Room)	1
Large to very large	Bone fragment	Mature	Feature 13 (Pueblo Room)	6
Large to very large	Long bone fragment	Mature	Feature 13 (Pueblo Room)	2
Unidentified mammal	Long bone fragment	Mature	Feature 13 (Pueblo Room)	1
Small mammal	Long bone fragment	Mature	Feature 13.3 (Pueblo Room	40
Medium to large	Long bone fragment	Mature	Feature 13.3 (Pueblo Room	2
Unidentified mammal	Long bone fragment	Mature	Feature 13.3 (Pueblo Room	6
Small rodent	Mandible	Mature	Feature 110 (Refuse Area B)	1
Cottontail	Mandible	Mature	Feature 110 (Refuse Area B)	1
Cottontail	Scapula	Mature	Feature 110 (Refuse Area B)	1
Cottontail	Femur	Mature	Feature 110 (Refuse Area B)	3
Jackrabbit	Cranial fragment	Mature	Feature 110 (Refuse Area B)	1
Jackrabbit	Mandible	Mature	Feature 110 (Refuse Area B)	4
Jackrabbit	Scapula	Mature	Feature 110 (Refuse Area B)	3
Jackrabbit	Innominate	Mature	Feature 110 (Refuse Area B)	2
Jackrabbit	Femur	Juvenile	Feature 110 (Refuse Area B)	2
Jackrabbit	Humerus	Mature	Feature 110 (Refuse Area B)	2
Jackrabbit	Tibia	Mature	Feature 110 (Refuse Area B)	3
Jackrabbit	Tibia	Juvenile	Feature 110 (Refuse Area B)	2
Jackrabbit	Calcaneum	Mature	Feature 110 (Refuse Area B)	2
Jackrabbit	Metatarsal III	Mature	Feature 110 (Refuse Area B)	1

Taxon / Class	Element	Age	Provenience	Count
Jackrabbit	Scapula	Mature	Feature 110 (Refuse Area B)	1
Jackrabbit	Femur	Mature	Feature 110 (Refuse Area B)	1
Dog/Coyote	Vertebra (cervical)	Mature	Feature 110 (Refuse Area B)	1
Dog/Coyote	Rib	Mature	Feature 110 (Refuse Area B)	1
Deer	Phalanx (second)	Mature	Feature 110 (Refuse Area B)	1
Deer	Astragalus	Mature	Feature 110 (Refuse Area B)	1
Deer	Phalanx (third)	Mature	Feature 110 (Refuse Area B)	1
Bison	Mandible	Mature	Feature 110 (Refuse Area B)	1
Bison	Femur	Mature	Feature 110 (Refuse Area B)	2
Medium artiodactyl	Vertebra (cervical)	Mature	Feature 110 (Refuse Area B)	1
Medium artiodactyl	Scapula	Mature	Feature 110 (Refuse Area B)	1
Medium artiodactyl	Metacarpal	Mature	Feature 110 (Refuse Area B)	2
Medium artiodactyl	Femur	Mature	Feature 110 (Refuse Area B)	2
Medium artiodactyl	Tibia	Mature	Feature 110 (Refuse Area B)	1
Medium artiodactyl	Astragalus	Mature	Feature 110 (Refuse Area B)	1
Medium artiodactyl	Phalanx (first)	Mature	Feature 110 (Refuse Area B)	3
Medium artiodactyl	Phalanx (second)	Mature	Feature 110 (Refuse Area B)	1
Medium artiodactyl	Metatarsal	Mature	Feature 110 (Refuse Area B)	1
Medium artiodactyl	Metapodial	Mature	Feature 110 (Refuse Area B)	1
Large artiodactyl	Tooth fragment	Mature	Feature 110 (Refuse Area B)	10
Small mammal	Long bone fragment	Mature	Feature 110 (Refuse Area B)	21
Small mammal	Cranial fragment	Mature	Feature 110 (Refuse Area B)	1
Small to medium	Rib	Mature	Feature 110 (Refuse Area B)	1
Medium to large	Long bone fragment	Mature	Feature 110 (Refuse Area B)	1
Medium to large	Cancellous tissue	Mature	Feature 110 (Refuse Area B)	1
Large mammal	Long bone fragment	Mature	Feature 110 (Refuse Area B)	255
Large mammal	Bone fragment	Mature	Feature 110 (Refuse Area B)	1
Large mammal	Vertebra fragment	Mature	Feature 110 (Refuse Area B)	1
Large mammal	Rib	Mature	Feature 110 (Refuse Area B)	2
Large mammal	Cancellous tissue	Mature	Feature 4	3
Large to very large	Long bone fragment	Mature	Feature 110 (Refuse Area B)	33
Large to very large	Cancellous tissue	Mature	Feature 110 (Refuse Area B)	40
Large to very large	Vertebra fragment	Mature	Feature 110 (Refuse Area B)	1
Very large mammal	Long bone fragment	Mature	Feature 110 (Refuse Area B)	26
Very large mammal	Vertebra fragment	Mature	Feature 110 (Refuse Area B)	1
Very large mammal	Scapula	Mature	Feature 110 (Refuse Area B)	1
Very large mammal	Innominate	Mature	Feature 110 (Refuse Area B)	1
Very large mammal	Femur	Mature	Feature 110 (Refuse Area B)	2
Unknown mammal	Long bone fragment	Mature	Feature 110 (Refuse Area B)	4
Jackrabbit	Cranial fragment	Mature	Feature 401 (Pueblo Room)	1
Medium artiodactyl	Tooth fragment	Mature	Feature 401 (Pueblo Room)	1
Medium to large	Tooth fragment	Mature	Feature 401 (Pueblo Room)	3
Medium to large	Long bone fragment	Mature	Feature 401 (Pueblo Room)	1
Large mammal	Long bone fragment	Mature	Feature 401 (Pueblo Room)	16
Large mammal	Tooth fragment	Mature	Feature 401 (Pueblo Room)	2
Large to very large	Long bone fragment	Mature	Feature 401 (Pueblo Room)	3
Medium artiodactyl	Tooth fragment	Mature	Feature 402 (Pueblo Room)	4
Medium artiodactyl	Metapodial	Mature	Feature 402 (Pueblo Room)	1
Small mammal	Long bone fragment	Mature	Feature 402 (Pueblo Room)	3
Medium to large	Long bone fragment	Mature	Feature 402 (Pueblo Room)	36
Medium to large	Tooth fragment	Mature	Feature 402 (Pueblo Room)	3

Taxon / Class	Element	Age	Provenience	Count
Large mammal	Bone fragment	Mature	Feature 402 (Pueblo Room)	13
Large mammal	Long bone fragment	Mature	Feature 402 (Pueblo Room)	35
Large mammal	Tooth fragment	Mature	Feature 402 (Pueblo Room)	2
Large to very large	Long bone fragment	Mature	Feature 402 (Pueblo Room)	14
Unknown mammal	Long bone fragment	Mature	Feature 402 (Pueblo Room)	21
Large mammal	Long bone fragment	Mature	Feature 402.4	3
Medium artiodactyl	Metatarsal	Juvenile	Feature 403 (Pueblo Room)	1
Medium to large	Tooth fragment	Mature	Feature 403 (Pueblo Room)	6
Small mammal	Long bone fragment	Mature	Feature 403 (Pueblo Room)	8
Medium to large	Bone fragment	Mature	Feature 403 (Pueblo Room)	2
Medium to large	Long bone fragment	Mature	Feature 403 (Pueblo Room)	4
Medium to large	Tooth fragment	Mature	Feature 403 (Pueblo Room)	1
Large mammal	Bone fragment	Mature	Feature 403 (Pueblo Room)	12
Large mammal	Long bone fragment	Mature	Feature 403 (Pueblo Room)	95
Large mammal	Cancellous tissue	Mature	Feature 403 (Pueblo Room)	4
Unknown mammal	Bone fragment	Mature	Feature 403 (Pueblo Room)	1
Medium to large	Tooth fragment	Mature	Feature 403.1 (Pueblo Room	1
Large mammal	Bone fragment	Mature	Feature 403.1 (Pueblo Room	2
Unknown mammal	Bone fragment	Mature	Feature 403.1 (Pueblo Room	7
Medium artiodactyl	Tooth fragment	Mature	Feature 404 (Pueblo Room)	5
Medium to large	Long bone fragment	Mature	Feature 404 (Pueblo Room)	14
Medium to large	Tooth fragment	Mature	Feature 404 (Pueblo Room)	2
Large mammal	Long bone fragment	Mature	Feature 404 (Pueblo Room)	19
Large mammal	Cancellous tissue	Mature	Feature 404 (Pueblo Room)	1
Large mammal	Tooth fragment	Mature	Feature 404 (Pueblo Room)	5
Large to very large	Long bone fragment	Mature	Feature 404 (Pueblo Room)	1
Unknown mammal	Bone fragment	Mature	Feature 404 (Pueblo Room)	9
Unknown mammal	Long bone fragment	Mature	Feature 404 (Pueblo Room)	14
Large mammal	Long bone fragment	Mature	Feature 404.1 (Pueblo Room	4
Large mammal	Long bone fragment	Mature	Feature 404.6 (Pueblo Room	1
Unknown mammal	Bone fragment	Mature	Feature 404.7 (Pueblo Room	1
Large mammal	Long bone fragment	Mature	Feature 404.8 (Pueblo Room	1
Large mammal	Long bone fragment	Mature	Feature 404.8 (Pueblo Room	1
Medium to large	Long bone fragment	Mature	Feature 405 (Activity Area)	1
Large mammal	Long bone fragment	Mature	Feature 405 (Activity Area)	5
Deer	Mandible	Mature	Feature 406 (Pueblo Room)	1
Deer	Scapula	Mature	Feature 406 (Pueblo Room)	1
Deer	Femur	Mature	Feature 406 (Pueblo Room)	1
Medium artiodactyl	Tooth fragment	Mature	Feature 406 (Pueblo Room)	14
Medium artiodactyl	Phalanx (third)	Mature	Feature 406 (Pueblo Room)	1
Small mammal	Bone fragment	Mature	Feature 406 (Pueblo Room)	1
Medium to large	Long bone fragment	Mature	Feature 406 (Pueblo Room)	27
Medium to large	Cancellous tissue	Mature	Feature 406 (Pueblo Room)	4
Medium to large	Tooth fragment	Mature	Feature 406 (Pueblo Room)	3
Large mammal	Bone fragment	Mature	Feature 406 (Pueblo Room)	8
Large mammal	Long bone fragment	Mature	Feature 406 (Pueblo Room)	276
Large mammal	Tooth fragment	Mature	Feature 406 (Pueblo Room)	7
Large mammal	Scapula	Mature	Feature 406 (Pueblo Room)	1
Large mammal	Innominate	Mature	Feature 406 (Pueblo Room)	1
Unknown mammal	Bone fragment	Mature	Feature 406 (Pueblo Room)	5
Unknown mammal	Long bone fragment	Mature	Feature 406 (Pueblo Room)	5

Taxon / Class	Element	Age	Provenience	Count
Large mammal	Bone fragment	Mature	Feature 406.5 (Pueblo Room	1
Large mammal	Long bone fragment	Mature	Feature 406.6 (Pueblo Room	1
Small mammal	Long bone fragment	Mature	Feature 406.6 (Pueblo Room	1
Small mammal	Rib	Mature	Feature 406.6 (Pueblo Room	1
Medium to large	Bone fragment	Mature	Feature 406.6 (Pueblo Room	26
Large mammal	Long bone fragment	Mature	Feature 406.6 (Pueblo Room	7
Large mammal	Bone fragment	Mature	Feature 406.7 (Pueblo Room	2
Jackrabbit	Metatarsal	Mature	Feature 407 (Pueblo Room)	1
Deer	Phalanx (third)	Mature	Feature 407 (Pueblo Room)	1
Medium artiodactyl	Tooth fragment	Mature	Feature 407 (Pueblo Room)	1
Medium artiodactyl	Humerus	Mature	Feature 407 (Pueblo Room)	1
Small mammal	Bone fragment	Mature	Feature 407 (Pueblo Room)	1
Medium to large	Bone fragment	Mature	Feature 407 (Pueblo Room)	2
Medium to large	Bone fragment	Mature	Feature 407 (Pueblo Room)	55
Medium to large	Long bone fragment	Mature	Feature 407 (Pueblo Room)	7
Medium to large	Cancellous fragment	Mature	Feature 407 (Pueblo Room)	2
Medium to large	Tooth fragment	Mature	Feature 407 (Pueblo Room)	1
Large mammal	Bone fragment	Mature	Feature 407 (Pueblo Room)	48
Large mammal	Long bone fragment	Mature	Feature 407 (Pueblo Room)	143
Large mammal	Cancellous tissue	Mature	Feature 407 (Pueblo Room)	6
Large mammal	Tooth fragment	Mature	Feature 407 (Pueblo Room)	1
Large to very large	Bone fragment	Mature	Feature 407 (Pueblo Room)	1
Unknown mammal	Bone fragment	Mature	Feature 407 (Pueblo Room)	55
Turtle/tortoise	Carapace fragment	Mature	Feature 407 (Pueblo Room)	1
Medium bird	Long bone fragment	Mature	Feature 407 (Pueblo Room)	1
Medium bird	Long bone fragment	Mature	Feature 407 (Pueblo Room)	1
Medium bird	Long bone fragment	Mature	Feature 407 (Pueblo Room)	1
Medium bird	Long bone fragment	Mature	Feature 407 (Pueblo Room)	1
Medium bird	Long bone fragment	Mature	Feature 407 (Pueblo Room)	1
Medium bird	Long bone fragment	Mature	Feature 407 (Pueblo Room)	1
Medium bird	Long bone fragment	Mature	Feature 407 (Pueblo Room)	1
Medium bird	Long bone fragment	Mature	Feature 407 (Pueblo Room)	1
Medium bird	Long bone fragment	Mature	Feature 407 (Pueblo Room)	1
Medium bird	Long bone fragment	Mature	Feature 407 (Pueblo Room)	1
Medium artiodactyl	Tooth fragment	Mature	Feature 408 (Activity Area)	1
Medium artiodactyl	Metapodial	Mature	Feature 408 (Activity Area)	1
Medium to large	Tooth fragment	Mature	Feature 408 (Activity Area)	1
Small mammal	Long bone fragment	Mature	Feature 408 (Activity Area)	2
Medium to large	Bone fragment	Mature	Feature 408 (Activity Area)	1
Medium to large	Long bone fragment	Mature	Feature 408 (Activity Area)	16
Large mammal	Bone fragment	Mature	Feature 408 (Activity Area)	4
Large mammal	Long bone fragment	Mature	Feature 408 (Activity Area)	56
Large mammal	Cancellous tissue	Mature	Feature 408 (Activity Area)	1
Large mammal	Tooth fragment	Mature	Feature 408 (Activity Area)	4
Large to very large	Long bone fragment	Mature	Feature 408 (Activity Area)	9
Large to very large	Cancellous tissue	Mature	Feature 408 (Activity Area)	2
Unidentified mammal	Bone fragment	Mature	Feature 408 (Activity Area)	4
Unidentified mammal	Long bone fragment	Mature	Feature 408 (Activity Area)	2
Unidentified vertebrate	Long bone fragment	Mature	Feature 408 (Activity Area)	1
Unidentified vertebrate	Long bone fragment	Mature	Feature 408 (Activity Area)	1
Unidentified vertebrate	Long bone fragment	Mature	Feature 408 (Activity Area)	1

Taxon / Class	Element	Age	Provenience	Count
Unidentified vertebrate	Long bone fragment	Mature	Feature 408 (Activity Area)	1
Unidentified vertebrate	Long bone fragment	Mature	Feature 408 (Activity Area)	1
Unidentified vertebrate	Long bone fragment	Mature	Feature 408 (Activity Area)	1
Unidentified vertebrate	Long bone fragment	Mature	Feature 408 (Activity Area)	1
Unidentified vertebrate	Long bone fragment	Mature	Feature 408 (Activity Area)	1
Unidentified vertebrate	Long bone fragment	Mature	Feature 408 (Activity Area)	1
Unidentified vertebrate	Long bone fragment	Mature	Feature 408 (Activity Area)	1
Unidentified vertebrate	Long bone fragment	Mature	Feature 408 (Activity Area)	1
Unidentified vertebrate	Long bone fragment	Mature	Feature 408 (Activity Area)	1
Unidentified vertebrate	Long bone fragment	Mature	Feature 408 (Activity Area)	1
Unidentified vertebrate	Long bone fragment	Mature	Feature 408 (Activity Area)	1
Unidentified vertebrate	Long bone fragment	Mature	Feature 408 (Activity Area)	1
Unidentified vertebrate	Long bone fragment	Mature	Feature 408 (Activity Area)	1
Jackrabbit	Femur	Mature	Feature 409 (Pit)	1
Medium artiodactyl	Tooth fragment	Mature	Feature 409 (Pit)	1
Medium to large	Tibia	Mature	Feature 409 (Pit)	1
Medium to large	Long bone fragment	Mature	Feature 409 (Pit)	5
Medium to large	Bone fragment	Mature	Feature 409 (Pit)	5
Large mammal	Long bone fragment	Mature	Feature 409 (Pit)	17
Large mammal	Bone fragment	Mature	Feature 409 (Pit)	8
Large to very large	Bone fragment	Mature	Feature 409 (Pit)	1
Unidentified mammal	Bone fragment	Mature	Feature 409 (Pit)	3
Unidentified vertebrate	Bone fragment	Mature	Feature 409 (Pit)	3
Cottontail	Innominate	Juvenile	Feature 410 (Pueblo Room)	1
Jackrabbit	Scapula	Mature	Feature 410 (Pueblo Room)	2
Jackrabbit	Tibia	Mature	Feature 410 (Pueblo Room)	1
Deer	Phalanx (first)	Mature	Feature 410 (Pueblo Room)	1
Bison	Innominate	Mature	Feature 410 (Pueblo Room)	1
Bison	Femur	Mature	Feature 410 (Pueblo Room)	1
Medium artiodactyl	Tooth fragment	Mature	Feature 410 (Pueblo Room)	1
Medium artiodactyl	Vertebra (lumbar)	Mature	Feature 410 (Pueblo Room)	1
Medium artiodactyl	Metacarpal	Mature	Feature 410 (Pueblo Room)	2
Medium artiodactyl	Metatarsal	Mature	Feature 410 (Pueblo Room)	1
Small mammal	Long bone fragment	Mature	Feature 410 (Pueblo Room)	1
Medium to large	Long bone fragment	Mature	Feature 410 (Pueblo Room)	3
Large mammal	Long bone fragment	Mature	Feature 410 (Pueblo Room)	239
Large mammal	Tooth fragment	Mature	Feature 410 (Pueblo Room)	7
Large mammal	Vertebra fragment	Mature	Feature 410 (Pueblo Room)	1
Large to very large	Bone fragment	Mature	Feature 410 (Pueblo Room)	1
Large to very large	Long bone fragment	Mature	Feature 410 (Pueblo Room)	3
Large to very large	Cancellous tissue	Mature	Feature 410 (Pueblo Room)	16
Large to very large	Rib	Mature	Feature 410 (Pueblo Room)	1
Very large mammal	Bone fragment	Mature	Feature 410 (Pueblo Room)	1
Very large mammal	Long bone fragment	Mature	Feature 410 (Pueblo Room)	24
Very large mammal	Rib	Mature	Feature 410 (Pueblo Room)	1
Medium to large	Bone fragment	Mature	Feature 410.1 (Pueblo Room	1
Large mammal	Bone fragment	Mature	Feature 410.1 (Pueblo Room	30
Unidentified mammal	Bone fragment	Mature	Feature 410.1 (Pueblo Room	2
Medium to large	Bone fragment	Mature	Feature 411 (Pueblo Room)	3
Large mammal	Long bone fragment	Mature	Feature 411 (Pueblo Room)	7
Large mammal	Bone fragment	Mature	Feature 411 (Pueblo Room)	2

Taxon / Class	Element	Age	Provenience	Count
Large mammal	Tooth fragment	Mature	Feature 411 (Pueblo Room)	1
Unidentified mammal	Bone fragment	Mature	Feature 411 (Pueblo Room)	1
Cottontail	Mandible	Mature	Feature 412 (Refuse Area C)	2
Cottontail	Humerus	Mature	Feature 412 (Refuse Area C)	1
Cottontail	Femur	Mature	Feature 412 (Refuse Area C)	1
Jackrabbit	Cranial fragment	Mature	Feature 412 (Refuse Area C)	1
Jackrabbit	Mandible	Mature	Feature 412 (Refuse Area C)	1
Jackrabbit	Scapula	Mature	Feature 412 (Refuse Area C)	2
Jackrabbit	Innominate	Mature	Feature 412 (Refuse Area C)	2
Jackrabbit	Humerus	Juvenile	Feature 412 (Refuse Area C)	1
Jackrabbit	Humerus	Mature	Feature 412 (Refuse Area C)	4
Jackrabbit	Radius	Mature	Feature 412 (Refuse Area C)	2
Jackrabbit	Femur	Juvenile	Feature 412 (Refuse Area C)	2
Jackrabbit	Femur	Mature	Feature 412 (Refuse Area C)	4
Jackrabbit	Tibia	Mature	Feature 412 (Refuse Area C)	1
Jackrabbit	Calcaneum	Mature	Feature 412 (Refuse Area C)	3
Jackrabbit	Metatarsal II	Mature	Feature 412 (Refuse Area C)	1
Jackrabbit	Metatarsal IV	Mature	Feature 412 (Refuse Area C)	1
Dog/coyote/wolf	Vertebra (cervical)	Mature	Feature 412 (Refuse Area C)	1
Dog/coyote/wolf	Vertebra (lumbar)	Mature	Feature 412 (Refuse Area C)	1
Dog/coyote/wolf	Ulna	Mature	Feature 412 (Refuse Area C)	1
Dog/coyote/wolf	Metatarsal III	Mature	Feature 412 (Refuse Area C)	1
Deer	Scapula	Mature	Feature 412 (Refuse Area C)	1
Deer	Innominate	Mature	Feature 412 (Refuse Area C)	1
Deer	Humerus	Mature	Feature 412 (Refuse Area C)	1
Deer	Ulna	Mature	Feature 412 (Refuse Area C)	1
Deer	Tibia	Mature	Feature 412 (Refuse Area C)	2
Deer	Astragalus	Mature	Feature 412 (Refuse Area C)	1
Deer	Phalanx (first)	Mature	Feature 412 (Refuse Area C)	2
Bison	Tooth fragment	Mature	Feature 412 (Refuse Area C)	1
Bison	Femur	Mature	Feature 412 (Refuse Area C)	2
Medium artiodactyl	Scapula	Mature	Feature 412 (Refuse Area C)	1
Medium artiodactyl	Humerus	Mature	Feature 412 (Refuse Area C)	1
Medium artiodactyl	Metacarpal	Mature	Feature 412 (Refuse Area C)	1
Medium artiodactyl	Femur	Mature	Feature 412 (Refuse Area C)	1
Medium artiodactyl	Metatarsal	Mature	Feature 412 (Refuse Area C)	6
Medium artiodactyl	Phalanx (first)	Mature	Feature 412 (Refuse Area C)	1
Small mammal	Long bone fragment	Mature	Feature 412 (Refuse Area C)	10
Medium mammal	Femur	Mature	Feature 412 (Refuse Area C)	1
Medium to large	Long bone fragment	Mature	Feature 412 (Refuse Area C)	1
Large mammal	Long bone fragment	Mature	Feature 412 (Refuse Area C)	280
Large mammal	Cancellous tissue	Mature	Feature 412 (Refuse Area C)	66
Large mammal	Cranial fragment	Mature	Feature 412 (Refuse Area C)	4
Large mammal	Vertebra (thoracic)	Mature	Feature 412 (Refuse Area C)	1
Large mammal	Rib	Mature	Feature 412 (Refuse Area C)	2
Large to very large	Vertebra fragment	Mature	Feature 412 (Refuse Area C)	2
Very large mammal	Long bone fragment	Mature	Feature 412 (Refuse Area C)	67
Very large mammal	Cancellous tissue	Mature	Feature 412 (Refuse Area C)	3
Very large mammal	Femur	Mature	Feature 412 (Refuse Area C)	1
Very large mammal	Tibia	Mature	Feature 412 (Refuse Area C)	2
Unknown mammal	Bone fragment	Mature	Feature 412 (Refuse Area C)	10

Taxon / Class	Element	Age	Provenience	Count
Snake	Vertebra	Mature	Feature 412 (Refuse Area C)	1
Cottontail	Femur	Mature	Feature 413 (Pueblo Room)	1
Jackrabbit	Femur	Mature	Feature 413 (Pueblo Room)	3
Jackrabbit	Tibia	Mature	Feature 413 (Pueblo Room)	1
Jackrabbit	Metatarsal	Mature	Feature 413 (Pueblo Room)	1
Deer	Phalanx (first)	Mature	Feature 413 (Pueblo Room)	1
Medium artiodactyl	Tooth fragment	Mature	Feature 413 (Pueblo Room)	3
Medium artiodactyl	Rib	Mature	Feature 413 (Pueblo Room)	1
Medium artiodactyl	Femur	Mature	Feature 413 (Pueblo Room)	1
Medium to large	Tooth fragment	Mature	Feature 413 (Pueblo Room)	1
Large artiodactyl	Long bone fragment	Mature	Feature 413 (Pueblo Room)	12
Large artiodactyl	Tooth fragment	Mature	Feature 413 (Pueblo Room)	4
Small mammal	Long bone fragment	Mature	Feature 413 (Pueblo Room)	9
Medium to large	Bone fragment	Mature	Feature 413 (Pueblo Room)	2
Large mammal	Bone fragment	Mature	Feature 413 (Pueblo Room)	29
Large mammal	Long bone fragment	Juvenile	Feature 413 (Pueblo Room)	1
Large mammal	Long bone fragment	Mature	Feature 413 (Pueblo Room)	161
Large mammal	Rib	Mature	Feature 413 (Pueblo Room)	1
Large to very large	Long bone fragment	Mature	Feature 413 (Pueblo Room)	43
Very large mammal	Bone fragment	Mature	Feature 413 (Pueblo Room)	5
Unidentified mammal	Long bone fragment	Mature	Feature 414 (Pueblo Room)	1
Large mammal	Long bone fragment	Mature	Feature 414 (Pueblo Room)	13
Jackrabbit	Radius	Mature	Feature 416 (Roasting Pit)	1
Bison	Mandible	Mature	Feature 416 (Roasting Pit)	1
Bison	Tooth fragment	Mature	Feature 416 (Roasting Pit)	8
Medium artiodactyl	Metatarsal	Mature	Feature 416 (Roasting Pit)	1
Medium to large	Tooth fragment	Mature	Feature 416 (Roasting Pit)	3
Small mammal	Bone fragment	Mature	Feature 416 (Roasting Pit)	1
Small mammal	Long bone fragment	Mature	Feature 416 (Roasting Pit)	5
Small to medium	Bone fragment	Mature	Feature 416 (Roasting Pit)	1
Medium to large	Long bone fragment	Mature	Feature 416 (Roasting Pit)	1
Medium to large	Bone fragment	Mature	Feature 416 (Roasting Pit)	88
Large mammal	Bone fragment	Mature	Feature 416 (Roasting Pit)	32
Large mammal	Long bone fragment	Mature	Feature 416 (Roasting Pit)	30
Large to very large	Bone fragment	Mature	Feature 416 (Roasting Pit)	1
Very large mammal	Bone fragment	Mature	Feature 416 (Roasting Pit)	1
Unidentified mammal	Bone fragment	Mature	Feature 416 (Roasting Pit)	19
Unidentified mammal	Long bone fragment	Mature	Feature 416 (Roasting Pit)	1

Lagomorphs are the second most common order of animals identified in the 2019 assemblage and comprise 2.15 percent of the total assemblage. Jackrabbit specimens (n=65) were present in greater numbers than cottontails (n=11), suggesting the local environment during the occupation of the site was slightly more favorable for jackrabbit success. In addition to remains positively identified as jackrabbit or cottontail, most of the bones and teeth classified as small mammal compare favorably with the leporids in size, although some are possibly rodent.

Rodents are represented in the assemblage by a single mandible fragment. Their paucity in the 2019 assemblage, as well as the 2015 assemblage, suggest rodents were not a significant food source at the Merchant site.

Carnivores remains are limited to six bones, although some of the specimens categorized as medium- or medium to large mammal are possibly the remains of carnivores. The six identified carnivore bones are all canid in origin and from either dogs or coyotes. One of the bones, a cervical vertebra, was calcined, suggesting dogs and/or coyotes were possibly used for food.

Reptiles are the only non-mammalian taxa identified in the 2019 faunal assemblage. The reptile remains consisted of an unidentified snake (rattlesnake size) vertebra and turtle/tortoise carapace fragments. The remains were unburned and exhibited no evidence of cultural modification. It is indeterminate if these animals are the remains of food items or were collected for other cultural purposes. The turtle/tortoise carapace fragments were found within Room 6 and Room 28; the snake vertebra was recovered from a refuse area.

Modified Bone

Approximately 7.6 percent of the 2019 faunal assemblage was modified. The modified bone consisted predominantly of thermally altered and butchered bone. In addition to burning and butchering, one bone was modified into a tool. Two hundred and forty-seven of the faunal specimens were culturally modified by cooking or discard processes (Table 15.3). The burning was predominantly evidenced by charring or calcining, although one bone was polished. The polishing appears to have formed during a cooking process.

Evidence of butchering was only observed on three bones: two large mammal shaft fragments and one deer femur. All three were impact breaks. The breaks were presumably intentional and associated with marrow extraction. Additionally, the high degree of bone fragmentation, particularly for large mammal long bones, potentially indicates that many of these bones were purposefully broken to extract marrow. The rarity of butchering or processing marks on the faunal remains is probably due, at least in part, to extensive post-depositional fragmentation and environmental alteration, notably weathering and root etching.

Animal alteration was not observed on any of the bones, although it is likely the bones at the site were impacted by carnivore and rodent activity. Fragmentation and environmental impacts have potentially obliterated any evidence of animal gnawing or bone consumption.

The bone artifact identified in the 2019 faunal assemblage was a bone awl fashioned from a small mammal long bone fragment (Figure 15.1). The awl is broken and only the tip portion is extant. The tip is sharp and pointed, and well-polished. It measures 13 mm in length and had a tip width of 1 mm. The awl was collected from Feature 416, a plant baking pit.

Combined, only four bone artifacts were collected from Merchant during the 2019 and 2015 excavations. The artifacts were three awl fragments and a modified jackrabbit tibia. The low counts are surprising when compared to the numbers of such items documented by Leslie and the LCAS. At least 104 bone artifacts were documented during the LCAS excavations, including awls (n=47), notched bone (n=47), carved/incised bone (n=7), and antler billets (n=3).

Table 15.3. Evidence of burning and butchering

Taxon	Calcined	Charred	Polished	Processed	Total Burned/ Butchered	Total NISP	Percent Burned/ Butchered
Small mammal	6	–	–	–	6	107	5.3
Small to medium mammal	–	–	–	–	–	4	0.0
Medium mammal	–	–	–	–	–	1	0.0
Medium to large mammal	35	9	–	–	2	4	50.0
Large Mammal	76	61	1	2	140	2,219	6.3
Large to very large mammal	7	1	–	–	8	189	4.06
Very large mammal	13	4	–	–	17	139	12.2
Small rodent	–	–	–	–	0	1	0.0
Cottontail	–	–	–	–	0	11	0.0
Jackrabbit	5	4	–	–	9	65	15.39
Dog/coyote/wolf	1	–	–	–	1	6	16.7
Deer	1	–	–	1	2	18	11.1
Bison	–	1	–	–	1	42	2.3
Medium artiodactyl	3	5	–	–	8	83	9.6
Medium to large artiodactyl	–	–	–	–	0	12	0.0
Large artiodactyl	–	–	–	–	0	28	0.0
Snake	–	–	–	–	0	0	0.0
Turtle/tortoise	–	–	–	–	0	0	0.0
Unidentified mammal	13	–	–	–	13	173	7.5
Unidentified vertebrate	–	1	–	–	1	3	33.3
Total	**160**	**86**	**1**	**3**	**250**	**3,285**	**7.6**

Figure 15.1. Bone awl fragment recovered from Feature 416 during the 2019 excavations.

Regional Context

Results from the 2015 and 2019 Merchant analyses indicate the Merchant faunal assemblage is similar in composition to other faunal assemblages documented for contemporaneously, or near contemporaneously, occupied sites on the plains of southeastern New Mexico and neighboring areas of West Texas (Figure 15.2). For regional comparison, the combined results from the 2015 and 2019 Merchant faunal analyses are used in the following section.

Other well-documented regional pueblos and pithouse villages include the Roswell, New Mexico area sites of Bloom Mound, Henderson, and Rocky Arroyo, and the Andrews Lake Locality Salt Cedar site near Andrews, Texas. The faunal assemblages from each site are predominantly composed of artiodactyl and leporid remains, indicating a common reliance on small- and large-bodied animals for animal protein. Fish were documented at the Roswell area sites and appear to have been a frequent food source for the site inhabitants (Akins 2002:146; Speth et al. 2004:306; Wiseman 2013:52). The fish were likely present in nearby tributary rivers that flowed into the Pecos River (Speth et al. 2004:305). Merchant and the Salt Cedar site were located long distances from permanent fish-bearing waters, thus precluding their availability as a food source, or at least a common food source at the sites. Fish remains were not identified in the Merchant or Salt Cedar assemblages (Collins 1968 and Loven and Speth 2016).

Birds are comparatively rare at all five sites; however, they are more numerous at the Roswell area sites (Speth 2004b). The greater frequency of birds at the Roswell sites was potentially influenced by a wetter, lusher, and generally more favorable environment for birds. Reptiles were present at the sites as well, most commonly in the form of carapace fragments and snake vertebrae.

Leporids were an important source of dietary protein at all sites. Jackrabbit and cottontail remains were recovered from each site, albeit in varying percentages. An examination of the LI for Merchant and the Roswell sites indicate a predominance of jackrabbit remains at Merchant, while cottontails are present in much higher percentages at Henderson and Bloom Mound; rabbits and hares were present in similar ratios at Rocky Arroyo, although jackrabbits were slightly more common (Table 15.4). Much of the difference is likely ecological, with cottontails being naturally more abundant in the wetter and lusher environments around the Roswell sites. In comparison, the local environment around Merchant is significantly drier, with sparser vegetation; a condition likely made more pronounced over time, with vegetation becoming increasingly cleared and gathered for use as fuel for fires. Although potentially influenced by natural conditions, the Rocky Arroyo LI is likely being influenced by sampling bias. Local avocational archaeologists that excavated at Rocky Arroyo presumably discarded many of the small cottontail bones or failed to recognize them in their screen. Resultantly, the LI value could be inappropriately skewed in favor of jackrabbits.

The high AI values for Merchant (AI=0.96), Rocky Arroyo (AI=0.96), and Henderson (AI=0.91) illustrate the importance of large-bodied mammals as a food source at these sites (Figure 15.3). Bison, deer, and pronghorn were identified in all three faunal assemblages. These animals were seemingly prevalent in the region during the occupation of these sites and were highly valued as a food resource and presumably as a trade item for upland Pueblos in the Sacramento Mountains.

The AI value at Bloom Mound is substantially lower; however, artiodactyls were likely still an important source of protein. Bloom Mound was occupied slightly after Rocky Arroyo, Henderson, and Merchant, during a time when the political environment on the Plains seems to have changed. During the Bloom Mound occupation, competition with Plains groups for bison and other resources resulted in increased violence and warfare, ultimately limiting long-distance hunting and travel and thus decreased encounters with large mammals, particularly bison (Speth and Staro 2012:19).

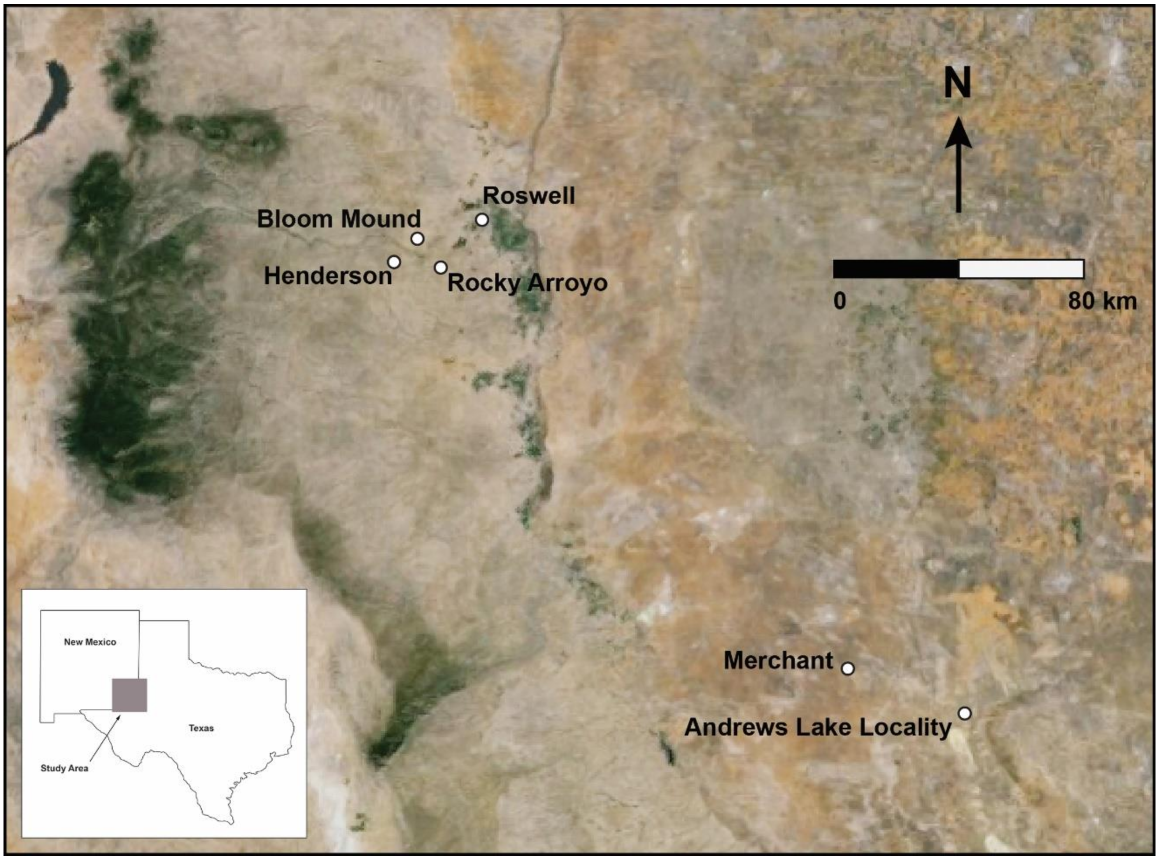

Figure 15.2. Location of Merchant and other sites in relation to Roswell, New Mexico.

Summary and Discussion

The 2019 excavations at the Merchant site recovered a substantial faunal assemblage that resembles in taxonomic composition of the assemblage collected during the 2015 fieldwork. Both assemblages are composed of leporids and artiodactyls, followed by miniscule amounts of rodent, carnivore, bird, and reptile remains. Large mammal remains were ubiquitous and recovered from most contexts. As such, it seems that bison, deer, and pronghorn were likely prevalent across the local landscape and a frequently encountered and captured for use as a common source of dietary protein by the inhabitants of the Merchant site.

Although, an important food source large mammals were possibly a valuable trade item. The scarcity of bison and deer/pronghorn ribs in faunal assemblages recovered from the Roswell sites (Speth and Rautman 2004:128–121; Speth and Staro 2012:22) and the 2015 Merchant investigations was interpreted to represent the likely trade of dried rib units and meat to villages in the Sierra Blanca region of the Sacramento Mountains (Driver 1985:61; Loven and Speth 2016). Ribs were even less frequent in the 2019 Merchant assemblage than in the 2015 Merchant assemblage. In the 2015 assemblage ribs accounted for 3.2 percent of all large ungulate specimens and 2.3 percent of all medium ungulate remains, whereas in the 2019 assemblage ribs totaled 0.5 percent of all large ungulate remains and 0.2 percent of all medium ungulate remains. The increased rarity of rib bones in the 2019 faunal assemblage further supports the hypothesis for trade in bison and medium ungulate ribs and meat between Merchant and the upland pueblos to the west.

Table 15.4. Lagomorph and artiodactyl indices for Merchant and Roswell sites

Indices	Merchant (NISP)	Rocky Arroyo (NISP)	Henderson Site (NISP)	Bloom Mound (NISP)
Lagomorph Index				
Sylvilagus sp.	27	80	6,110	3,373
Lepus sp.	218	104	2,590	1,294
Total Lagomorphs	245	184	8,700	4,667
Lagomorph Index	**0.11**	**0.43**	**0.70**	**0.72**
Artiodactyl Index				
Artiodactyls + large mammals	6,162	4,231	9,010	1,155
Lagomorphs	245	184	8,700	4,667
Total Artio./large mammals + Lago.	6,407	4,415	17,710	5,822
Artiodactyl Index	**0.96**	**0.96**	**0.51**	**0.20**

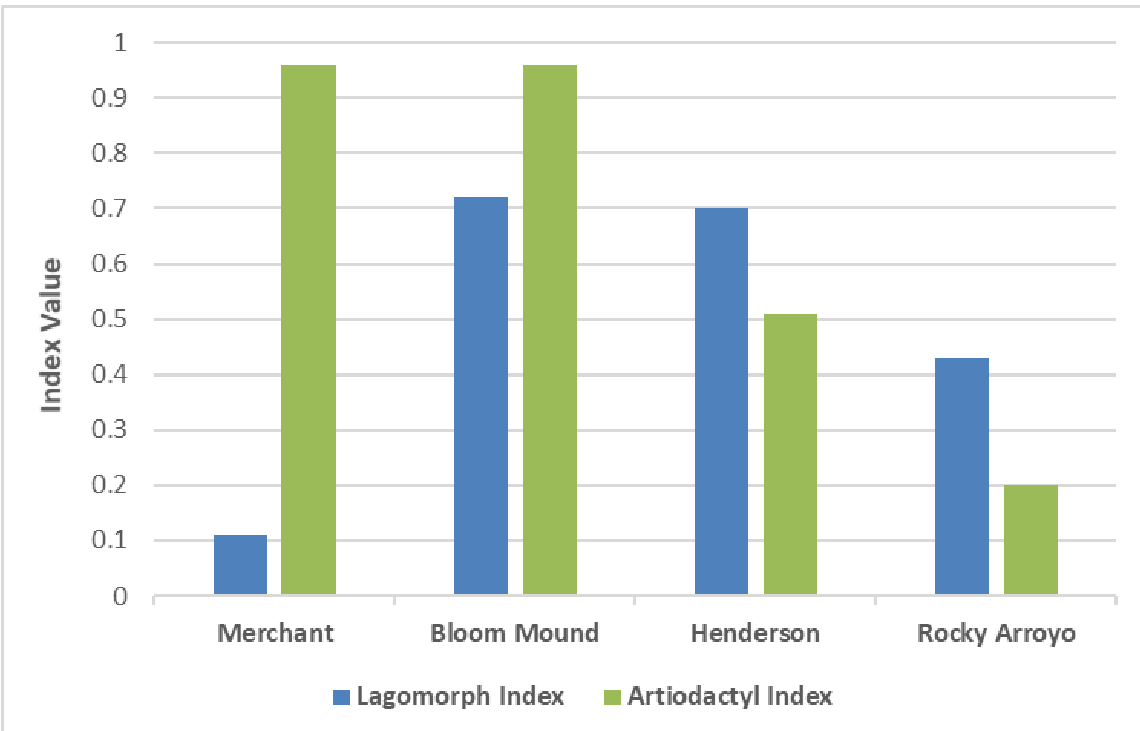

Figure 15.3. Bar chart comparing Lagomorph and Artiodactyl Index values for Merchant and Roswell sites.

Jackrabbits would have been prevalent in the local environment directly around Merchant. These animals were likely actively hunted and captured and were probably a frequent food source. Cottontails were comparatively rare. This disparity was partly ecological, although anthropogenic changes to the immediate environment around the site could have further decreased their numbers.

Rodents would have been available for use as a food source at Merchant. However, given the abundance of larger mammal remains at the site, notably bison and deer/pronghorn, their necessity for use as a food source was likely limited. As such, rodents were probably rarely hunted and only passively captured, and when captured, their bones may have been consumed along with the meat, thus preventing the bones from being incorporated into the archaeological record and subsequently recovered during excavation.

Dog or coyote remains from Merchant were recovered from the Feature 1 pit structure and refuse areas. Burning present on a couple of the bones and the presence of several of the bones in the refuse areas suggests these animals were also used as a food source. DNA analysis on some of the bones is necessary to determine species and would be valuable for understanding if the inhabitants of Merchant had dogs or were hunting coyotes for food.

Evidence for the use of animals as ceremonial objects at Merchant is mostly limited to the bone bed layer documented by Leslie in Pit Structure 1, which appears to be a civic-ceremonial or kiva-like structure. As described by Loven and Speth (2016), the solid layer of bone in this structure was almost certainly the result of deliberate placement, possibly associated with the ceremonial closing of the structure. Bone rasps collected from the site by Leslie could have been used during ceremonies, in which case they would have performed ceremonial function, if not being specifically a ceremonial object. All other animal remains collected from the site appear to be food debris or materials collected for modification into tools.

Chapter 16

Ochoa Ware

Myles R. Miller, Genevieve Woodhead, Jeffrey R. Ferguson, and Mary Ownby

Ochoa ware is the signature and diagnostic ceramic of the Ochoa Phase of southeastern New Mexico, usually accounting for 95 percent or more of the ceramic assemblages of Ochoa Phase settlements. The primary type, Ochoa Indented Corrugated, was first named and described by Robert Leslie in the "Facts and Artifacts" Newsletter of the Lea County Archaeological Society (Leslie 1965b). Additional details of the production and morphological attributes of the type were provided by Michael Collins in his 1968 thesis on the Andrews Lake sites (Collins 1968). The description developed by Leslie is based on the materials excavated from the Merchant site, and, accordingly, Merchant is considered the "type site" for the ware. Leslie (2016a) notes that the name was taken from the nearby ghost town of Ochoa, a community known throughout the region for producing bootleg "Ochoa Whiskey" during the Prohibition era and oil boom of the 1920s.

Ochoa Indented Corrugated is the primary type, and perhaps the only type, of Ochoa ware. As corrugated wares go, it is a comparatively exuberant or elaborate style of corrugation (Figure 16.1). It is characterized by distinctively textured surfaces with indented, scallop-like corrugations formed by impressions that were most likely made with the fingertip.

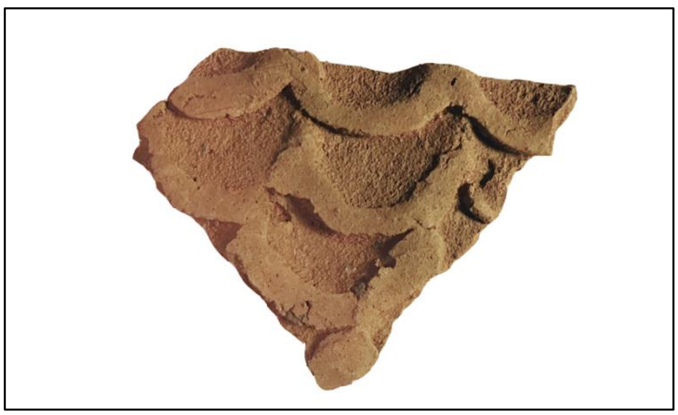

Figure 16.1. A typical Ochoa Indented Corrugated sherd.

The research design for the second season of fieldwork at the Merchant site included a comprehensive study of Ochoa ware that covered functional, stylistic, technological, and compositional analyses. Several of the proposed technological and functional studies were thwarted by the small sample sizes recovered from most proveniences combined with the rarity of large, analytically diagnostic sherds. The total assemblage recovered from the nine rooms, middens, and extramural spaces numbered only 894 sherds. In many ways the Ochoa assemblage is reminiscent of El Paso brownware collections from the Jornada region to the west. Both traditions produced low-fired ceramics with friable, coarse pastes. In both regions, settlements are typically situated in shallow cultural and natural deposits. Together, these two factors—friability and shallow deposits—have resulted in extensive sherd breakage and size reduction. Upwards of 70 percent of the Merchant site collection measured less than 2.5 cm in size and therefore offered limited potential for recording information on vessel form, corrugated designs, and other attributes.

Several studies were completed despite the problems of sample sizes and sherd sizes. Vessel form and rim forms, as well as the incidence of sooting, smudging, and secondary use were documented by Miller and Woodhead. In addition to the study of vessel form and use attributes, samples of Ochoa ware sherds were submitted to the University of Missouri Research Reactor for NAA analysis of chemical composition and to Mary Ownby for petrographic analysis. These studies provided important insights into the production and distribution of Ochoa ware ceramics. Another significant contribution is Genevieve Woodhead's study of the manufacturing practices and corrugation production methods of Ochoa ware ceramics and the comparison of metric and stylistic attributes with other Southwestern corrugated pottery traditions.

Distribution and Dating

Ochoa wares are primarily found in the extreme southeastern corner of New Mexico and into Texas. The Ochoa ware distribution ranges from southeastern Eddy County, across Lea County, and as far as southeastern Chaves County, New Mexico, and into Loving, Winkler, Gaines, Andrews, and Crane counties of the eastern Trans-Pecos and southern Panhandle regions of Texas (Leslie 1965b, 1979, 2016; Runyon and Hedrick 1973). Leslie (1979:Figure 5) mapped a limited distribution within southern Eddy and Lea counties with an artificial limit at the Texas-New Mexico border, and he notes that Ochoa ware sherds were seldom found north of US Highway 82/180 between Carlsbad and Hobbs. Small numbers of Ochoa ware sherds have been reported from Glasscock, Irion, Sterling, and Taylor counties farther to the east along the southern edge of the Plains (Alvarado 2008; Collins 1968) and from the Lubbock Lake site in the central Texas panhandle (Johnson 1993), leading Alvarado (2008) to expand Leslie's distributional map (Figure 16.2). The broad distribution illustrated in Figure 16.2 likely represents intermittent episodes of exchange with groups across the southern Plains. As revealed by the results of neutron activation analysis described in this chapter, the core area of Ochoa production probably lies within the original sphere defined by Leslie and other avocational archaeologists of the Lea County and Llano Estacado archaeological societies who were intimately familiar with the region.

The distribution of Ochoa ware lies mostly to the east of the Pecos River and surprisingly few sherds of Ochoa ware have been reported from villages along the Pecos River or the Roswell Oasis (Jelinek 1967; Katz and Katz 1993; Clark and Speth 2022; Wiseman 2004, 2013). Ceramic assemblages at two major village settlements provide noteworthy examples: Wiseman (2002:107) reports only a single possible Ochoa sherd out of the 30,000 sherds recovered from the Fox Place site and no Ochoa sherds were noted among the 35,000 sherds from the first two excavation seasons at the Henderson site (Wiseman 2004:92). A non-systematic review of the ceramics from subsequent excavation seasons at Henderson also failed to find any Ochoa ceramics. The restricted distribution of Ochoa ware is one of its most unique and intriguing characteristics.

Leslie originally proposed a production period of A.D. 1375 to 1425 for Ochoa ware based on associations with relatively well-dated imported ceramic types, while Collins (1968:179) proposed a longer span of A.D. 1300 to 1500 based on the association of Ochoa ware sherds with dated strata at the Salt Cedar site. Calibrating two of the three dates (Tx319, 420 ± 100 B.P.; Tx318, 370 ± 100 B.P.) reported in Valastro et al. (1967:445–446) using modern curves yields calibrated age ranges of A.D. 1305–1665 and 1395–1685, respectively. Noting that neither date was corrected for isotopic fractionation, it can only be concluded that some areas of the calibrated probability distributions of both dates fall within the conventionally accepted production span of Ochoa ware.

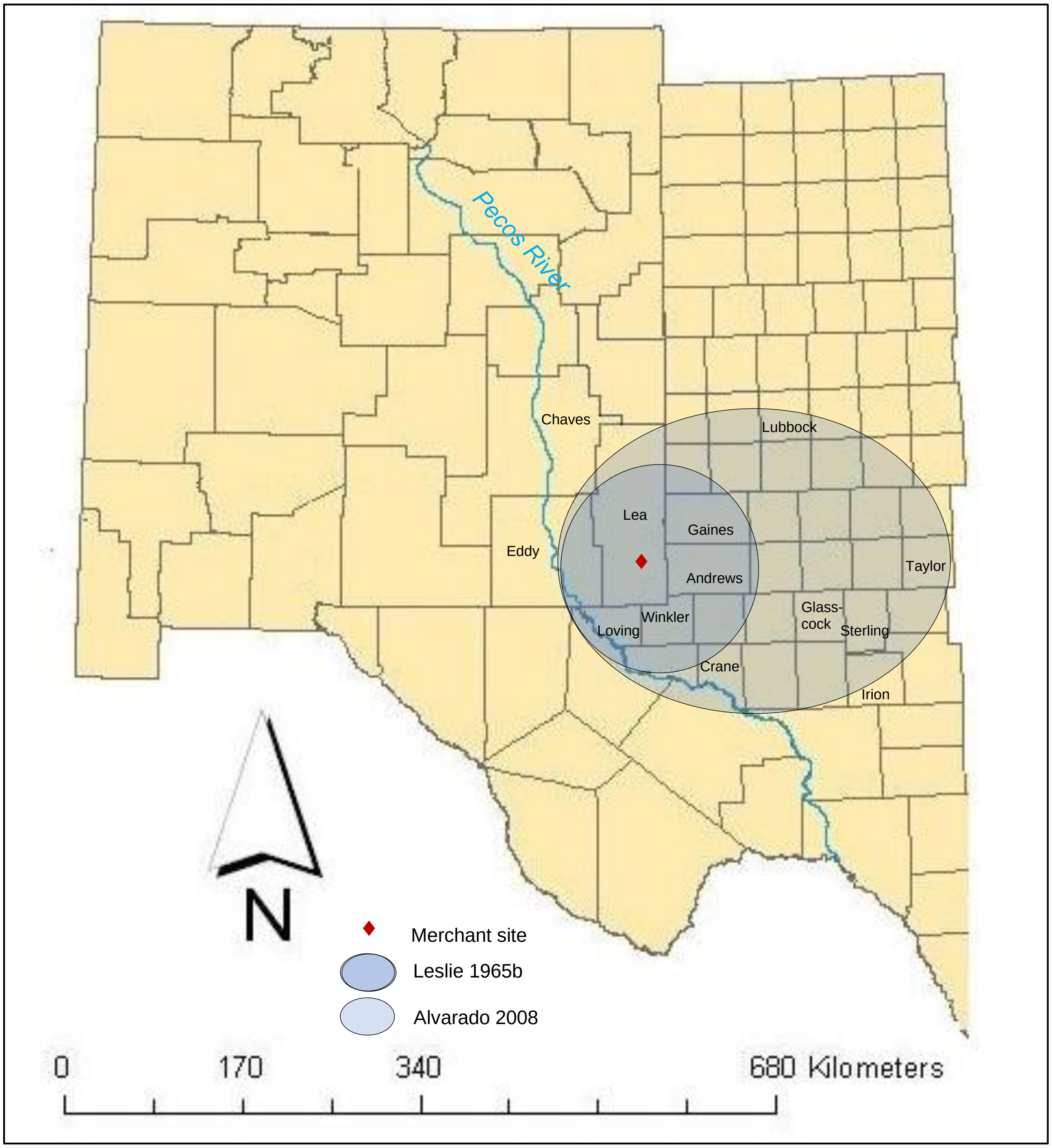

Figure 16.2. Geographic distribution of Ochoa ware (modified from Alvarado 2008:43) showing counties where Ochoa ware ceramics have been reported.

The dating of Ochoa wares was not revised or refined over the next 50 years, mainly because so few Ochoa phase settlements were investigated. Most studies simply referenced the association of Ochoa ware sherds with better-dated types of the fourteenth and fifteenth centuries, such as Chupadero Black-on-white, El Paso Polychrome, Medio Period polychromes, Three Rivers Redware, and early varieties of Rio Grande Glazewares. Based on the current knowledge of the production spans for the imported ceramics and the chronometric dates at the Merchant site (see Chapter Eleven), Ochoa wares were produced between A.D. 1300 and 1400 and possibly through the first couple decades of the 1400s.

Classification and Nomenclature

The ware-level classificatory term, Ochoa ware, is used here to describe the Ochoa ceramic tradition. Several varieties were proposed by Leslie (2016a) and those types and varieties have occasionally been identified in ceramic collections from southeastern New Mexico. Leslie describes three variants of Ochoa ware at the Merchant site: Ochoa Plain Brown, Ochoa Plain Corrugated, and Ochoa Indented Smudged. The variants appear to be rare components of Ochoa ware assemblages, as only 47 Plain Brown, 32 Plain Corrugated, and 83 Indented Smudged sherds were tabulated, collectively representing only 1.5 percent of the 10,536 Ochoa ware sherds recovered during the LCAS excavations of the 1960s.

As described by Leslie, Ochoa Plain Brown is identical in paste, temper, color, and interior finish to Ochoa Indented Corrugated with the difference that the exterior was smoothed and polished rather than textured (Figure 16.3, upper panel). Leslie notes that the type is associated with the "early part" of the Ochoa phase at the Merchant site and other Ochoa phase settlements. Leslie also notes that a small Ochoa Plain Brown jar was reconstructed from sherds collected from the surface of LA43415 (LCAS site E23) located 0.5 km south of the Merchant village. Such a vessel would confirm the existence of the type, but no photographs or drawings were included in Leslie's archives and thus the vessel cannot be evaluated. Curiously, the rim form was similar to El Paso Polychrome. The presence of a plain, untextured variant is sometimes mentioned by other researchers. For example, Wiseman (2002) notes the existence of a plain variant of Ochoa ware and suggests it was the precursor to Ochoa Indented Corrugated.

Ochoa Indented Smudged is another variety of Ochoa ware proposed by Leslie. The type is restricted to bowl sherds with intentionally smudged interior surfaces that were polished to semi-lustrous to highly lustrous finishes. Leslie notes that 20 sherds out of a small sample of 100 bowl sherds were assigned to the smudged variety. Of interest is that the smudged corrugated ware at the Merchant site was considered by Leslie to have a Southwestern origin or affinity and was one of the discussion points for the proposed eastern extension of the Jornada region (Corley 1965; Leslie 1979). In opposition to that view, Katz and Katz (1993) and Wiseman (2002) suggest the type belongs to a southern Plains ceramic tradition but they acknowledge that further research is required to verify that assertion.

All 83 sherds of Ochoa Indented Smudged identified in the LCAS collections by Leslie were recovered from a single context in Midden A located at the northern edge of the pueblo. An intriguing possibility is that bowls with interior smudging were used during a single feast or ritual activity and were broken and deposited in middens afterwards.

Leslie assigns the somewhat confusing name Ochoa Plain Corrugated to a third variant of Ochoa ware. As he noted for Ochoa Plain Brown, the paste, temper, and color of Ochoa Plain Corrugated sherds are identical to Ochoa Indented Corrugated, but a different texturing was applied to vessel exteriors. The finish is described as similar to Eastern Roswell Corrugated (an equally obscure type) with plain, unindented corrugations that were partially smoothed or obliterated. Leslie states that this type is another early variant of Ochoa ware along with Plain Ochoa Brown.

It has proven difficult to confirm the existence of the three subtypes, especially since the original Merchant site collections were lost and therefore no examples of the subtypes identified by Leslie can be inspected. Leslie's typology was applied to the preliminary laboratory sort of Ochoa ware recovered during the 2015 excavations (Miller et al. 2016:325) and the three types were present in significantly higher proportions than reported by Leslie (24.5 percent vs. 1.6 percent). A closer examination of the 2019 collection found that vessels with intentionally smudged and polished bowl interiors were present but not in the quantities identified in 2015. Several of the smudged surfaces observed in 2015 were the result of sooting over dark surfaces resulting from being fired in reducing and low temperature atmospheres. In developing his original typology, Leslie may have sought to identify analogs to ceramic types from other parts of the Southwest. Because there are smudged and polished corrugated vessels elsewhere in the Southwest (e.g., Reserve Indented Corrugated Smudged), the presence of dark, potentially smudged interiors on Ochoa sherds signaled to Leslie the existence of an Ochoa Indented Smudged type.

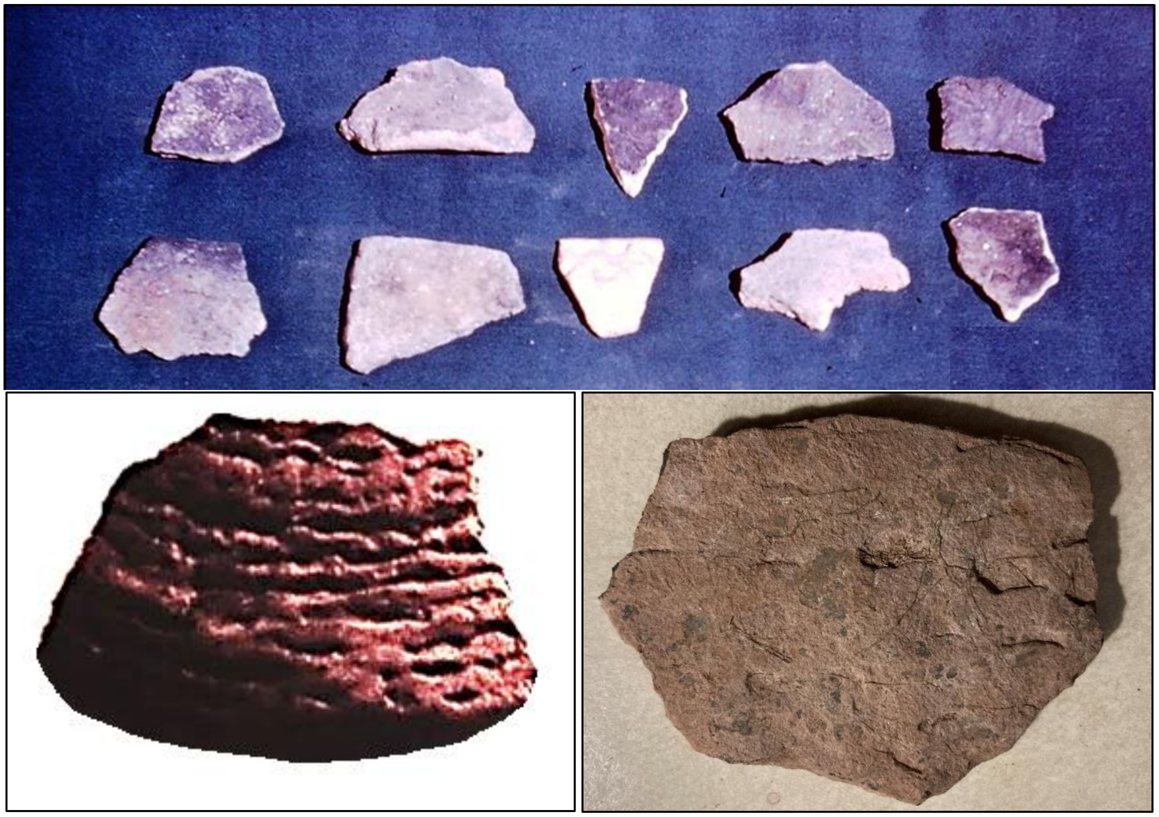

Figure 16.3. Examples of sherds representing the variants of Ochoa ware: (upper panel) examples of Ochoa Plain Brown (from Leslie 2016a); (lower left) example of the Ochoa Plain Corrugated variant (from Leslie 2016a); (lower right) lower body jar sherd showing the increasing obliteration of corrugations along the lower portions of vessels.

Resemblance to other ceramic types may have also led to the definition of the Ochoa Plain Corrugated variant. There is some overlap between the surface appearance of Ochoa Indented Corrugated sherds with shallow indentions that were smoothed and Corona Corrugated sherds with clapboard-like corrugations that were smoothed to a lesser degree than usual. The two types can usually be separated by an inspection of temper, but this is not always possible without microscopic examination, particularly on heavily burned and sooted sherds. The small number of sherds Leslie classified as Ochoa Plain Corrugated could either be a minor variant of Ochoa Indented Corrugated with less pronounced and more heavily smoothed indentation (see Figure 16.3, lower right), or perhaps they were Corona Corrugated sherds. Several sherds with similar texturing attributes were collected during the TRU surveys of the Mescalero Plains, and those sherds were assigned to the primary Corona Corrugated compositional based on NAA analysis.

The Ochoa Plain Brown category is also troublesome. Examination of rim sherds from the Merchant village site found little evidence for the Plain Brown variant. The few larger rims illustrated by Leslie (2016a) and those recovered during the recent excavations all have indented corrugated surfaces beginning immediately below the rim or a few centimeters below. At the other end of the vessels, however, there is evidence that the lower portions of jars were not fully corrugated. Sherds from the lower or mid-central areas of globular jars often have almost completely obliterated corrugations or coils, and areas below the inflection point were sometimes smoothed (see Figure 16.3, lower right). On some body sherds it was possible to track the progression from partially obliterated to almost fully obliterated and smoothed from the top to the bottom of the sherd (and by inference the location on a vessel the sherd came from).

Moreover, a surprising proportion of 70 percent of the 894 Ochoa ware sherds recovered during the 2019 excavations lacked visible corrugations and could be classified as Ochoa Plain Brown, with the exception that few of the untextured sherds have the polished exteriors described by Leslie. The majority of sherds lacking corrugations fall within the non-diagnostic group of sherds that were too small to characterize beyond noting they are body sherds. A key observation is that many of the untextured sherds are burned or sooted, indicating contact with cooking fires along the lower portions of vessels. It is possible that plain (untextured) and polished Ochoa vessels were occasionally produced, but it appears that Ochoa jars were more commonly not fully textured and instead had smoothed and sometimes slightly polished lower thirds or quarters.

It should be noted that Robert Leslie, John Runyan, and John Corley were quite observant in their research on the sites and material culture of southeastern New Mexico, and it is possible the variants they identified were true subtypes of Ochoa ware. At any rate, however, the variants are rarely found among Ochoa assemblages and were probably rather inconsequential.

Description of Ochoa Ware

The description of Ochoa ware, and specifically Ochoa Indented Corrugated, presented in this chapter builds upon the prior type descriptions of Leslie (1965b, 1979, 2016) and Collins (1968). A few observations and clarifications resulting from analysis of the 2019 collections are also provided. The ceramics recovered during the 2015 remedial excavations were sorted and classified, but attribute and compositional analyses were not a component of that project.

Construction

Coil and scrape with smoothing of plain surfaces and the addition of indentations on exterior corrugations. Coils were poorly welded and vessel breakage often occurs along the lines of coils and corrugations.

Wall Thickness

Collins (1968) notes that the thickness measurements of Ochoa ware sherds from the Salt Cedar site range from 4 to 10 mm with an average of around 6 mm and Leslie (2016a) describes the same range for measurements from the Merchant site. The 2019 collection from the Merchant site is slightly thinner. Wall thickness averages 5 mm with most of the sherds measuring between 4 and 6 mm. A small number of thinner sherds measuring 3 to 4 mm were noted and a few sherds measured as thick as 7 mm and were presumably from larger ollas. Some of the observed variation in wall thickness is attributable to the protrusion of the corrugations from the surface. Leslie noted little difference in thickness between bowl and jar sherds and no differences were observed during the present analysis.

Paste and Texture

All sherds have a moderately compact to friable paste texture. Jar pastes range from black to dark brown and light gray to tan (Figure 16.4). Jar exteriors often have darkened and sooted exteriors resulting from use as cooking vessels; residues were sometimes observed adhering to jar interiors. Leslie claims that bowls were not used as cooking vessels and that bowl sherds have a wider range of paste colors including gray, reddish-tan, light to dark tan, and light brown to dark black. However, a similar range of colors was noted among jar sherds in the 2019 collections.

Ochoa ware vessels were produced under low-temperature reducing fires which accounts for the wide range of variation in paste colors. A sample of sherds examined in cross-section noted that interior cores were usually dark and unoxidized, the exception being a group of sherds from the southern room block that had uniform tan surfaces and cores, indicating that some vessels were fired at slightly higher temperatures.

Figure 16.4. Variation in paste and surface color.

Temper

Leslie describes the temper of Ochoa ware as consisting of medium to very coarse crushed caliche and sandstone fragments. This describes the few visible whitish grains in the paste, but much of the temper of Ochoa ware is actually very fine-grained and many temper grains are difficult to see in the paste without magnification, especially on sherds with dark cores from low firing temperatures. Based on macroscopic examination, the temper would best be described as fine- to medium-grained with a few larger white to light gray particles of limestone or caliche. Some of the limestone/caliche grains are so large (2–3 mm) that they protrude through the surfaces of vessel walls (Figure 16.5), but most grains average less than 1 mm in size. A diagnostic trait of most Ochoa sherds also shown in Figure 16.5 is that the large temper grains are somewhat sparse compared to Corona Corrugated and El Paso brownware.

Leslie notes that many of the larger temper grains are not caliche, have smooth rounded edges on one or more sides, and are usually dark gray to black in color. Fine to medium rounded sand grains are also present. He additionally noted the presence of small flakes of light-colored biotite mica in some sherds, although the petrographic study of the current project identified such inclusions as muscovite. Leslie noted all these materials are available in local sandstone outcrops such as the layer below the terrace of the Merchant site (see Chapter 2) and suggested that crushed sandstone, unburned caliche, and perhaps even crushed bone were being used to temper the Ochoa pastes.

As with many of Leslie's observations regarding the archaeology of the Merchant site, his characterization of Ochoa ware temper is generally confirmed by recent petrographic studies. Hill (2002) describes the temper of the single Ochoa ware sherd from the Fox Place site as a moderately well-sorted arkosic sandstone with 25 percent feldspar, quartz grains, and medium to coarse rock fragments. Almost all the inclusions in the paste were thought to be tempering agents. The single Ochoa ware specimen was the sole specimen of the petrographic sample that was tempered with crushed sandstone, in contrast to the igneous tempers observed among the petrographic slides prepared from 16 El Paso brownware, Jornada brownware, and South Pecos brownware sherds. Sandstone outcrops are rare among the limestone Permian era geology of southeastern New Mexico, which led Hill (2002, 2019) to conclude that Ochoa wares were produced in a different location than other ceramic types, local and imported, that are commonly found across the region.

Figure 16.5. Examples of Ochoa sherds with large limestone or caliche temper grains protruding from sherd surfaces.

Seven Ochoa ware sherds were submitted for petrographic analysis as part of the current study. The results are described later in the chapter. In summary, sandstone and limestone were identified as the primary temper constituents, thus corroborating the earlier observations of Leslie and Hill, although no evidence of bone temper was observed through the recent petrographic analyses.

Interior Surface Finish

Jar interiors are usually smoothed, but a much wider range of variation was noted among the 2019 collection than described in previous accounts (Figure 16.6). Many jar sherds have a smooth, even surface and some have a streaky, slightly polished finish with temper drag marks and pits that is similar to El Paso brownware. A few jar sherd interiors have coil indentations and coarsely finished, striated interiors that almost resemble the interiors of Chupadero Black-on-white vessels. In fact, a heavily burned and sooted Ochoa sherd with a deeply striated interior surface was misclassified as a Chupadero Black-on-white sherd and the misidentification was revealed through NAA analysis (see Appendix C.2). Unsmoothed interiors were often found on sherds with deep curvatures indicating they came from small jars and the coarse interiors were probably due to the difficulties in accessing the interiors of such vessels.

Bowl interiors are smoothed and have very even surfaces and are sometimes semi-polished, but examples with streaky finish were also noted. In practice, it is difficult to differentiate among bowls and jars in the collection of small body sherds on the basis of interior finish because of the overlap of finishing treatments. The smoothed surfaces and surfaces with streaky polish were the result of using polishing stones as finishing tools. Sixteen polishing stones, representing 15 percent of the ground stone tools recovered from five rooms in both the northern and southern room blocks, indicate that ceramic production was probably conducted at the household level.

Figure 16.6. Variation in interior surface finish. From left to right: smoothed with temper drag marks and pits, smoothed, smoothed with slight streaky polish, and smoothed with slight polish.

Smudged Vessels: Leslie states that approximately 20 percent of bowl interiors have intentional smudging but again it is noted that his entire sample of smudged bowl sherds was from a single context. It is difficult to determine the presence and degree of vessel smudging among the Ochoa ware from the Merchant village. One technical issue is that the sherd collections were not washed in order to preserve residues adhering to surfaces and small niches and striations absorbed into the fabric. While the choice to forego washing sherds contributed to the successful recovery of plant microfossil and phytolith remains described in Chapters 13 and 14, it meant sherd surfaces were often left covered in coatings of silt or burned organic matter and making it difficult to identify whether polished surfaces were present or absent on many of the unwashed sherds. The presence or absence of smudging could not be determined for 13 (26.0 percent) of the subsample of 50 sherds examined by Woodhead and 378 (42.3 percent) of the total collection of 894 sherds examined by Miller. The difference is simply due to the fact the larger sample examined by Miller included hundreds of very small sherds that were non-diagnostic of any attribute.

Among the total collections, it is noteworthy that roughly similar proportions of smudged sherds have been identified by three analysts: 83 sherds (0.8 percent) of the LCAS collection were classified as smudged by Leslie, a single sherd of the 50 samples (2.0 percent) examined by Woodhead has a smudged interior, and 25 of the 894 sherds (2.8 percent) of the total collection reviewed by Miller have possible smudged surfaces. The proportion observed by Miller is inflated by the fact that the 21 of the 25 sherds are very small (16 are less than 2 cm) and appear to be from a single vessel or perhaps a large sherd tool found in the extramural hearth area north of Room 49. The context of these sherds is somewhat similar to that reported by Leslie for his sample of smudged specimens, in that the majority were found in a single location. Also notable is that Woodhead noted a much higher proportion (40 percent) of smudged sherds among a sample of Corona Corrugated from Robinson pueblo.

Examples of the smudged sherds are displayed in Figure 16.7. A critical attribute is that the interiors are not finely polished and definitely are not burnished in a manner similar to Mogollon smudged corrugated wares. The polishing is intermittent and streaky and usually can only be seen when the sherd is viewed at a certain angle against a light source. This observation is contrary to Leslie's (2016:164) description that intentionally smudged sherds "always have a well-executed polish."

Figure 16.7. Sherds with smudged interiors and streaky polish.

Another attribute is that the interior and exterior surfaces of smudged sherds appear the same and many sherds are completely black from the core to both surfaces. Several sherds have darkened surfaces that look like they were smudged but there is no evidence of any polishing. This treatment is often present on both jar exteriors and interiors. Temper grains are usually visible on the surface of such sherds, indicating that they were not coated with layer of carbon to seal the vessel as is the intended result of smudging. It is apparent that the firing of vessels in reducing environments was often variable and resulted in different surface and core colors. The manner and method of vessel smudging practiced among the Ochoa ware potters was also inconsistent and variable, and it remains uncertain if smudging was an intentional technological production step involved in a specific or special type of vessel use or was simply a byproduct of the unstandardized production of Ochoa ceramics.

Exterior Surface Finish

Coils on vessel exteriors were decorated with indented corrugations. The variation in corrugation treatments is described in greater detail below. As noted above, untextured sherds are common. The exterior surfaces of untextured jars are similar to the treatments of the interiors. Smooth, even surfaces are most common, and occasional wiped, polished, or streaky-polished sherd exteriors were observed. Some exterior surfaces could be classified as coarsely finished, but those are invariably the lower or middle portions of vessels where corrugations have been mostly obliterated as seen in the example shown previously in Figure 16.3.

Vessel Forms

Only one complete or partially reconstructed Ochoa ware vessel has been recovered during controlled excavations and presented in a report. Leslie notes that portions of two vessels were reconstructed from large sherds found in Midden A and adjacent rooms at the Merchant site, but no drawings or photographs of the vessels are available. Lacking a representative sample of complete vessels, the sizes and shapes of Ochoa ware bowl and jar forms are mainly inferred from rim sherds. Leslie (1979:196-198) illustrates the range of forms observed among 136 rims from sites across southeast New Mexico; a more restricted range of forms is illustrated in his 2016 manuscript on the Merchant site. Collins (1968:Figure 28) provides profiles of the primary rim forms at the Salt Cedar site. These series of rim illustrations are reproduced in Figure 16.8. Profiles of the rim sherds collected during the 2019 excavations are provided for comparison.

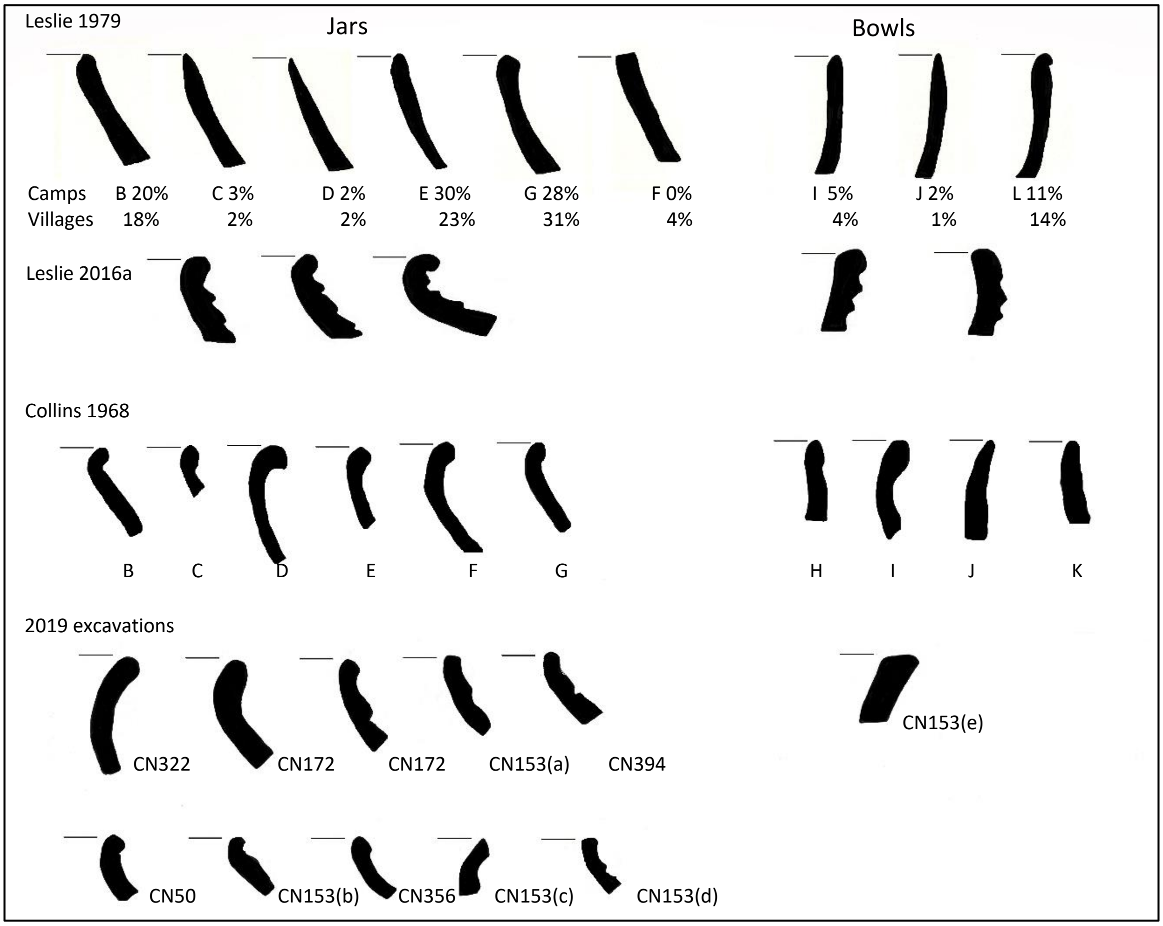

Figure 16.8. Rim forms recorded among collections of Ochoa ware: (top row) rim forms from southeastern New Mexico (from Leslie 1979:196–197, Figures 6 and 7 [with proportions of rims observed among camps and villages as listed in Figures 7 and 8]); (second row) Merchant site rim forms (Leslie 2016a:Figure 5.1); (third row) rim forms from the Salt Cedar site (Collins 1968:202, Figure 27); (lower rows) rims recovered during 2019 excavations.

Leslie's 1979 rim profiles for Ochoa ware differ in some respect from his later illustrations. Jar rim forms B, E, and G are by far the most common, and the profiles of those forms show a slight degree of rim eversion and rounded lips that are typical of the rims illustrated in other studies. Rims C, D, and F more closely resemble the typical rim shapes of short-necked and neckless El Paso Brown, Bichrome, and Early Polychrome jars. Leslie's second series of profiles from the Merchant site display everted forms with uniform walls and rounded lips and better capture the rim forms observed elsewhere.

The series of rim forms from the Salt Cedar site illustrated by Collins more closely matches the recent collection from the Merchant site. The most common jar rims among both series have everted (or "flaring") and uniform rim walls with rounded lips. The presence of corrugations on the jar rims varies. In some cases, the texturing begins immediately below the rims, while other rims have an untextured band between the rim and uppermost band of corrugations.

Bowl forms are difficult to evaluate based on the past profiles and present sherd collections. The most common form is a simple direct, uniform rim with a rounded or beveled lip and vertical or slightly outward sloping vessel wall. Collins types *I* and *J* are everted forms that were not observed in Leslie's sample or the present study. Some bowl rims have a narrow band of clay at the lip that overlaps the uppermost corrugation. Leslie's rim type *L* and Collins's type *H* seem to display this variant and thus establishes that it was relatively common among bowl forms. The single unambiguous bowl rim from the 2019 excavations has an expanding wall and flattened lip.

Through the examination of rim forms it can be concluded that the most common vessel forms of Ochoa ware include an everted rim globular jar, a short-necked jar, and a hemispherical bowl with vertical or slightly outward slanting walls. This observation is generally confirmed by the few available descriptions of partially reconstructed vessels, although a small number of variants has also been described. Collins (1968:Figure 28) illustrates a partially reconstructed jar from the Salt Cedar site. It is a globular form with a rounded base, strong shoulders, a restricted orifice at the neck, and everted rim (Figure 16.9). It is a medium-size vessel measuring 25 cm in height, 35 cm in diameter, and had an orifice diameter of 15.5 cm. Leslie (2016a) suggests this is the most common jar form represented among the rim sherds from the Merchant site.

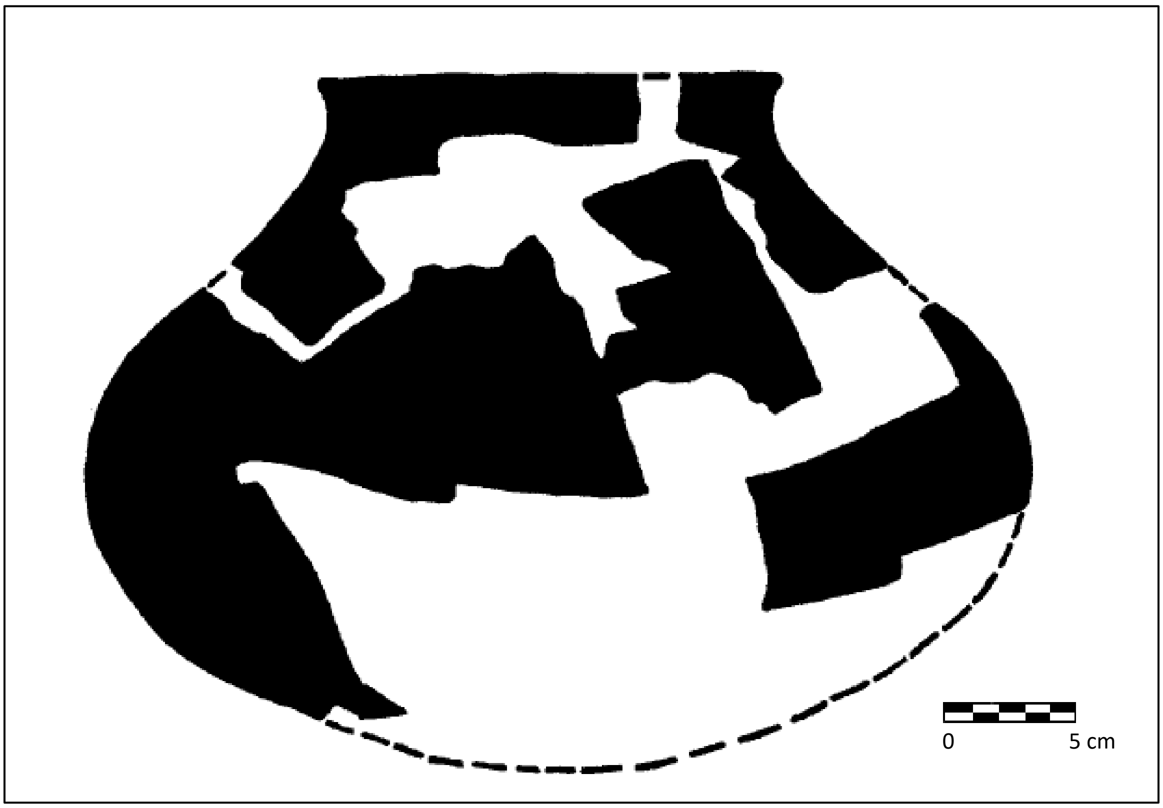

Figure 16.9. Partially reconstructed Ochoa Indented Corrugated olla from the Salt Cedar site, Andrews County, Texas (from Alvarado 2008:Figure 13, based on Collins 1968:202, Figure 28).

Leslie notes that two vessels could be partially reconstructed from sherds recovered from Refuse Area A and adjacent domestic rooms. One form was a minor variant of the jar described above that had a slightly longer neck, weaker shoulders, a less everted rim, and a smaller orifice diameter. The third variant is a small jar that was probably around half the size of the example restored by Collins. This small jar form had a rounded base, weak shoulders, a long neck, everted rim, and a small orifice diameter. Leslie (2016a) also notes that no accessory or molded additions such as handles or lugs were present on any of the rims from the Merchant site. This observation was confirmed during examination of the collections from the 2015 and 2019 excavations.

Based on conjoined rims from the LCAS excavations, Leslie determined that small- and medium-sized bowls were produced at the Merchant site, but the criteria for those size descriptions are not provided. One conjoined rim comes from a medium-sized hemispherical bowl with a rounded base, vertical walls, and slightly inverted rim with a rounded lip. The form is similar to the bowl forms illustrated by Leslie but has a slightly outward slanting wall, straight rims, and rounded or slightly beveled lips.

It was hoped that partially restorable vessels or at least large, conjoinable rim sherds would be recovered from room floors and midden deposits during the 2019 fieldwork, but we were not as fortunate as Leslie and the LCAS. Over 70 percent of the assemblage (636 of 894 sherds) is smaller than 2.5 cm and thus non-diagnostic of vessel form, corrugated designs, and other attributes. Another issue is the overall low count of ceramics. Leslie and the LCAS report over 10,000 sherds from their excavations in the 1960s. In contrast, less than 900 sherds were recovered in 2019 during the complete excavation of nine rooms, midden units, and extramural spaces. We recovered over 2,000 sherds during the 2015 excavations. The low counts of the present study can be attributed to the different focus of the investigations. The 1960s LCAS work and our 2015 work focused on the refuse and termination deposits in Pit Structures 1 and 2 that contained thousands of artifacts. The domestic rooms at the Merchant site did not have many sherds in the fill layers and even fewer sherds on the floors.

The low ceramic counts affected the sample numbers of rim sherds available for study. Only 36 rim sherds were recovered from rooms, middens, and extramural spaces. Several rims measuring 5 or 6 cm in length or width were recovered, but the majority of rims were less than 2 cm wide and/or 2 cm long and offered little insight into the overall form, shape, and decoration of Ochoa ware vessels. Of the 36 rim sherds, 26 were tentatively identified as jars, 1 as a bowl, and 9 were too small to be classified with any confidence. Only 14 rims were of sufficient width and length for a reliable vessel form assignment and attribute analysis. Woodhead examined the rim attributes using the criteria illustrated in Figure 16.10: the wall profile as it reaches the lip, the lip profile, and rim eversion (inversion, straight, medium eversion, or flared eversion).

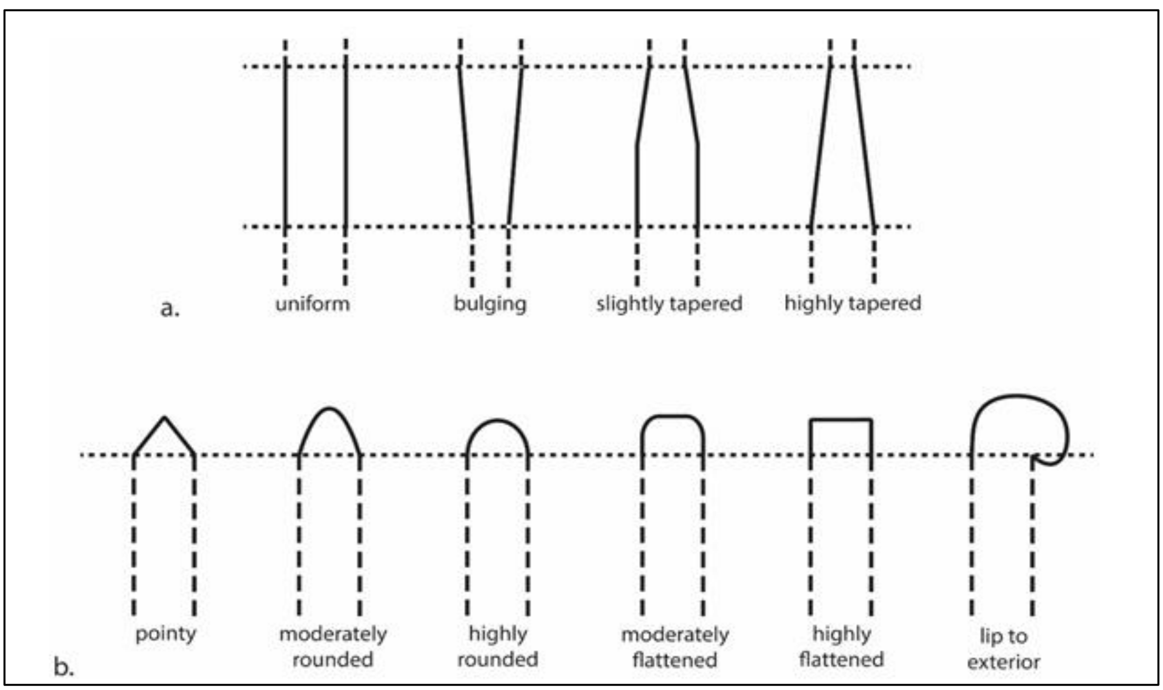

Figure 16.10. Rim sherd attributes: (a) the shape of the wall profile as it reaches the lip; (b) the lip profile itself. Rims were also described as everted (outcurving), direct, or inverted (incurving) (from Colton 1953:43–44).

The 2019 collection of rims was also compared to the forms illustrated by Collins and Leslie (see Figure 16.8). The rim walls, curvature, and lips generally match those of previous studies. Jar rims have uniform wall thicknesses, are everted, and have variable lip shapes. One Merchant site Ochoa rim sherd was slightly tapered approaching the rim lip, 11 had uniform wall thickness, and 2 expanded in wall thickness. One rim lip was pointy, 1 moderately rounded, 3 highly rounded, 2 moderately flattened, 1 highly flattened, and 6 curled over to the exterior. One rim sherd exhibited inversion, 4 (including the 1 bowl rim sherd) were moderately everted, and 1 was flared.

A surprisingly variable range of forms and sizes is present among the small sample of rims (Figure 16.11). It is difficult to measure orifice diameters on the small rims but based on visual inspection of thickness and curvature it can be surmised that both medium and small jars are represented. Both very thin, everted rims and thick everted rims are present. Most jar necks are short, although it is possible that the thin, everted rims derived from the smaller jar form described by Leslie were more easily fragmented due to the thinness of the walls. Some jar rims had inward-slanting vessel walls and were probably from short-necked jars. It is also possible that some bowls had very short, everted rims.

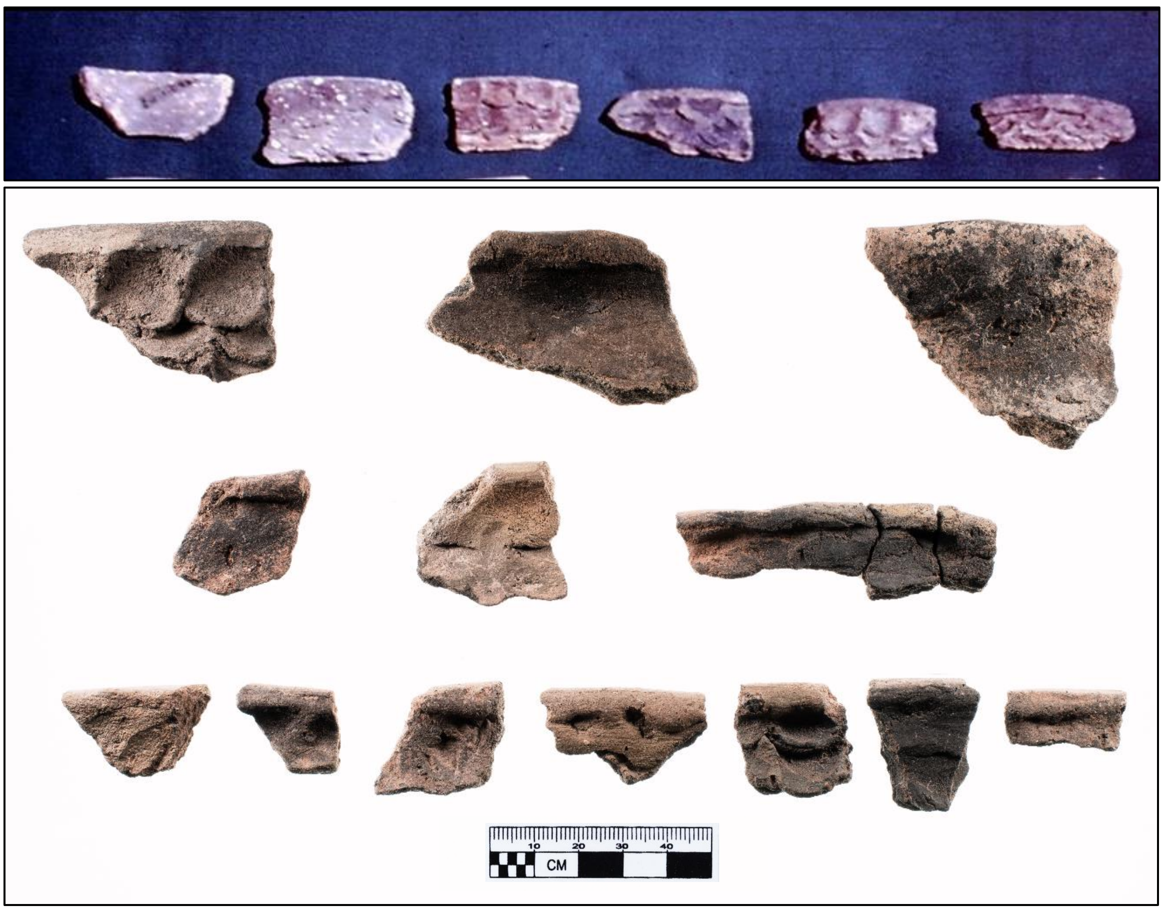

Figure 16.11. Rim sherds. Upper panel is from Leslie (2016a); lower group displays rim sherds recovered during the 2019 excavations.

An attempt was made to classify vessel form among the collection of body sherds. Such classifications proved to be difficult, especially among the dozens of small sherds comprising the assemblages of most contexts. Leslie (2016a:162) seems to have encountered similar problems as he notes that "Most bowl sherds are not distinguishable from those of jars but those that are (sic) generally thinner than jars." Many jar sherds were smoothed on the interior, and it appears that few of the bowls were polished, and therefore it is difficult to discern bowl and jar sherds based on interior surface finish. Moreover, only one partial jar vessel is available for examination and therefore the variability of finishing treatments from rim to base within jars and bowls remains unknown.

Functional Uses of Ochoa ware

Collins (1968) found no direct evidence that Ochoa ware vessels were used as cooking pots at the Salt Cedar site. Referring to Rice's (1987) functional studies of vessel form, Alvarado (2008) observed that globular jars, the most common vessel form observed among rim collections, were preferred vessels for cooking and heating. Based on several lines of evidence from the eastern and southern room blocks of the Merchant site, it can be convincingly argued that Ochoa vessels were used extensively as cooking pots. Perhaps the most convincing evidence is that maize pollen and starch grains were found on 30 percent of the Ochoa sherds submitted for microfossil analysis (see Chapter 14).

The presence of soot deposits and burned surfaces from contact with heating fires offers additional evidence of vessel function (Figure 16.12). Nearly 25 percent (219 of 894) of Ochoa body sherds had evidence of sooting and/or burning on exterior surfaces, some of which was quite extensive. Woodhead's examination of 50 rim and body sherds found an almost identical proportion (26.0 percent) of sooted Ochoa ware specimens but noted a higher proportion (46.7 percent) of sooted Corona Corrugated sherds from Robinson pueblo. Sooting is often present over corrugations but is more commonly present on non-corrugated plain exterior surfaces from the lower parts of vessels. It is possible that Ochoa jars were partially corrugated in a manner similar to how El Paso Polychrome jars were left unpainted on the lower ⅓ or ½ of the vessels, leaving the portions that were in contact with heating fires undecorated.

Spatial differences in the proportions of exterior sooting were noted (Figure 16.13). The incidence of sooting and burning ranges from a median proportion of around 12 percent in middens, to a range of 20 to 60 percent (median of 20) in rooms, to a median of nearly 40 percent in extramural spaces. These values would appear to correlate with the frequency of cooking activities around extramural hearths and inside domestic rooms.

Ochoa ware jars were undoubtedly used as cooking pots as indicated by the presence of sooting and burning on roughly 25 percent of the sherds. The fact that the majority of the sample was not sooted or burned demonstrates 1) that not every part of a vessel was equally likely to come into contact with fire or accumulate soot and 2) that Ochoa ware was a multifunctional ceramic that also served as storage, serving, and transport vessels. There is some confirmation for the second point. The presence of mesquite and hackberry residues indicate that some vessels may have been used for storage or serving, although mesquite beans may also have been boiled as part of their preparation (Bell and Castetter 1937). Despite the variation in rim forms, the production of Ochoa ware probably involved a limited number of utility forms for cooking, storage, and serving. Were Ochoa vessels used as exchange items or for transport of goods? That is an interesting and important issue and one that is addressed through compositional analysis presented later in the chapter.

Figure 16.12. Ochoa sherds with sooted and burned exteriors.

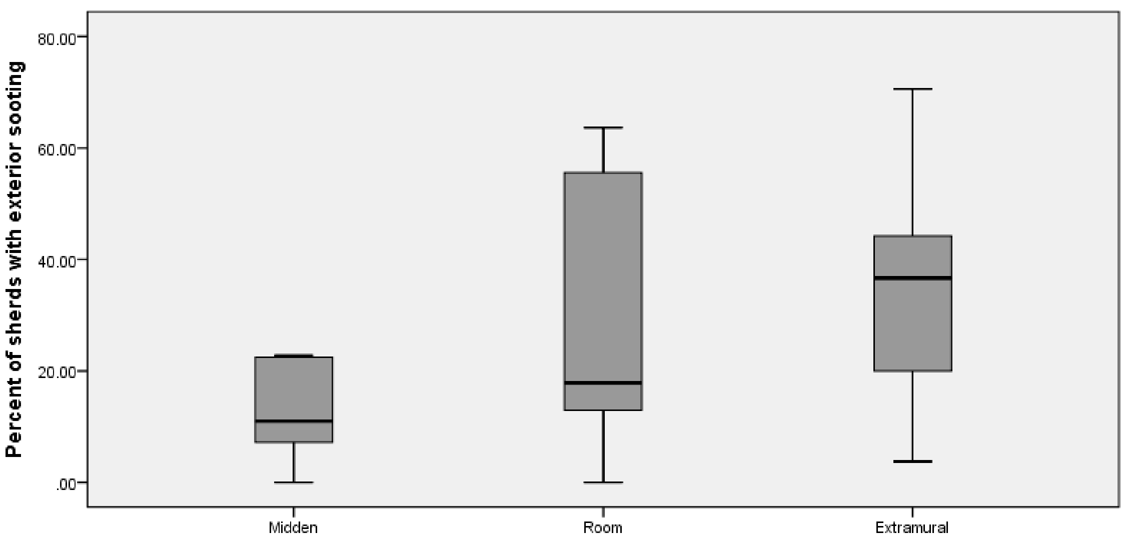

Figure 16.13. Proportions of sooted and/or burned sherds among three major contexts.

The potential use of certain vessels in ritual and for consumption of ritual drinks was also examined. Communal ceremonies were conducted in the civic-ceremonial facilities and plaza areas at the Merchant site, and it is likely that certain rituals involved ceramic vessels. Several non-utilitarian uses were considered, including preparation and consumption of meat or maize during feasts, corn beer or mescal fermentation, and drinking of ritual beverages. Sherd interiors were examined for evidence of pitting and etching that might indicate fermentation, and both jar and bowl interiors were examined for the presence of food residues. The westernmost extent of Yaupon holly, the primary ingredient in black drink, is along the Edward's Plateau escarpment only 400 km from the Merchant site. Theobromine and caffeine, the two major compounds of Yaupon holly, have been detected on Leon Plain sherds from central Texas (Dozier et al. 2020). A sample of sherds was submitted for residue analysis to determine if caffeine and theobromine compounds could be detected on Ochoa sherds.

These analyses yielded mostly negative results. No pitted or etched interiors were observed on the sample of Ochoa ware sherds. Residue analysis (see Chapter 14) of a sample of jar and bowl sherds did not identify theobromine or caffeine. However, smudged bowl sherds were not included in this analysis, and the results may have been biased by the inclusion of only cooking and storage vessels. It is possible that smudged bowls were the preferred vessel for ritual drinks, and future analyses should focus on that rare subtype of Ochoa ware.

Secondary Use of Ochoa Ware: One of the more unusual aspects of Ochoa ware from the Merchant site is the rarity of sherd modifications and evidence of secondary use. Among the 894 Ochoa ware sherds recovered during excavations of the rooms, middens, and extramural spaces, only a single sherd has evidence of secondary modification and use in the form of a smooth abraded edge (Figure 16.14). No repair holes were present, and no irregular edge abrasions were noted that would indicate the secondary use of partial vessels or large sherds as scoops or as shaped plates for cooking or parching seeds.

Figure 16.14. Edge-abraded Ochoa rim sherd from Midden B.

The 0.1 percent incidence of sherd modification is exceptionally low when compared to the Jornada region and other Southwest traditions. Typically, from 5 to 10 percent of sherd assemblages of Jornada pithouse and pueblo settlements are modified in one way or another (Miller 1989, 1990; Legare and Greenwald 2019; Sale et al. 2012). Edge-modified sherds at Jornada sites include locally produced El Paso brownware as well as imported types. The reasons for these differences are unclear. The Merchant site pueblo was of equivalent size, complexity, and occupation span as Jornada villages, and it is assumed that a similar range of production and maintenance tasks took place at each site. El Paso brownware and Ochoa ware are both low-fired, friable ceramics used for storage and cooking, and ceramics in each region would have been subject to roughly equivalent frequencies of breakage resulting from thermal fatigue and handling.

Compositional Analysis of Ochoa Ware

Samples of Ochoa ware from the Merchant village and two sites recorded during the Merchant Vicinity and Mescalero Plains surveys were submitted for neutron activation analysis (NAA) and petrographic analysis. Building upon previous compositional studies by Alvarado (2008, 2009), Creel et al. (2002, 2013), Hill (2012, 2016, 2019), and Miller and Ferguson (2014), the intent of the present study was to further refine the series of chemical compositional groups in southeastern New Mexico and west Texas, identify geographic production areas for those groups, and ultimately to examine the direction and magnitude of inter-village exchange of Ochoa ware ceramics across the region.

Ochoa ware sherds and samples of natural clay from the Merchant site and vicinity were submitted to the University of Missouri Research Reactor Center (MURR) for NAA. Due to the rarity of Ochoa ware sherds encountered outside of the Merchant village, several sherds provisionally classified as Corona Corrugated or Ochoa ware were included in the study. Upon receiving the chemical data and statistical compositional groups identified among the samples, a representative subsample of sherds from each group was submitted to Mary Ownby of Desert Archaeology, Inc. for petrographic analysis.

Previous NAA Studies

Thirty-one Ochoa Indented Corrugated sherds were submitted for NAA as part of Luis Alvarado's (2008, 2009) compositional analysis of plain and corrugated brownwares from southeastern New Mexico. The sample included 28 Ochoa ware sherds from the Merchant site and 3 sherds collected as isolated finds in Crane County, Texas approximately 110 km southeast of Merchant. Another 63 ceramic samples consisted of Corona Corrugated, Roswell Brown, Seco Corrugated, Middle Pecos Micaceous, and McKenzie Brown. The 94 ceramic samples were collected from Henderson pueblo (Speth 2004) in the Roswell Oasis and several sites in southeastern New Mexico and around the junction of the southern Texas Panhandle and eastern Trans-Pecos. Eleven clay samples were analyzed, including five collected from outcrops near the Merchant site, four from a location in Gaines County, Texas, and two prehistorically fired clay samples were submitted from the Salt Cedar site and another site in west Texas.

Five compositional groups were identified among the 94 sherd samples (Alvarado 2008; Ferguson and Glascock 2007). Groups 1, 2, and 3 were chemically distinct from Groups 4 and 5. The first three groups represented Ochoa ware and miscellaneous types produced in southeastern New Mexico and west Texas, of which the Ochoa ware sherds from Merchant were assigned to Group 1. Groups 2 and 3 were small groups consisting of nine and eight samples, respectively. Several ceramic types from sites across southeastern New Mexico and west Texas were assigned to these groups, including Corona Corrugated, Seco Corrugated, McKenzie Brown, and Roswell Brown. Three Ochoa ware sherds from the sites in Crane County and the Merchant site were assigned to Group 2.

Groups 4 and 5 were chemically similar groups that were likely produced in the Middle Pecos Valley and locations to the northwest in the Sierra Blanca and Capitan mountains. Group 4 consisted mainly of Roswell Brown while most of the Corona Corrugated samples from the Henderson site were assigned to Group 5.

Alvarado's study also incorporated the results of fourteen Ochoa ware samples previously submitted by Darrell Creel as part of the Chupadero Black-on-white NAA study (Creel et al. 2002) and the Central Texas Ceramics Project study (Creel et al. 2013). Ten samples were from the Salt Cedar site (41AD2) excavated by Collins (1968) and two other sites in the Andrews Lake area of west Texas. Four samples were from more distant locations in Taylor, Nolan, and Potter counties.

Thirteen of the samples were found to cluster with Group 2, while one sample was a statistical outlier to all five groups.

Natural clay samples included two pieces of "fired clay," one excavated at the Salt Cedar site and the second collected from a site in Crane County. The samples were determined to be chemical outliers. Five natural clay samples from the Merchant site and four samples from locations in Gaines County yielded interesting results. The typical outcome of comparing natural clays to sherds was evident as all the samples plotted far outside the 95% confidence interval ellipses of the ceramic chemical groups. However, there was a general pattern where both the Merchant site and Gaines County clay samples had a closer chemical similarity to Groups 1 and 2 as opposed to Groups 4 and 5 of the Middle Pecos Valley and Sierra Blanca regions.

Alvarado's samples of Ochoa ware and other types were included in the comprehensive classification of NAA data from south-central New Mexico, southeastern New Mexico, and Trans-Pecos Texas completed in 2014 (Miller and Ferguson 2014). Twenty-six of the 28 Ochoa ware sherds from the Merchant site were assigned to Group 91, one of the most chemically distinct compositional groups identified among the entire database of 2,151 NAA samples comprising the 2014 analysis. Group 91, as with Alvarado's Group 1, was composed entirely of Ochoa ware ceramics from the Merchant site. The chemical group had a wide range of discriminating elements including sodium and calcium, as well as various transition metal and rare earth elements such as ytterbium, zirconium, samarium, aluminum, lanthanum, and tantalum. Clays were not included in the 2014 analysis.

A notable aspect of the chemical profile of Ochoa ware was the exceptionally low sodium concentrations combined with exceptionally high calcium concentrations (Figure 16.15). In fact, the collection of Ochoa ware NAA samples from the Merchant site can be differentiated from the entire 2,151 members of the southeastern Southwest (SE SW) NAA dataset on the basis of just these two elements. This chemical composition appeared to support Leslie's (1965b) description of Ochoa wares as tempered with crushed caliche and sandstone. Sodium concentrations in prehistoric and historic southwestern ceramics usually derive from the use of igneous rock rich in plagioclase (sodic, or sodium-rich) feldspars as tempering material or the use of clays consisting of decomposed feldspar from igneous sources.

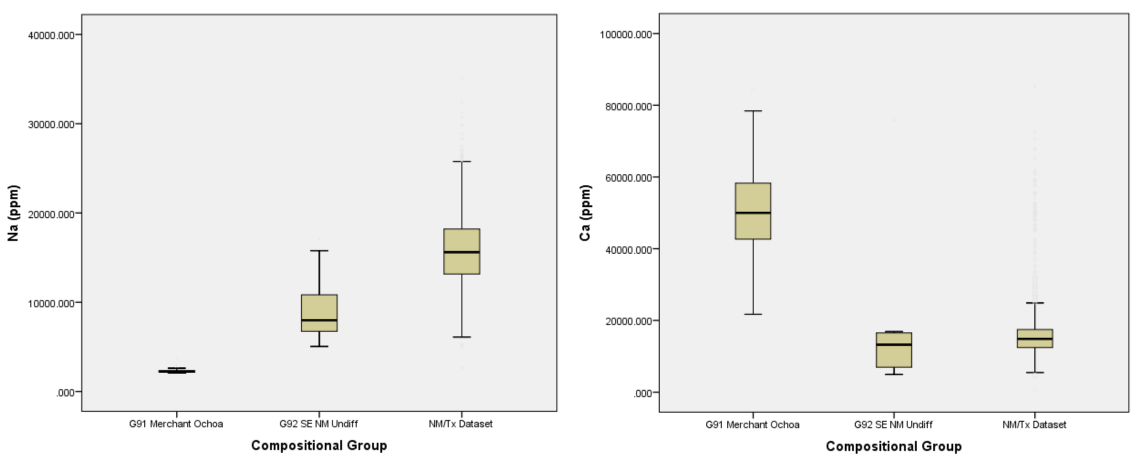

Figure 16.15. Boxplots comparing sodium and calcium concentrations (parts per million) for Merchant Ochoa Group 91, SE New Mexico Group 92, and the combined southeastern Southwest geochemical dataset.

The exceptionally low sodium and high calcium concentrations in Ochoa ware were thought to be related to the use of caliche rather than igneous rock as temper (Miller et al. 2016). However, this had not been confirmed through thin-section petrographic analysis. The use of bone temper, such as that used in the manufacture of Leon Plain ceramics at contemporaneous Toyah Phase sites of neighboring regions of central and Panhandle Texas (Kelley 1947; Johnson 1994), might impart a similar chemical profile. In light of the mass quantities of animal bone observed at the Merchant site, bone would have been a plentiful resource for ceramic temper.

A robust compositional profile had been established for Ochoa wares through the 2008 and 2014 NAA projects, but two issues had yet to be resolved: the petrographic aspects of the ware remained mostly unknown and it was also uncertain if additional production areas of Ochoa ware existed that might have a slightly different geochemistry than the primary Ochoa group defined by Alvarado (Group 1) and Miller and Ferguson (Group 91). Three integrated analyses were proposed to resolve these issues. First, additional samples of Ochoa ware ceramics recovered from the Merchant site investigations were submitted for compositional analysis using NAA. Second, it was proposed that a broader geographic sample of Ochoa ceramics should be analyzed. The intent of this study was to identify potential variation within the type itself. The scalar approach would narrow the focus from identifying Ochoa as a compositional group among the dozens of pan-regional compositional groups characterized by Miller and Ferguson (2014) and would instead examine Alvarado's data combined with new data to explore if minor variations exist within Ochoa wares that might identify different production areas across the Mescalero Plain and neighboring counties in Texas. The third component of the compositional analysis was petrography to identify the non-plastic inclusions in the paste of Ochoa ceramics.

Sampling Design

Eighty samples of Ochoa ware, Corona Corrugated, and clay and rock temper material collected during the 2019 survey and excavation projects were submitted for the NAA study. The original sampling design was intended to augment Alvarado's sample of 28 Ochoa ware sherds from the Merchant site with an additional sample of 22 sherds from well-documented excavation contexts for a total of 50 samples. The second component of the study was intended to provide a broader geographic coverage across the Mescalero Plain and further explore the regional production of Ochoa ware through an analysis of 50 samples from sites recorded during the two survey components of the project. Unfortunately, few Ochoa ware settlements and Ochoa ware ceramics were encountered during those surveys. A selection of only seven sherds was available from the Merchant Vicinity survey, all collected from the previously defined area of site LA 132848 located 1.2 km north of the Merchant village. Only two sherds were collected from LA 121688 of the Mescalero Plains survey of the Custer Mountain area, 32 km southeast of the Merchant site. A closer examination of the sherds in the laboratory determined that several were probably Corona Corrugated and those reassignments further reduced the geographic sample of Ochoa ware.

Accordingly, the sampling design was adjusted and a larger number of 65 sherds was submitted from the Merchant village. The increased sample number did allow for a more comprehensive sampling design that incorporated a greater range of ceramic attributes, as well as allowing for more robust statistical analysis of the NAA chemical data. Specifically, a wide range of variation in corrugation style, paste color, and vessel part could be sampled to explore the compositional variation among these attributes and technological differences.

The assemblage from each primary provenience—rooms, middens, extramural areas—was examined. Sherds of insufficient size for NAA (less than 2.5 cm) were removed, which as noted earlier constituted over 70 percent of the assemblage. Few rim sherds were of sufficient size for analysis, so only body sherds were selected. A stratified random sampling procedure was implemented to select sherds from the remaining subset of textured body sherds. A 5 to 10 percent sample of the textured body sherds was selected from each of the 11 excavated rooms, the two middens, and extramural areas. To provide background chemical data for local source materials, samples of clay and indurated caliche were collected from outcrops below the Merchant site, room interiors, and other locations in the vicinity of the San Simon swale.

Results and Classification

Analysis of the chemical data from the 80 samples followed the standard protocol of log-10 transformed element data, group assignments, and statistical assignment based on Mahalanobis probabilities (Bishop and Neff 1989; Neff 2002; see Appendix C.1). The samples were first analyzed as an independent group to identify Ochoa ware and Corona Corrugated compositional groups. The compositional groups were then cross-checked against the master NAA database to determine if any of the groups would classify with other known corrugated compositional groups.

Three compositional groups and one provisional group were identified among the samples of Ochoa ceramics. A fifth group identified among the sherds reclassified as Corona Corrugated matches the larger compositional group of this type identified in Alvarado's study. Bivariate scatterplots comparing the element concentrations of the groups are shown in Figures 16.16 and 16.17. The primary compositional group of Corona Corrugated, another common textured ware of southeastern New Mexico, is included for comparison. Clay and rock samples and unassigned outliers are not included in the plots.

The two small groups (Ochoa 2 and 4) were identified through visual inspection of elemental scatterplots. These small groups are difficult to statistically validate because of their low number of members. Robust statistical tests such as Mahalanobis distance require more members than variables. While it is possible to use a reduced number of variables through techniques such as principal component analysis, the tests remain unreliable with such small groups. These small groups represent distinct clusters, but they are also more prone to including unrelated members that can only be detected when future sampling increases the group membership to the point of allowing more robust tests. Thus, these small groups should be considered tentative.

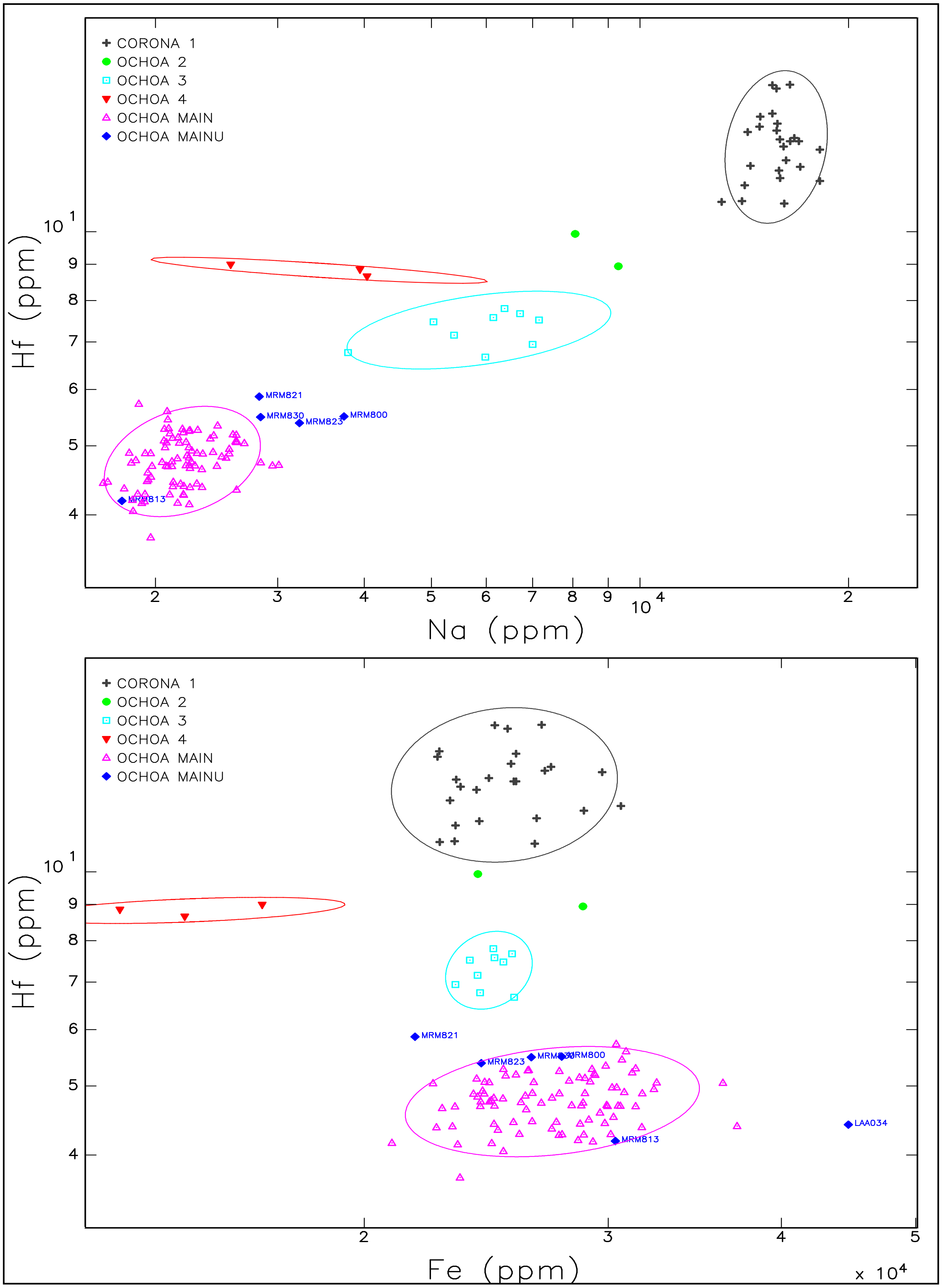

Figure 16.16. Ochoa ware and Corona Corrugated compositional groups. Bivariate plots of log-10 transformed element data for sodium and hafnium (upper panel) and iron and hafnium (lower panel). The ellipses represent 90% confidence intervals of group membership. Merchant Ochoa Main unassigned (U) samples are plotted against the Merchant Main Ochoa group.

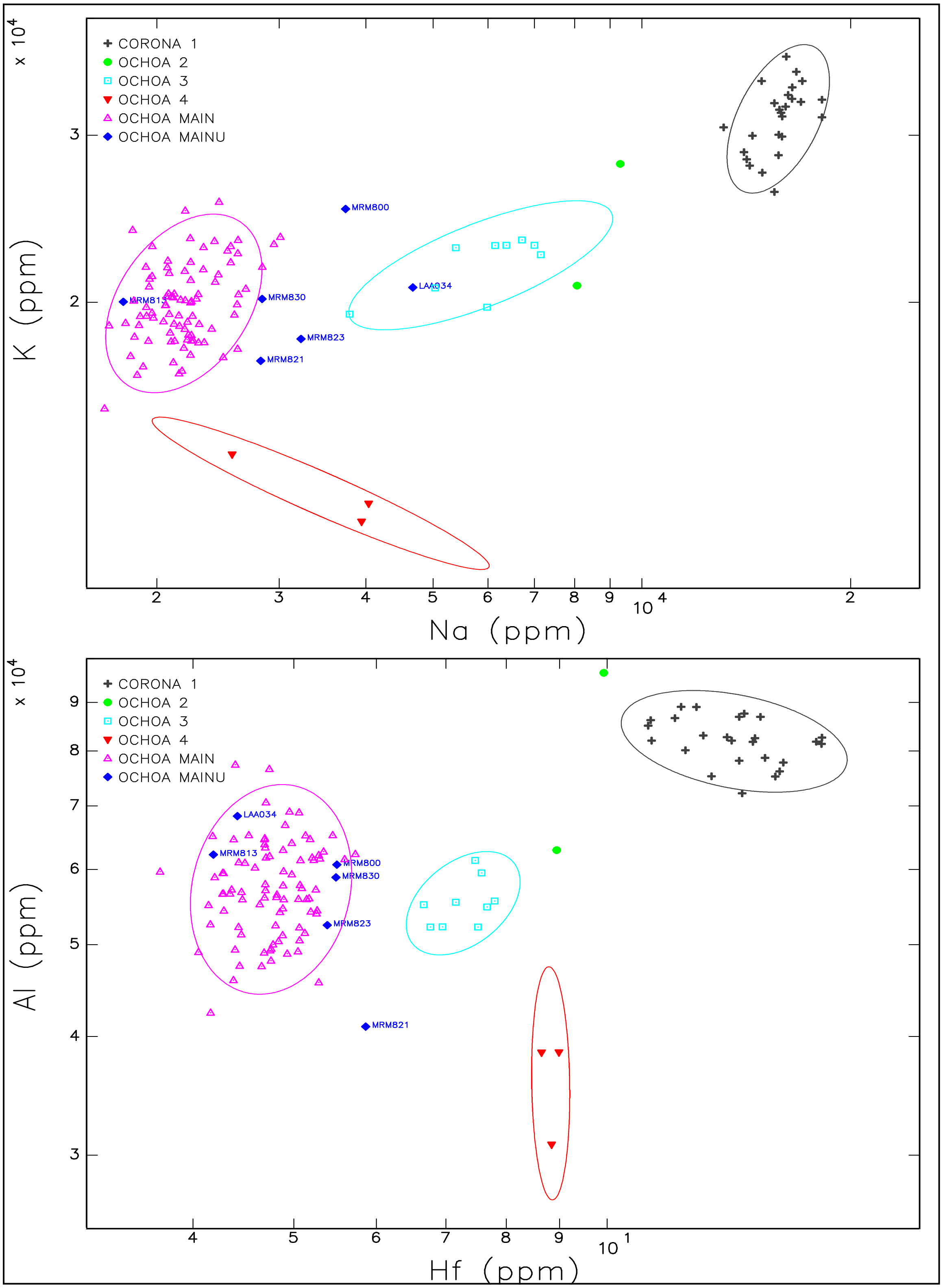

Figure 16.17. Ochoa ware and Corona Corrugated compositional groups. Bivariate plots of log-10 transformed element data for sodium and potassium (upper panel) and aluminum and hafnium (lower panel). The ellipses represent 90% confidence intervals of group membership. Merchant Ochoa Main unassigned (U) samples are plotted against the Merchant Main Ochoa group.

Corona Group 1 is included for comparison and to demonstrate the distinctiveness of the two primary textured ceramic types of southeastern New Mexico. It clearly discriminates from the Ochoa groups on several elements, including elevated concentrations of sodium (Na), potassium (K), aluminum (Al), and most rare earth elements such as tantalum (Ta). The Ochoa groups can be discriminated on aluminum, hafnium (Hf), thorium (Th), and iron (Fe), as well as several rare earth elements that are not included in the four plots.

Ochoa Group 3 is a well-defined cluster that tends to plot between Corona Group 1 and the other Ochoa groups. Ochoa Group 4 is a tentative group consisting of only three members with particularly low concentrations of Fe and Al. While it presently consists of only three members, those members consistently cluster on various elemental plots and it represents a probable production group. On the other hand, Ochoa Group 2 consists of only two consistent members and perhaps a few unassigned sherds, and those members sometimes plot widely apart on certain elemental graphs.

The Main Ochoa group is the primary cluster of specimens in Figures 16.16 and 16.17. This group was further refined by calculating group membership probability by Mahalanobis distance. Samples that usually plotted with the main group but were removed due to low membership probability are designated as Main Group unassigned (or MainU) to indicate that they have greater affiliation with the Main group than other unassigned specimens. Eight sherds could not be assigned to any group. The total of 13 unassigned specimens represents slightly less than 11 percent of the total sample of 121 sherds, and it should be noted that five of the 13 samples were isolated finds from peripheral areas of west Texas. This is a remarkably low proportion of unassigned samples for a typical NAA analysis and indicates that Ochoa ware was both chemically distinctive and chemically homogeneous.

Correspondence of Compositional Groups: As often happens during a series of NAA studies conducted over the course of several years, compositional groups are reorganized, members of groups are reassigned to other groups, nebulous groups are broken up, new groups emerge, and the provenance of certain groups is resolved through additional sampling and comparative analysis. This frequently results in a confusing series of group names, and the present study is no exception. Table 16.1 provides a summary of past and present groups so that the evolution can be tracked. It should be noted that the table is a work in progress, and certain groups may again change with additional sampling. For example, Ochoa Group 2 may be subsumed within another group and disappear.

Table 16.1. Correspondence of compositional groups, 2008–2021

This Study	Miller and Ferguson 2014	Alvarado 2008
Ochoa Group 1 Merchant Main Ochoa	SE New Mexico 1 (G91)	Group 1 (Merchant Ochoa)
Ochoa Group 2	SE New Mexico 2 (G92)	None
Ochoa Group 3 (Texas Ochoa 1)	SE New Mexico 2 (G92)	Group 2
Ochoa Group 4	None	Unassigned samples
Corona Group 1	Middle Pecos 1 (G95)	Group 5 (Corona corrugated)
Not used in this study	Middle Pecos 2 (G94)	Group 3 (Misc. corrugated)
Not used in this study	Middle Pecos 2 (G94)	Group 4 (Roswell Brown)

Group Assignments and Descriptions: The 138 individual group assignments are listed in Table 16.2. The table includes the 80 samples of the current study, Alvarado's 43 sherd and clay samples, and 15 sherds from Creel's central Texas and Chupadero studies.

Table 16.2. Ochoa ware NAA samples from the Merchant site and other locations in New Mexico and Texas

Group	MURR ANID #	Location	Site #	CN #	Sample Type	Context	Ware/Type	Petrography	Comment
Merchant village samples (Alvarado 2008; this study)									
Ochoa Main	MRM796	Merchant	LA43414	178	Ceramic	Midden B F110 L5	Ochoa ware		
Ochoa Main	MRM797	Merchant	LA43414	178	Ceramic	Midden B F110 L5	Ochoa ware		
Ochoa Main	MRM798	Merchant	LA43414	187	Ceramic	Midden B F110 L6	Ochoa ware		
Ochoa Main	MRM799	Merchant	LA43414	187	Ceramic	Midden B F110 L6	Ochoa ware		
Ochoa MainU	MRM800	Merchant	LA43414	172	Ceramic	Midden B F110 L4	Ochoa ware	Limestone/Sandstone	
Ochoa Main	MRM801	Merchant	LA43414	172	Ceramic	Midden B F110 L4	Ochoa ware		
Ochoa Main	MRM802	Merchant	LA43414	166	Ceramic	Midden B F110 L3	Ochoa ware		
Ochoa Main	MRM803	Merchant	LA43414	166	Ceramic	Midden B F110 L3	Ochoa ware		
Ochoa Main	MRM804	Merchant	LA43414	155	Ceramic	Midden B F110 L2	Ochoa ware		
Ochoa Main	MRM805	Merchant	LA43414	155	Ceramic	Midden B F110 L2	Ochoa ware		
Ochoa Main	MRM806	Merchant	LA43414	153	Ceramic	Midden B F110 L1	Ochoa ware		
Ochoa Main	MRM807	Merchant	LA43414	153	Ceramic	Midden B F110 L1	Ochoa ware	Limestone/Sandstone	
Ochoa Main	MRM808	Merchant	LA43414	153	Ceramic	Midden B F110 L1	Ochoa ware		
Ochoa Main	MRM809	Merchant	LA43414	153	Ceramic	Midden B F110 L1	Ochoa ware		
Ochoa Main	MRM810	Merchant	LA43414	35	Ceramic	Room 24 F400	Ochoa ware		Atypical tan paste
Ochoa Main	MRM811	Merchant	LA43414	24	Ceramic	Room 7 F7	Ochoa ware		Tan paste, high temp firing
Ochoa Main	MRM812	Merchant	LA43414	21	Ceramic	Room 7 F7	Ochoa ware		Atypical tan paste; Mn outlier
Ochoa MainU	MRM813	Merchant	LA43414	20	Ceramic	Room 7 F7	Ochoa ware		Atypical tan paste
Ochoa Main	MRM814	Merchant	LA43414	23	Ceramic	Room 7 F7	Ochoa ware		Atypical tan paste; Mn outlier
Ochoa Main	MRM815	Merchant	LA43414	23	Ceramic	Room 7 F7	Ochoa ware	Limestone/Sandstone	Atypical tan paste
Ochoa Main	MRM816	Merchant	LA43414	10	Ceramic	Room 7 F7	Ochoa ware		Atypical tan paste; Mn outlier
Ochoa Main	MRM817	Merchant	LA43414	10	Ceramic	Room 7 F7	Ochoa ware		Atypical tan paste; Mn outlier
Ochoa Main	MRM818	Merchant	LA43414	38	Ceramic	Room 24 F400	Ochoa ware		Atypical tan paste
Ochoa Main	MRM819	Merchant	LA43414	38	Ceramic	Room 24 F400	Ochoa ware		Atypical tan paste
Ochoa Main	MRM820	Merchant	LA43414	50	Ceramic	Room 13 F13	Ochoa ware		
Ochoa MainU	MRM821	Merchant	LA43414	167	Ceramic	Room 13 F13	Ochoa ware		
Ochoa Main	MRM822	Merchant	LA43414	180	Ceramic	Room 13 F13	Ochoa ware		
Ochoa MainU	MRM823	Merchant	LA43414	84	Ceramic	Room 13 F13	Ochoa ware		
Ochoa Main	MRM824	Merchant	LA43414	259	Ceramic	Room 6 F6	Ochoa ware		
Ochoa Main	MRM825	Merchant	LA43414	264	Ceramic	Room 6 F6	Ochoa ware		
Ochoa Main	MRM826	Merchant	LA43414	382	Ceramic	Room 24 F400	Ochoa ware	Limestone/Sandstone	
Ochoa Main	MRM827	Merchant	LA43414	65	Ceramic	Room 31 F401	Ochoa ware		

Group	MURR ANID #	Location	Site #	CN #	Sample Type	Context	Ware/Type	Petrography	Comment
Ochoa Main	MRM828	Merchant	LA43414	192	Ceramic	Room 26 F402	Ochoa ware		
Ochoa Main	MRM829	Merchant	LA43414	57	Ceramic	Room 26 F402	Ochoa ware		
Ochoa MainU	MRM830	Merchant	LA43414	60	Ceramic	Room 26 F402	Ochoa ware		
Ochoa Main	MRM831	Merchant	LA43414	58	Ceramic	Room 30 F403	Ochoa ware		
Ochoa Main	MRM832	Merchant	LA43414	72	Ceramic	Room 25 F404	Ochoa ware		
Ochoa Main	MRM833	Merchant	LA43414	306	Ceramic	Room 25 F404	Ochoa ware		
Ochoa Main	MRM834	Merchant	LA43414	311	Ceramic	Room 25 F404	Ochoa ware		
Ochoa Main	MRM835	Merchant	LA43414	76	Ceramic	Room 25 F404	Ochoa ware		
Ochoa Main	MRM836	Merchant	LA43414	71	Ceramic	Room 55 F405	Ochoa ware		
Ochoa Main	MRM837	Merchant	LA43414	344	Ceramic	Room 27 F406	Ochoa ware		Ca outlier
Ochoa Main	MRM838	Merchant	LA43414	102	Ceramic	Room 27 F406	Ochoa ware		
Ochoa Main	MRM839	Merchant	LA43414	101	Ceramic	Room 27 F406	Ochoa ware		
Ochoa Main	MRM840	Merchant	LA43414	205	Ceramic	Room 28 F407	Ochoa ware		
Ochoa Main	MRM841	Merchant	LA43414	212	Ceramic	Room 28 F407	Ochoa ware		
Ochoa Main	MRM842	Merchant	LA43414	213	Ceramic	Room 28 F407	Ochoa ware		
Ochoa Main	MRM843	Merchant	LA43414	143	Ceramic	Extramural F408	Ochoa ware		
Ochoa Main	MRM844	Merchant	LA43414	105	Ceramic	Extramural F408	Ochoa ware		Ca outlier
Ochoa Main	MRM845	Merchant	LA43414	114	Ceramic	Extramural F408	Ochoa ware		
Ochoa Main	MRM846	Merchant	LA43414	389	Ceramic	Extramural F408	Ochoa ware		
Ochoa Main	MRM847	Merchant	LA43414	394	Ceramic	Extramural F409	Ochoa ware		Ca outlier
Ochoa Main	MRM848	Merchant	LA43414	130	Ceramic	Extramural F409	Ochoa ware		
Ochoa Main	MRM849	Merchant	LA43414	394	Ceramic	Extramural F409	Ochoa ware	Limestone/Sandstone	
Ochoa Main	MRM850	Merchant	LA43414	197	Ceramic	Midden C F412	Ochoa ware		
Ochoa Main	MRM851	Merchant	LA43414	195	Ceramic	Midden C F412	Ochoa ware		
Ochoa Main	MRM852	Merchant	LA43414	276	Ceramic	Room 49 F413	Ochoa ware	Limestone/Sandstone	Ca outlier
Ochoa Main	MRM853	Merchant	LA43414	269	Ceramic	Room 49 F413	Ochoa ware		Ca outlier
Ochoa Main	MRM854	Merchant	LA43414	340	Ceramic	Extramural F415	Ochoa ware		
Ochoa Main	MRM855	Merchant	LA43414	380	Ceramic	Extramural F416	Ochoa ware		Ca outlier
Ochoa Main	MRM856	Merchant	LA43414	247	Ceramic	Room 29 F410	Ochoa ware		
Ochoa Main	MRM857	Merchant	LA43414	361	Ceramic	Room 29 F410	Ochoa ware		
Ochoa Main	MRM858	Merchant	LA43414	255	Ceramic	Room 29 F410	Ochoa ware		
Ochoa Main	MRM859	Merchant	LA43414	338	Ceramic	Room 28 F407	Ochoa ware		
Ochoa Main	MRM860	Merchant	LA43414	126	Ceramic	Room 28/29 F407/410	Ochoa ware		
Ochoa Main	LAA027	Merchant	LA43414		Ceramic	1984 surface collection	Ochoa ware		
Ochoa Main	LAA028	Merchant	LA43414		Ceramic	1984 surface collection	Ochoa ware		

Group	MURR ANID #	Location	Site #	CN #	Sample Type	Context	Ware/Type	Petrography	Comment
Ochoa Main	LAA029	Merchant	LA43414		Ceramic	1984 surface collection	Ochoa ware		
Ochoa Main	LAA030	Merchant	LA43414		Ceramic	1984 surface collection	Ochoa ware		
Ochoa Main	LAA031	Merchant	LA43414		Ceramic	1984 surface collection	Ochoa ware		
Ochoa Main	LAA032	Merchant	LA43414		Ceramic	1984 surface collection	Ochoa ware		
Ochoa Main	LAA033	Merchant	LA43414		Ceramic	1984 surface collection	Ochoa ware		
Ochoa MainU	LAA034	Merchant	LA43414		Ceramic	1984 surface collection	Ochoa ware		
Ochoa Main	LAA035	Merchant	LA43414		Ceramic	1984 surface collection	Ochoa ware		
Ochoa Main	LAA036	Merchant	LA43414		Ceramic	1984 surface collection	Ochoa ware		
Corona Group 1	LAA037	Merchant	LA43414		Ceramic	1984 surface collection	Ochoa ware	Fe-rich sandstone	Corona NAA group
Ochoa Main	LAA038	Merchant	LA43414		Ceramic	1984 surface collection	Ochoa ware		
Ochoa Main	LAA039	Merchant	LA43414		Ceramic	1984 surface collection	Ochoa ware		
Ochoa Main	LAA040	Merchant	LA43414		Ceramic	1984 surface collection	Ochoa ware		
Ochoa Main	LAA041	Merchant	LA43414		Ceramic	1984 surface collection	Ochoa ware		
Ochoa Main	LAA042	Merchant	LA43414		Ceramic	1984 surface collection	Ochoa ware		
Ochoa Main	LAA043	Merchant	LA43414		Ceramic	1984 surface collection	Ochoa ware		
Ochoa Main	LAA044	Merchant	LA43414		Ceramic	1984 surface collection	Ochoa ware		
Ochoa Main	LAA045	Merchant	LA43414		Ceramic	1984 surface collection	Ochoa ware		
Ochoa Main	LAA046	Merchant	LA43414		Ceramic	1984 surface collection	Ochoa ware		
Ochoa Main	LAA047	Merchant	LA43414		Ceramic	1984 surface collection	Ochoa ware		
Ochoa Main	LAA048	Merchant	LA43414		Ceramic	1984 surface collection	Ochoa ware		
Ochoa Main	LAA049	Merchant	LA43414		Ceramic	1984 surface collection	Ochoa ware		
Ochoa Main	LAA050	Merchant	LA43414		Ceramic	1984 surface collection	Ochoa ware		
Ochoa Group 3	LAA051	Merchant	LA43414		Ceramic	1984 surface collection	Ochoa ware	Limestone/Sandstone	Sole ID of another Ochoa
Ochoa Main	LAA052	Merchant	LA43414		Ceramic	1984 surface collection	Ochoa ware		
Ochoa Main	LAA053	Merchant	LA43414		Ceramic	1984 surface collection	Ochoa ware		
Ochoa Main	LAA054	Merchant	LA43414		Ceramic	1984 surface collection	Ochoa ware		
Salt Cedar site (41AD2), Andrews County, Texas (Alvarado 2008; Creel et al. 2013)									
Ochoa Group 3	OT0402	Salt Cedar	41AD2		Ceramic	Collins (1968)	Ochoa ware		
Ochoa Group 3	OT0404	Salt Cedar	41AD2		Ceramic	Collins (1968)	Ochoa ware		
Ochoa Group 3	OT0405	Salt Cedar	41AD2		Ceramic	Collins (1968)	Ochoa ware		
Ochoa Group 3	OT0406	Salt Cedar	41AD2		Ceramic	Collins (1968)	Ochoa ware		
Ochoa Group 3	OT0408	Salt Cedar	41AD2		Ceramic	Collins (1968)	Ochoa ware		
Ochoa Group 3	OT0409	Salt Cedar	41AD2		Ceramic	Collins (1968)	Ochoa ware		
Ochoa Group 4	OT0403	Salt Cedar	41AD2		Ceramic	Collins (1968)	Ochoa ware		

Group	MURR ANID #	Location	Site #	CN #	Sample Type	Context	Ware/Type	Petrography	Comment
Ochoa Group 4	OT0401	Salt Cedar	41AD2		Ceramic	Collins (1968)	Ochoa ware		
Unassigned	OT0407	Salt Cedar	41AD2		Ceramic	Collins (1968)	Ochoa ware		
Other Sites in southeast New Mexico and west Texas (Alvarado 2008; Creel et al. 2013; this study)									
Ochoa Main	MRM785	Merchant TRU	LA43414	463	Ceramic	Surface collection	Ochoa ware		
Ochoa Main	MRM786	Merchant TRU	LA43414	464	Ceramic	Surface collection	Ochoa ware		
Ochoa Group 2	MRM790	Mesc Plains	LA121668	37	Ceramic	Surface collection	Ochoa ware		
Ochoa Group 2	OT0470	n/a	Q:5:5		Ceramic	Surface collection	Ochoa ware		Crane County, TX
Unassigned	LAA019	n/a	Isolate		Ceramic	Surface collection	Ochoa ware		Crane County, TX
Unassigned	UT235	n/a	41TA202		Ceramic	Surface collection	Ochoa ware		Taylor County, TX
Unassigned	UT257	n/a	41NL10		Ceramic	Surface collection	Ochoa ware?		Nolan County, TX
Ochoa Group 3	LAA089	n/a	Q:10:2		Ceramic	Surface collection	Ochoa ware		[UT0042] Crane County, TX
Ochoa Group 3	LAA090	n/a	Q:10:8		Ceramic	Surface collection	Ochoa ware		[UT0043] Crane County, TX
Ochoa Group 4	LAA085	n/a	L:3:5		Ceramic	Surface collection	Ochoa ware		[UT0038] Gaines County, TX
Unassigned	MRM789	Mesc Plains	LA121688	14	Ceramic	Surface collection	Ochoa ware?		May be Corona Corrugated
Unassigned	OT0400	n/a	1N-8		Ceramic	Surface collection	Ochoa ware		Potter County, TX
Unassigned	UT266	n/a	41TA103		Ceramic	Surface collection	Ochoa ware		Taylor County, TX
Unassigned	UT205	n/a	41IR38		Ceramic	Surface collection	Ochoa ware		Irion County, TX
Unassigned	MRM781	Merchant TRU	LA43414	462	Ceramic	Surface collection	Corona Corr		Unassigned Corona
Corona Group 1	MRM782	Merchant TRU	LA43414	468	Ceramic	Surface collection	Corona Corr		
Corona Group 1	MRM783	Merchant TRU	LA43414	468	Ceramic	Surface collection	Corona Corr	Fe-rich sandstone	
Corona Group 1	MRM787	Merchant TRU	LA43414	466	Ceramic	Surface collection	Corona Corr		
Corona Group 1	MRM788	Merchant TRU	LA43414	467	Ceramic	Surface collection	Corona Corr		
Clay and rock samples (Alvarado 2008; this study)									
Distant outlier	MRM784	Merchant TRU	LA43414	468	Rock	From sherd	n/a		Large grain in paste of MRM783
Distant outlier	MRM795	Merchant	LA43414	361	Rock	Room 29 F410	n/a		Indurated caliche from room
Outlier	MRM791	Merchant	LA43414	473	Clay	Natural stratum	n/a		Stratum 650 west of village
Outlier	MRM792	Merchant	LA43414	445	Clay	Natural stratum	n/a		Escarpment below Merchant
Outlier	MRM793	Merchant	LA43414	433	Clay	Natural stratum	n/a		From arroyo in escarpment

Group	MURR ANID #	Location	Site #	CN #	Sample Type	Context	Ware/Type	Petrography	Comment
Outlier	MRM794	Merchant	LA43414	413	Clay	Room 7 F7	n/a		Clay from adobe wall of
Outlier	LAA095	Salt Cedar	41AD2		Clay	Fired clay	n/a		Andrews County
Outlier	LAA096	n/a	Q:10:6		Clay	Fired clay	n/a		Crane County
Outlier	LAA097	Merchant	LA43414		Clay	Natural stratum	n/a		Chinle Formation grey
Outlier	LAA098	Merchant	LA43414		Clay	Natural stratum	n/a		Chinle Formation grey
Outlier	LAA099	Merchant	LA43414		Clay	Natural stratum	n/a		Chinle Formation grey
Outlier	LAA100	Merchant	LA43414		Clay	Natural stratum	n/a		Ogallala clay loam
Outlier	LAA101	Merchant	LA43414		Clay	Natural stratum	n/a		Ogallala clay loam
Outlier	LAA102	n/a	Non-site		Clay	Natural stratum	n/a		Blackwater clay loam
Outlier	LAA103	n/a	Non-site		Clay	Natural stratum	n/a		Blackwater clay loam
Outlier	LAA104	n/a	Non-site		Clay	Natural stratum	n/a		Tahoka clay loam
Outlier	LAA105	n/a	Non-site		Clay	Natural stratum	n/a		Tahoka clay loam

Merchant TRU = Merchant Vicinity TRU survey (Graves et al. 2021a)
Mesc Plains = Mescalero Plains survey (Graves et al. 2021b)
Ochoa MainU = probable Ochoa Main group but unassigned due to marginal probability of group membership
Mn = manganese Ca = calcium Fe = iron

Group 1, Merchant Main Ochoa: Group 1 is the primary compositional group of Ochoa ware, at least until a future time when Ochoa phase sites in Texas are more intensively sampled. The group has remained consistent through three classifications performed over 13 years, including Alvarado's 2008 analysis, the 2014 regional NAA classification (Miller and Ferguson 2014), and the present study.

Of the 28 Ochoa ware sherds submitted from the Merchant site as part of Alvarado's study, 25 were assigned to his Group 1 based on Mahalanobis distance probabilities. Two sherds (LAA037 and LAA051) were assigned to other groups and LAA034 was unassigned. In 2014, the same 28 samples were included in the regional analysis of the southeast Southwest NAA database and the group assignments made in 2008 were confirmed. For the most part, the original group assignments remain unchanged in the present analysis. The only significant change is that LAA037 has been identified as a Corona Corrugated sherd and is no longer included among the Ochoa samples from Merchant. Sample LAA034 has been designated as one of the Merchant Main Ochoa Unassigned sherds.

Compositional Homogeneity of the Merchant Main Ochoa Group: The Merchant Main Ochoa group subsumes all of the technological and design variation—including paste, surface finish, corrugation treatment, and sooting—observed among the total assemblage of Ochoa wares from the Merchant village. The chemical group exhibits, however, a remarkable degree of homogeneity in element concentrations. Figure 16.18 displays bivariate plots of a selection of eight elements. A few sherds with slight variations in element concentrations appear in each plot but overall, the point clouds are consistently and evenly distributed.

The bivariate plots of 30 of the suite of 32 measured elements are essentially the same. The only variation among the entire suite of elements was observed for Ca and Mn (Figure 16.19; see Table 16.2) where small clusters of 4 to 6 outliers are present. The cluster of slightly lower Ca concentrations consists of six sherds from Rooms 26, 27, and 49 and the adjacent extramural activity area. The cluster of four Mn outliers are among the group of sherds with atypical tan pastes collected from Rooms 7 and 24 in the southern room block. Each of these variations are very minor and should not be considered separate groups or subgroups. For example, while four sherds with tan pastes have slightly higher Mn concentrations, six sherds with identical pastes from the same rooms all plot within the central point cloud of the Merchant Main Ochoa group. No systematic or patterned variation was found among the chemical profiles of sherds with different surface finishes, corrugation treatments, or sherds with sooted or burned exteriors.

The Unique Geographic Distribution of the Merchant Main Ochoa Group: While the geochemistry of the Merchant Main Ochoa group is highly distinctive, the geographic distribution of the group is equally unique and informative. One of the more intriguing aspects of this compositional group is its restricted geographic distribution. It is found exclusively at the Merchant site and, in turn, almost all the Ochoa ware samples from the Merchant village site are assigned to this single group.

If the Merchant Ochoa Main Unassigned samples are included (which they probably should be given their distinctiveness from any other chemical group), then 100 percent of the 65 sherds of the present study submitted from rooms, middens, and extramural areas belong to that single chemical group. A similar distribution is evident among Alvarado's samples from the Merchant site. Excluding the sample assigned to Corona Group 1, 26 of 27 (96 percent) of Alvarado's samples belong to the main group. Combining the samples from both studies, a total of 92 of the 93 of the Ochoa ware samples (98 percent) from Merchant are assigned to a single chemical compositional group.

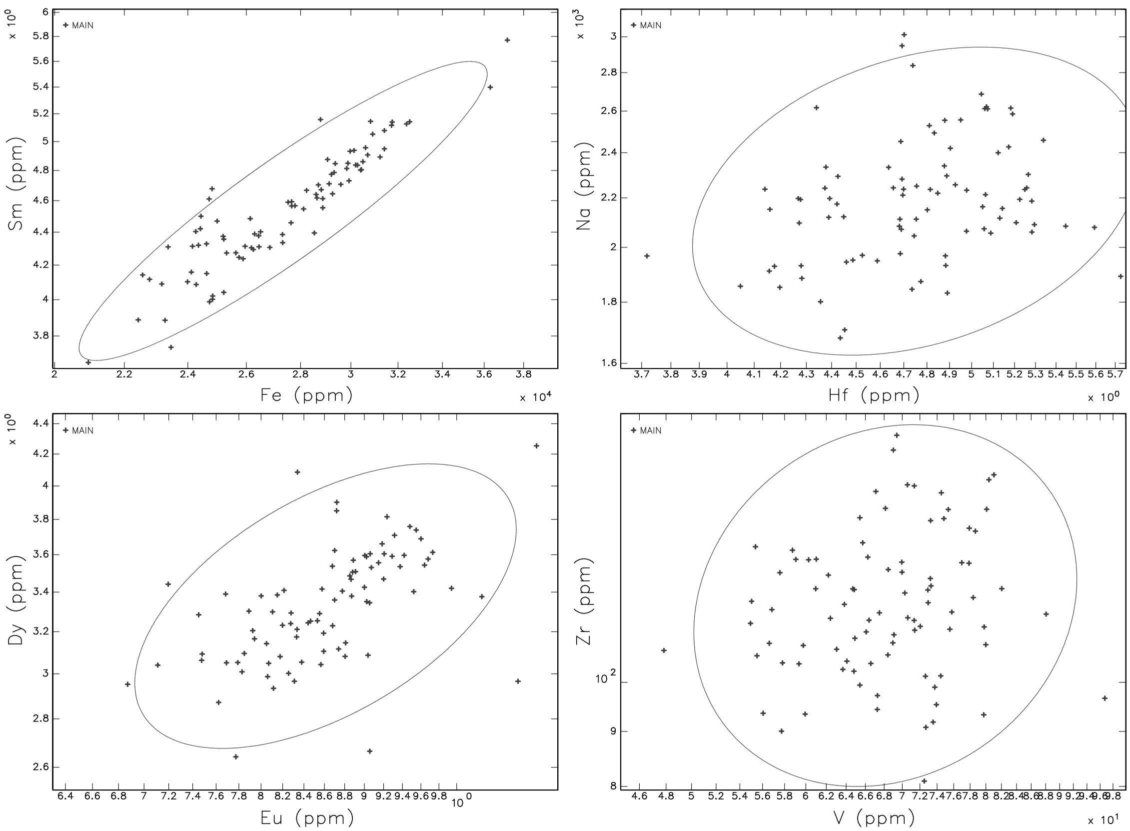

Figure 16.18. Bivariate scatterplots of log-transformed element concentrations illustrating the chemical homogeneity of the Merchant Main Ochoa group. Ellipses represent the 95% confidence intervals of variation for each pair of elements.

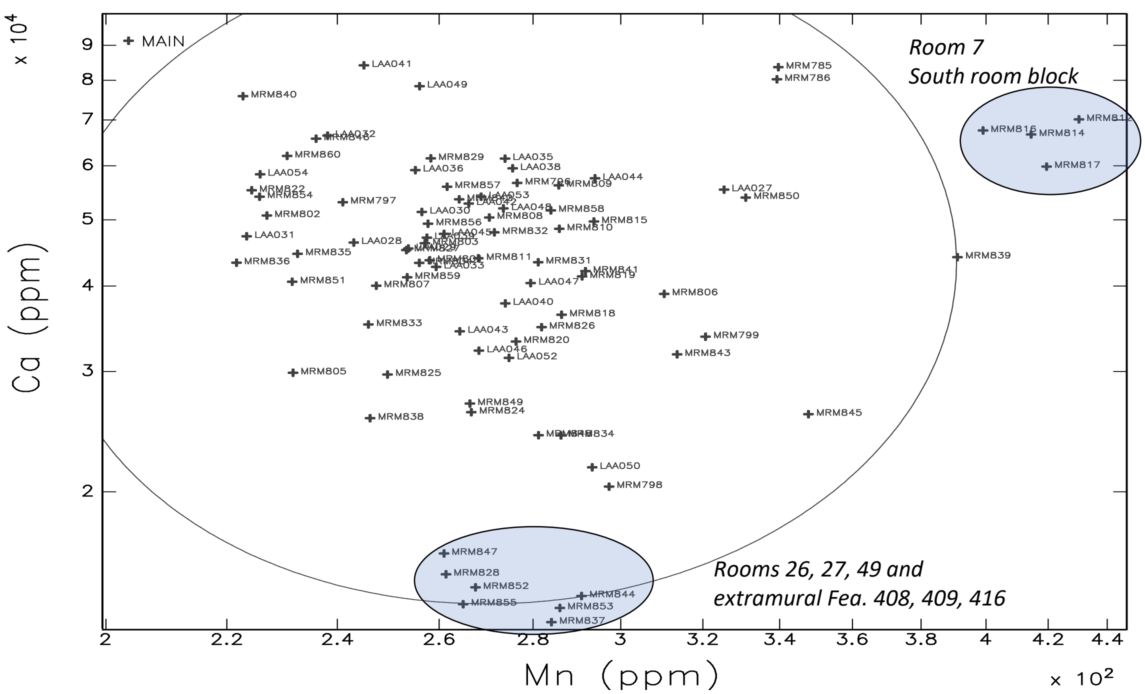

Figure 16.19. Slight variations of calcium and manganese concentrations among the Merchant Ochoa Main samples.

This is an exceptionally rare occurrence among site-specific assemblages of geochemical compositional groups, at least in the southeastern Southwest. Reviewing the 2014 classification study, it is found that of the 24 sites with at least 10 NAA samples, only the Tortolita site (LA 89652) of Otero County, south-central New Mexico (see Hard 1997), has a similar degree of assemblage homogeneity with all sherds assigned to a single chemical group. The typical NAA profiles of most sites in southeastern New Mexico consist of two to five compositional groups, even at small pithouse settlements.

In addition to the Merchant Ochoa Main group being the dominant chemical group, it is also noteworthy that no occurrences of the group have been identified beyond the Merchant site. The group has not been identified among the samples from the Salt Cedar site or other locations in Texas or southeastern New Mexico, although this may be due to sampling bias in that so few Ochoa sherds and even fewer Ochoa-bearing sites have been sampled. However, considering the primacy of the group at a village of the size and population of the Merchant site, one would expect at least one or two such sherds would show up among the samples from western Texas and southeastern New Mexico, but that is not the case. These observations are considered in greater depth in the chapter and report summary discussions.

Ochoa Group 3 (Texas Ochoa 1): Group 3 is a well-defined and chemically distinct group of 9 samples that appears to be centered in the southeastern Texas Panhandle area. It could tentatively be referred to as Texas Ochoa Group 1 because six of the nine samples from the Salt Cedar site in Andrews County, Texas are assigned to the group, as are two samples from Crane County, Texas. Also noteworthy is that sample LAA051 has been assigned to Group 3. This is the only sherd of the 93 Ochoa samples from the Merchant village that was not assigned to the Merchant Main Ochoa group.

The same group of samples was originally assigned to Alvarado's Group 2, although the nature and provenance of the group was somewhat complicated by the fact that it also included several sherds of Seco Corrugated and Corona Corrugated from the Henderson site. Those samples have now been assigned to different groups.

Group 3 sometimes plots between the Merchant Main Ochoa group and the southeastern SW groups but is generally much more compositionally similar to Ochoa in the majority of plots, including those of Al, Ta, and Th (see Figures 16.16 and 16.17). Moreover, as discussed in greater detail below, Group 3 has a very similar paste and temper composition to the Merchant Main Ochoa group.

Ochoa Group 2: Ochoa 2 is a poorly defined group of two samples and perhaps a few unassigned outliers. It has some similarities to the SE New Mexico 2 group defined in 2014—a rather amorphous collection of plain and corrugated sherd samples from Southeastern New Mexico and the southern Texas Panhandle. Only two Ochoa ware samples have been assigned to this group: an Ochoa sherd from LA 121668 located on the Mescalero Plain, 30 km southeast of the Merchant site and one from site Q:5:5 in Crane County, Texas. Alvarado's sample LAA019, an isolated sherd from Crane County, and two samples from Taylor and Nolan counties, Texas, plot near the Group 2 samples on some elements but cannot be confidently assigned to the group.

As discussed below, the Group 2 specimens are similar to other Ochoa groups on certain elements while also plotting among the SE SW groups on other elements. Group 2 members do not have the low sodium concentrations or the high calcium concentrations that characterize the other three Ochoa groups, suggesting a different production area. To test whether the Group 2 samples were perhaps misclassified sherds from other SE SW types or wares, the chemical data was projected against the 2,151 samples of the SE SW dataset and the 600 samples of the central Texas dataset. The two Group 2 and three unassigned (possible Group 2) samples have 0.0 probabilities of group membership with any SE SW or central Texas compositional group.

<u>Ochoa Group 4</u>: This is a tentative group of just three samples, two from the Salt Cedar site in Andrews County and one from a location in Gaines County a few miles north of the Salt Cedar site. The samples tend to plot with the Merchant Main Ochoa group on some elements, but often clearly form a separate cluster on metallic elements Al, Fe, and K.

Ochoa Groups 2 and 4 are small groups with only two or three members at the present time. Caution is warranted when interpreting such small groups. Statistical validation is difficult because of the "group to variable" problem of Mahalanobis distance classification and similar multivariate procedures. With additional sampling, such groups often evolve into well-defined compositional groups. In other cases, however, they may simply represent chemical anomalies and statistical outliers. Group 4 and especially Group 2 should be considered tentative until a larger sample of Ochoa ceramics from locations in Texas is available.

<u>Corona Group 1</u>: Although not an Ochoa compositional group, the Corona Group 1 merits discussion. Four sherds identified as Ochoa ware in the field during the Merchant Vicinity Survey were reclassified as Corona Corrugated. The reclassifications were confirmed through the NAA data and classification procedure that assigned the four samples to a group matching Alvarado's Group 5 and Miller and Ferguson's Middle Pecos 1 (Group 95). Both groups consist of the majority of Corona Corrugated ceramics from the Henderson site. Additionally, sample LAA037 is another sherd identified as Ochoa ware that was found to chemically match Corona Group 1. Sample LAA037 and MRM783 were included in the petrographic analysis and were found to be petrographically distinct from the Merchant Main Ochoa samples.

The Chemical Distinctiveness of Ochoa Ware: The Merchant Main Ochoa group, as well as Ochoa Groups 3 and 4, are the most chemically distinctive compositional groups of the entire southeastern Southwest (SE SW) NAA database examined by Miller and Ferguson (2014). As shown in Figure 16.20, three of the Ochoa groups clearly separate from all of the SE SW compositional groups on the basis of their low concentrations of rare earth lanthanide elements Europium (Eu) and Ytterbium (Yb), low concentrations of metal and transition metal elements aluminum (Al), sodium (Na), thorium (Th), and tantalum (Ta), and high concentrations of calcium (Ca). The two Ochoa Group 2 samples appear to fall within the larger plots of the SE SW igneous-tempered sherds, but they cannot be assigned to any groups within that data set.

The higher sodium concentrations reflect the use of igneous tempers and clay sources derived from igneous rocks. As noted by Hill (1988, 1990, 2019), the Lincoln County porphyry belt of the Capitan and Sierra Blanca mountains and igneous rock formations of mountain chains bordering the Tularosa and Hueco basins are the source of tempers used in El Paso brownware, Jornada brownware, Corona Corrugated, and other major wares of southern New Mexico. Those chemical signatures are absent in samples of Ochoa ware.

Additional comparisons can be made against the 385 samples of bone tempered Leon Plain and Goliad Plain ceramics from central Texas characterized during the Central Texas Ceramics project (Creel et al. 2013). Figure 16.21 compares the 88 Merchant Main Ochoa samples to the central Texas and southeastern Southwest samples. While it might be tempting to conclude that Ochoa ware had a geographic or cultural connection to the brownware technologies of Late Prehistoric and Historic central Texas, it should be emphasized that the figure is intended only to demonstrate the general chemical similarities of paste compositions based on a combination of non-igneous and calcium-rich tempering material. Ochoa ware falls within a chemical spectrum of low sodium concentrations similar those identified among the majority of central Texas samples, presumably owing to the absence of igneous tempering material that is common among ceramic wares of the southeastern Southwest. On the other hand, the median calcium concentration of Ochoa is slightly lower than most of the bone tempered ceramics. Apparently, the use of bone temper often imparts an even higher concentration of calcium to the chemical signature of the paste.

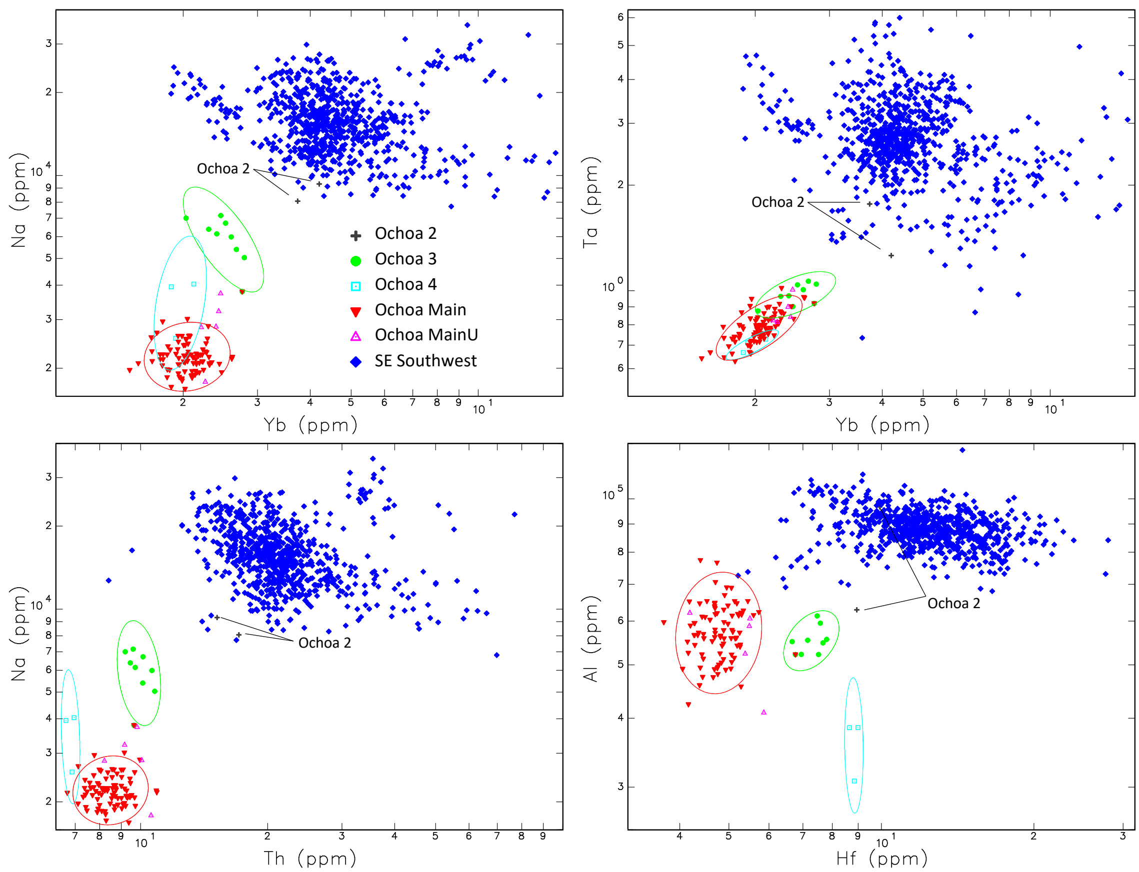

Figure 16.20. Scatterplots of log-10 transformed element concentrations comparing the four Ochoa compositional groups to the combined groups of the southeastern SW NAA database.

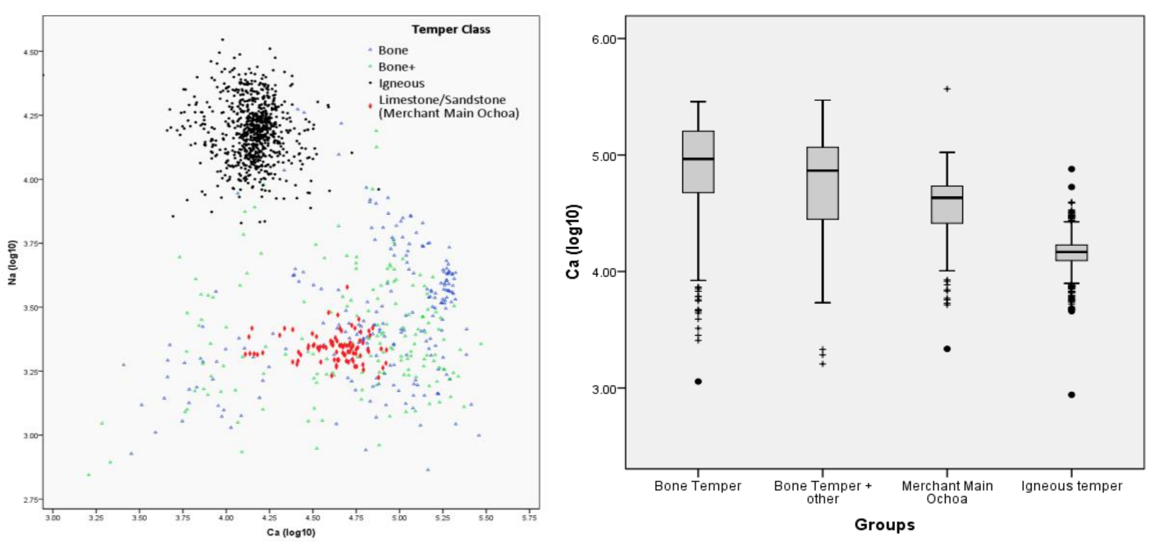

Figure 16.21. Plot of the Merchant Main Ochoa samples compared to the SE SW database of igneous-tempered ceramics and the Central Texas NAA database of bone tempered types.

Clay Samples

Seventeen clay and rock samples were submitted in 2008 and 2019. Alvarado submitted five clay samples collected from the vicinity of the Merchant site, four clay samples from Gaines County, Texas, and two "fired clay" samples from sites in Andrews and Crane counties, Texas. As part of the 2019 study, three clay samples collected from deposits below the Merchant site and around the San Simon swale were submitted. A fourth sample of clay comprising the floor of Room 7 was also submitted as an example of a local clay.

Two rock samples were submitted in an attempt to provide background chemical data on the local caliche and limestone. One (MRM795) was a fragment of limestone from below the floor of Room 29 and the second (MRM784) was a large fragment of igneous rock that was incorporated into the paste of a Corona Corrugated sherd (Figure 16.15). Both samples plot as distant outliers on almost all element bivariate graphs and will not be considered further.

The analysis of raw clay samples found that they do not match the chemical composition of the locally produced Ochoa ceramics. These results are quite common among ceramic compositional studies. Ceramic paste preparation involved significant modifications of raw clay material through mixing of two or more sources, addition of tempering material, and/or levigating to extract the fine-grained particles that might differ in composition from the coarser-grained component of a clay deposit. Raw clay samples usually plot at considerable distances from ceramic compositional groups on bivariate or 3-D plots and usually have low to non-existent probabilities of group membership based on multivariate statistics.

This situation is present among the Merchant project clay samples. Using a reduced variable set based on principal components, Alvarado observed some moderate probabilities of group membership of his clay samples and his Group 2 (Ochoa Group 3 in the present study). However, this included the four clay samples from the Merchant site as well as the samples from Gaines County, Texas. For the current study, the 15 clay samples submitted in 2008 and 2019 were projected against the total Merchant Main Ochoa dataset of 88 sherds. None of the 15 clays, including the nine samples collected from the Merchant site and around the San Simon swale, can be assigned to the group on statistical grounds.

Plotting clay samples against compositional groups reveals some trends of interest. Although none of the clays can be assigned to a group through statistical procedures, some similarities are evident in the plots (Figure 16.22). First, it is evident that the group of clays as a whole tend to match the distinctive chemistry of the three or four Ochoa ware groups as opposed to Corona Corrugated and other ceramic types of southeastern New Mexico. Second, there are some general (albeit inconsistent) patterns where clays from the Merchant site tend to plot near the Merchant Main Ochoa group and Ochoa 3 while clays from Gaines County plot near Ochoa Group 4. On the other hand, as Alvarado noted in his classification, several clays from the Merchant site also seem to be related to Ochoa Group 3 which does not make sense unless the Ochoa ware at the Salt Cedar site was manufactured in the vicinity of the San Simon swale.

It is relatively certain that the Ochoa ceramics from the Merchant site assigned to the Merchant Main Ochoa compositional group (as well as most of the other the 12,000 sherds not submitted for NAA) were produced at the village. However, analysis of clay samples did not help corroborate or identify the subregions or specific locations where the clays used manufacture the Ochoa vessels were obtained beyond a general southeastern New Mexico and west-central Texas production area. Future studies should include the analysis of "cookies" consisting of local clays combined with the various tempering material identified through the petrographic study to evaluate whether a particular combination matches a compositional group.

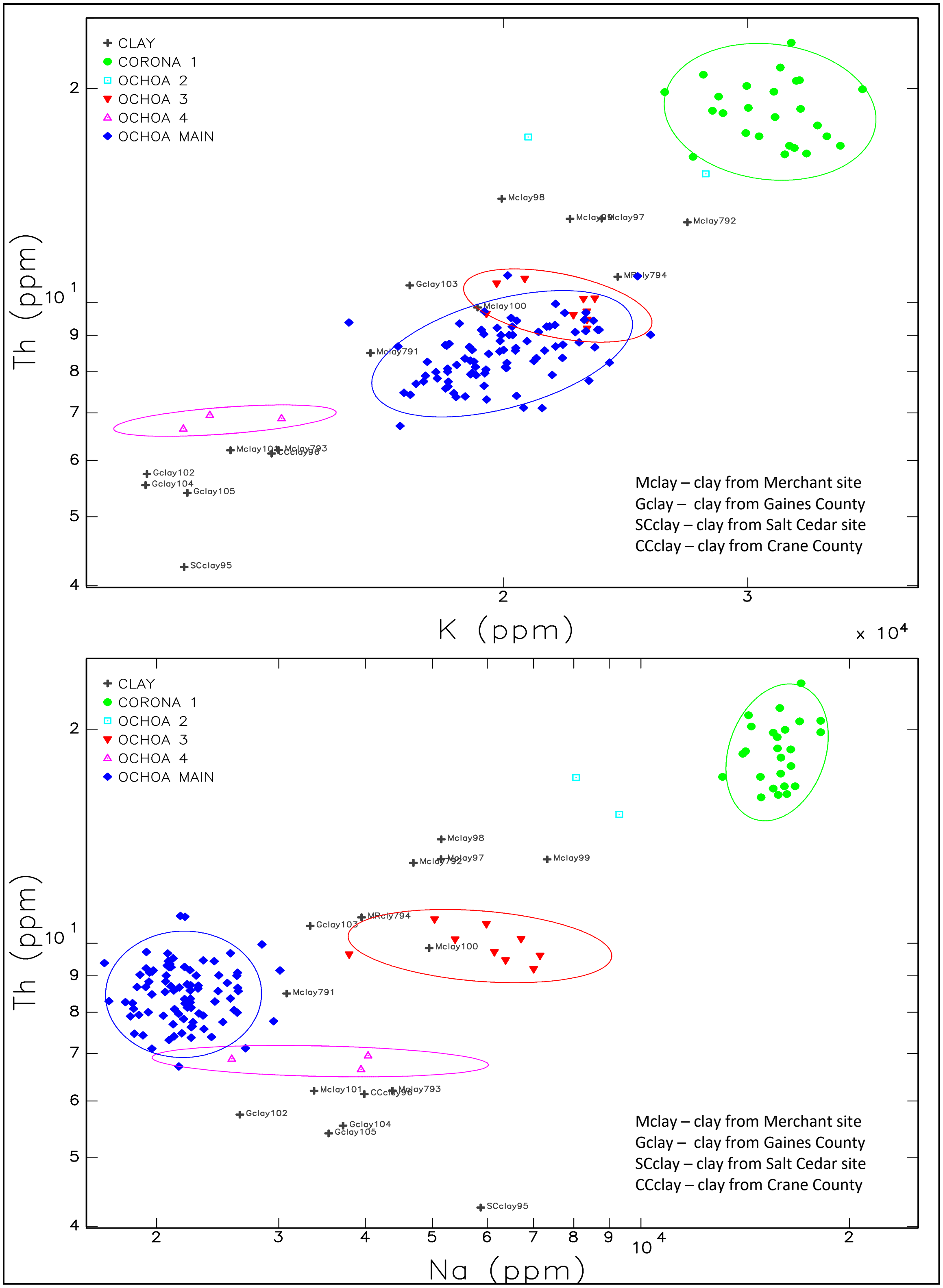

Figure 16.22. Plot of clay samples against Ochoa and Corona compositional groups.

Petrographic Analysis

Petrography is the third component of the Ochoa ware compositional analysis. A sample of 9 Ochoa ware sherds that were securely assigned to NAA compositional groups was submitted for thin section petrographic analysis. The petrographic analysis was intended to evaluate whether Leslie's (1965b) original description of crushed caliche temper is accurate or if other materials were used. In addition to crushed caliche, Leslie (2016a) noted in a later description that biotite mica, small black to grey gravel fragments, and sand particles were present, perhaps relating to the use of sandstone as temper.

Another component of the analysis was to examine if differences in temper types and constituents might exist among chemical compositional groups of Ochoa ware. The scope of this analysis was limited by the fact that very few samples of Ochoa Groups 2, 3, or 4 were available for study. The one sample of the present study assigned to Ochoa Group 3 was used up for NAA. A check for curated samples at MURR found that only two of Alvarado's samples had sufficient amounts for thin sectioning: LAA037 (Corona Group 1) and LAA051 (Ochoa Group 3). No samples of Group 2 or 4 were available, and so the analysis focused on six Merchant Main Ochoa samples, one Merchant Main Ochoa unassigned, two Corona Group 1 samples, and a single Ochoa Group 3 sample.

Sherd samples were submitted to Mary Ownby of Desert Archaeology, Inc. for thin sectioning and petrographic examination. A general summary of the analysis results is presented here; the full report, including microphotographs and tabulated data, is provided as Appendix C.3.

Ochoa Indented Corrugated

The seven analyzed Ochoa Indented Corrugated sherds all had analogous pastes. The clay appears related to shale. The common inclusions are likely natural to the clay and are dominated by quartz grains. The other frequent components are caliche fragments (some with quartz, feldspar, and chert inclusions), quartzite, and chert. Less common are grains of potassium feldspar, plagioclase, and chalcedony. Rare are opaques, muscovite, pyroxene, zircon, tourmaline, glauconite, and sparry limestone. The caliche fragments are the large grains visible in the paste of Ochoa sherds.

Samples 23 and 153 have a dominance of medium to coarse-sized inclusions, while 172 has more common fine-sized grains including the caliche. Sample 276 has mostly medium-sized inclusions and rare plant material. The latter could be natural to the clay deposit. Sample 382 is similar to Sample 276 but lacks the plant material. However, some plant material was noted in Sample 394 with mostly fine and medium-sized inclusions. Sample 1_38, assigned to Ochoa NAA Group 3, has the same set of inclusions and a similar clay as the Merchant Main Ochoa samples, but is dominated by fine-sized angular grains. A single grog fragment was also noted.

The components of these pastes suggest a disaggregated sandstone provided most of the mineral grains. Based on their type and features, the sandstone(s) are subarkose to sublitharenite due to the presence of feldspars, chert, and quartzite (Adams et al. 1984:24). In none of the samples was intact sandstone with matrix observed, so information on that component cannot be acquired. However, the shape and sorting of the loose grains suggest the sandstone(s) were texturally submature. Mineralogically, the presence of silica rock fragments, zircon, and rare tourmaline indicates they are mostly mature.

Corona Corrugated

The two Corona Corrugated sherds had similar pastes. The clay is iron-rich and could be from the erosion of sandstone with hematite/clay matrix and common quartz and feldspar, i.e., arkosic. A few such fragments were seen in Sample 468. The paste contains common quartz and potassium feldspar (mostly perthite), with a few grains having granophyric textures. These sometimes appear as alkali feldspar granite rock fragments with attached rare opaques and sphene. Also in the paste are some limestone/caliche fragments along with uncommon pyroxene, zircon, sphene, microcline, muscovite, and chert. All of the inclusions appear natural to the clay.

Discussion

This small study of nine sherds of Ochoa Indented Corrugated and Corona Corrugated has provided data on their production. The most common paste comprises a likely shale clay with natural inclusions from disaggregated sandstone and larger fragments of indurated caliche (similar to limestone; Table 16.3). Such a raw material was probably available near the Merchant site within washes downcutting the Ogallala Formation of the mesa. Along the mesa edge are exposures of sandstone, shale, and caliche that would be cut by washes whose material would form a secondary deposit of clay rich in disaggregated sandstone minerals and caliche fragments (Nicholson and Clebsch 1961:37–39). Such deposits have been described and the harder caliche may resist weathering producing larger fragments within the secondary clay (Miller et al. 2016:16). Unfortunately, no additional information on the specific mineralogical components of the Ogallala Formation was found.

Table 16.3. Summary of petrographic results. “Local” means resources available within 3 km of the site

Sample	MURR	NAA Group	Pottery Type	Petrographic Description	Local
1_30	LAA037	Corona 1	Corona Corrugated	Iron-rich arkosic sandstone	No
468	MRM783	Corona 1	Corona Corrugated	Iron-rich arkosic sandstone	No
1_38	LAA051	Ochoa 3	Ochoa Indented Corrugated	Sandstone and limestone	Yes
23	MRM815	Merchant Main Ochoa	Ochoa Indented Corrugated	Sandstone and limestone	Yes
153	MRM807	Merchant Main Ochoa	Ochoa Indented Corrugated	Sandstone and limestone	Yes
172	MRM800	Merchant Main OchoaU	Ochoa Indented Corrugated	Sandstone and limestone	Yes
276	MRM852	Merchant Main Ochoa	Ochoa Indented Corrugated	Sandstone and limestone	Yes
382	MRM826	Merchant Main Ochoa	Ochoa Indented Corrugated	Sandstone and limestone	Yes
394	MRM849	Merchant Main Ochoa	Ochoa Indented Corrugated	Sandstone and limestone	Yes

These vessels were not highly fired based on their optical activity and it was probably a short firing as the cores and many surfaces remain dark and unoxidized. The samples with finer and less angular inclusions suggest clay was also likely acquired in the swale some distance from the original outcrops. In this area, coarser fragments would have dropped out along the water course leaving only finer material, which would have become rounder due to the additional water action. Further, this raw material was probably not heavily processed as most samples contain clay pellets indicative that water did not fully hydrate all parts of the clay.

The six samples with this paste correspond to the Merchant Main NAA Group. Sample 1_38 in NAA Ochoa Group 3 is petrographically related to the other Ochoa Indented Corrugated samples, though having finer inclusions. However, a slightly different raw material source for this vessel cannot be excluded given the geographic extent of the limestone and sandstone outcrops and their unknown heterogeneity.

Very little petrographic work has previously been conducted on Ochoa ware. Hill (in press) examined a few sherds and noted common limestone and sand inclusions. Hill (2019:168–171) further clarifies that Ochoa Indented Corrugated appears to be a rare example of possible local production of brownwares, while for most sites in southeastern New Mexico brownwares are made of materials from the Lincoln County Porphyry belt, which includes the Capitan and Sierra Blanca mountains.

The two Corona Corrugated sherds, both in NAA Corona Group 1, had identical pastes that could relate to the erosion of sandstone with an iron-rich matrix and granite inclusions of quartz and potassium feldspar. On the east side of Clayton Basin is a thick exposure of Gatuna Formation reddish brown sandstone (Bachman 1980:36–37). Other areas also have deposits of this material in the Pecos region (Nicholson and Clebsch 1961:39–45). Significantly, the formation can contain pisolitic caliche clasts and Tertiary igneous pebbles. These are believed to have originated from the erosion of the Sierra Blanca and Capitan mountains to the far northwest. Those mountains are dominated by granite, often feldspar rich and with sphene (Scholle 2003). If the Gatuna Formation in the area does not contain such deposits, these sherds could be non-local to the Merchant site. Further, older formations of red beds comprising sandstone, siltstone, and clay are known in the area so there is a chance those were exploited (Nicholson and Clebsch 1961:34–36). Both sherds appear to have been low fired in an incompletely oxidizing atmosphere.

Some Corona Plain sherds from Gran Quivira were previously examined petrographically by Warren (1981), who did not identify any produced with material described here. However, Hill (2012:10) mentions that some Corona Corrugated sherds grouped with others having igneous tempers. This study included NAA data that incorporated the classification of Miller and Ferguson (2014) and most of the Corona Corrugated sherds were assigned to Group 95. Those samples have been reclassified and are now designated Corona Group 1 (see Table 16.1). As demonstrated in Figures 16.17 and 16.18, Corona Group 1 is compositionally distinct from the Ochoa ware groups.

Hill (2012:8) described the Corona Corrugated sherds as having plutonic sediments of loose quartz, potassium feldspar, and plagioclase. This could be similar to what Ownby observed here. More recently, Hill (2016) analyzed Corona Corrugated sherds from a site near Glencoe and also identified what he termed "fine-grained leucocratic igneous rocks that might be characterized as monzonite and quartz monzonite". These were ascribed to a source in the Capitan Mountains. How this material relates to what has been identified in the two Corona Corrugated sherds here is unclear, although the common theme of quartz and feldspar inclusions is apparent.

This small petrographic study has provided important clarity on the components of Ochoa Indented Corrugated and Corona Corrugated. For the former, the pastes appear to contain natural inclusions from caliche and sandstone. For the latter, a similar approach was taken, exploiting secondary deposits of clay possibly from the erosion of arkosic sandstone.

The Manufacturing of Ochoa Indented Corrugated Ware

In this section it becomes clear that while Ochoa Indented Corrugated reflects the widespread southwestern tradition of textured ceramics made by coil-and-scrape, it also has its own unique features. A sample of 50 Ochoa Indented Corrugated sherds (53 including refits) and a small comparative sample of 16 Corona Corrugated sherds were examined. The Ochoa ware sherds are a subsample of large, corrugated body and rim sherds from the Merchant site. Fifteen sampled Corona sherds are from the Robinson Site, New Mexico (LA 46326), and are in the Maxwell Museum of Anthropology collections. One Corona Corrugated sherd was collected from a location near the Merchant village during the Merchant Vicinity survey. It is an isolated sherd that was examined but is not included in the quantitative analysis of sherds from the Robinson site. Analyses focused on the characterization of Ochoa manufacturing techniques, specifically the forming and fashioning stages of the ceramic operational chain.

To better understand the Ochoa Indented Corrugated pottery type, a quantitative and qualitative comparison of manufacturing techniques of indented corrugated wares from throughout the U.S. Southwest is presented. The goal is to measure and assess the relationships between Ochoa and other indented corrugated pottery types. These relationships may inform explanatory models for the Merchant site as a whole. Ceramic data alone cannot explain the material culture or population dynamics of the Merchant site, but the data may support certain explanatory models over others. The overall conclusion is that Ochoa Indented Corrugated pottery stands apart from other indented corrugated types, although it does bear some resemblance to corrugated wares from the Mogollon and Rio Grande regions. The uniqueness of Ochoa ware might in part be a consequence of temporal trends (i.e., a trend toward the use of larger, thicker coils). However, much of what sets Ochoa apart is equally explained by various models for diffusion or specific models for migration.

Methods

To learn more about how Ochoa Indented Corrugated pottery was made and how its production compares to other indented corrugated types, Woodhead conducted quantitative and descriptive analyses and compared results to published data from elsewhere in the U.S. Southwest. Data collection methods, attribute definitions, and comparative data come from prior research into indented corrugated pottery, including Barker (2020), Hegmon et al. (2000), Horton and Harry (2017), Mattson (2016), Neuzil (2005), and Peeples (2011, 2018).

Basic data recorded for each sherd include the portion of the vessel from which the sherd came (rim or body), vessel form (jar, bowl, indeterminate), and the presence of sooting or smudging. Six descriptive attributes were recorded for each sherd related to corrugation style: (1) coil placement, (2) corrugation type, (3) indentation direction, (4) indentation alignment, (5) indentation implement, and (6) surface elaboration. Four quantitative attributes relating to corrugation style were recorded: (1) coil height, (2) coil width, (3) indentation depth, and (4) indentation width. No basal sherds were available for collecting information on base form or building direction.

Coil placement refers to where a potter adheres a coil relative to preceding coils. A potter can place a coil on the exterior of a preceding coil, the interior of the preceding coil, or directly on top of the preceding coil (Figure 16.23). Geib (1996) and Hensler and Blinman (2002) have suggested that coil placement could vary geographically or even ethnically and is, therefore, useful in the study of migration (see Snow 2017 for alternate view). The coiling technique for one part of a vessel can be independent of the coil technique used on another part of a vessel (Snow 2017). A conservative approach was taken to the estimation of coil placement in the present study so as to remain open to the possibility of interior coil placement and the possibility that a potter might use variable coil placement sites in the process of building a single vessel. To discern coil placement, the preferred orientation of paste particles and voids in cross section and visible *seams*, or coil juncture slants was scrutinized. The degree of indentation distinctiveness also relates to coil placement for, as Hensler and Blinman (2002:375) state, "Strong indented corrugated textures can only be achieved with the exterior coil application technique." Smoothed or nearly smooth sherds without clear particle orientation or seams were deemed indeterminate.

Corrugation type refers to how the coils were treated upon being adhered and during surface finishing. The categories from Peeples (2011) and Barker (2020) were utilized. Eight types occur in the Ochoa and Corona samples: indeterminate, nearly smooth, indented corrugated, clapboard corrugated, flattened corrugated, polished obliterated, wiped obliterated, and heavily obliterated. A nearly smooth surface might indicate the sherd came from a plain ware, though the ceramic surfaces in the sample were still rough, not finely and evenly smoothed. Indented corrugated sherds have indentations that create a shingled effect and are not finished with scraping or polishing. Clapboard corrugated sherds have plain, raised fillets without indentations. Flattened corrugations are also plain and unindented but do not project as far as clapboard corrugations. For all obliterated corrugation types, the primary coil can be either unindented (clapboard or flattened) or indented. On polished obliterated sherds, raised surfaces are polished and are smooth, shiny, and reflective. On wiped obliterated sherds, coils and indentations are partially obscured through wiping and scraping. The texture of implement used to wipe and scrape (e.g., a hand, a cloth, a rib, or a leaf) leaves behind small parallel striations. And finally, on heavily obliterated sherds the coils and indentations are largely erased and barely visible.

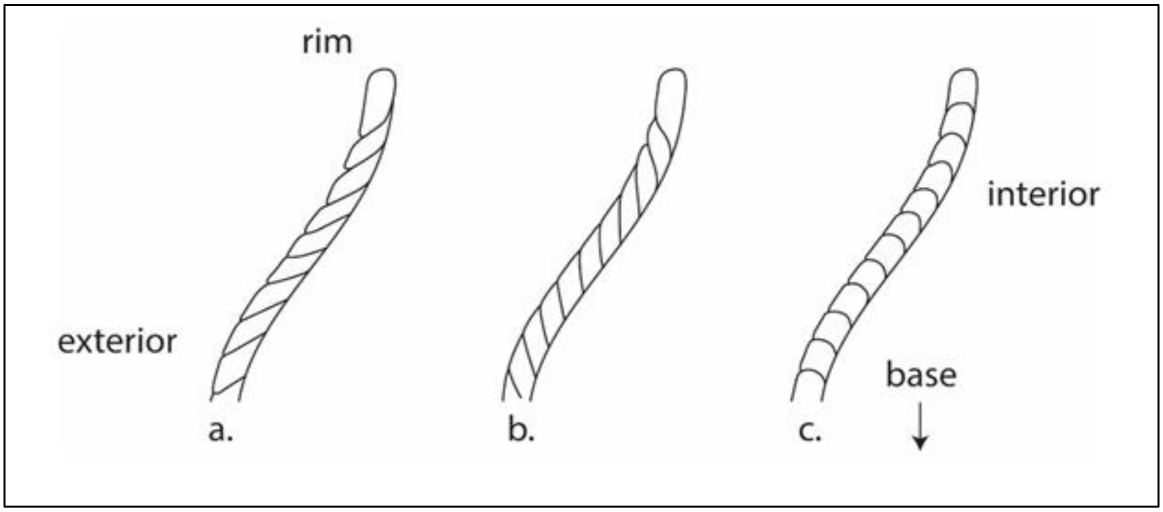

Figure 16.23. Schematic representations of ceramic coiling construction techniques: a) the exterior coil placement technique, b) the interior coil placement technique, and c) the directly-on-top coil placement technique. Exterior coil placement is prevalent among Colorado Plateau Ancestral Pueblo gray wares and the Ochoa and Corona sherds sampled here. The interior coil placement technique is dominant in the Rio Grande and Fremont regions. This schematic is adapted from images in Hensler and Blinman (2002:376, Figure 22.5) and Geib (1996, Figure 36).

Indentation direction describes the orientation of the indentations in relation to the coils (Barker 2020; Peeples 2011). The potter lays coils horizontally, then orients the indentation implement in one of four ways or leaves the coil unindented (among sherds sampled here, unindented coils only occurred with Corona sherds). Indentations may be parallel, perpendicular, or oblique, either moving down-to-the-left or down-to-the-right. Indentations in this sample were indeterminate, parallel, down-to-the-left, or down-to-the-right. Parallel indentations form a U-shaped depression and indicate that the indentation implement was held parallel to the direction of the coils. Oblique indentations, the norm for Ancestral Pueblo gray wares, result from holding the indentation implement at an angle.

Indentations may be aligned or unaligned. Unaligned indentations are randomly distributed across a vessel or sherd surface. Aligned indentations may stack one on top of the other to create a vertical “pinstripe” effect; they may align every other coil to form a crisscross effect with the trough of one indentation on top of two meeting peaks; or they may create a pinwheel effect either down-to-the-left or down-to-the-right.

Typically, one assumes potters of the past used their fingers, likely their thumbs or index fingers, to indent coils. Visible fingerprints offer the only definitive proof of finger indenting. Contemporary potters may use tools to indent. For example, Lucy Lewis and her kin would use a carved cedar stick (Peterson 1984). Leslie (1965b, 2016) believed Ochoa potters used thumb scrapers as indenting tools for Ochoa ware. When contemporary potters use tools, they may intentionally shape the tool to leave behind a regular decorative pattern. Regular patterning to indentation impressions would constitute evidence of tool use.

Surface elaboration refers to any treatment, typically decorative, applied to the vessel exterior. Neither Ochoa nor Corona exhibit surface elaboration—no incising, no tooling, no punctate, and no appliqué. Woodhead’s ongoing studies of corrugated northern Ancestral Pueblo gray wares and Mogollon brown wares suggest that such surface elaboration is generally rare, with the latter more often exhibiting incising (see also Hays-Gilpin and van Hartesveldt 1998; Wilson 1999).

Different analyses have employed different definitions for coil height and coil width. This study follows Horton and Harry (2017). Coil height is the distance between two coil junctures, measured parallel to the vessel surface and taken as the average of three typical coils (Horton and Harry 2017:8). Coil height was measured in places with the most coil exposure. This choice may have introduced bias toward higher values. It was clear from sherd cross sections that much of the actual coil height was hidden by additional coils, creating a sort of "iceberg" effect where portions of the coil remained hidden from view. For this reason, the measurement method was intended to capture as much of the coil height as possible.

Coil width is synonymous with wall thickness and, following Horton and Harry (2017:8), "refers to the thickness of the coil remaining after finishing the surface." Coil width was recorded at the thickest and thinnest points, taking the average of three measurements. The thickest points should better approximate the coil prior to deformation during coil placement. For this reason, the maximum coil width was used as the primary coil width measurement. This choice matches that of Horton and Harry (2017:Figure 2) but contrasts with that of Mattson (2016) and others (e.g., Gifford and Gifford 1978:45–46). Indentation depth was calculated by subtracting the minimum coil width measurement from the maximum coil width measurement. There was no control for vessel portion, and coils may vary in thickness and indentations in depth according to where on a vessel they were placed.

The widest part of a single indentation is the indentation width (Horton and Harry 2017:8; Neuzil 2005:110). Indentation width can be measured from peak to peak or trough to trough. It was more often possible to take peak-to-peak measurements given the small sherd surface areas.

Results

Merchant site Ochoa coil placement was predominantly exterior (n=32, 64.0 percent). Sixteen Ochoa sherds (32.0 percent) had indeterminate coil placement, but again it is noted that the measurements were conservative. Coils were rarely placed directly on top of preceding coils (n=2, 4.0 percent). All Robinson Corona corrugated sherds exhibited exterior coil placement (n=15, 100 percent).

For the Ochoa sample, indentation direction was mostly parallel, that is, U-shaped (n=35, 70.0 percent when including sherds of indeterminate indentation direction, 97.2 percent excluding indeterminates). Fourteen Ochoa sherds (28.0 percent) were too smooth or had coils too heavily obliterated to determine indentation direction. On one Ochoa sherd (2.0 percent), indentations moved down-to-the-right. Nearly half of the Corona sample was intentionally unindented (n=7, 46.7 percent), and a third of the Corona sample exhibited indeterminate indentation direction (n=5, 33.3 percent). Of the Corona sherds with identifiable indentations, 1 (6.7 percent) sherd had parallel indentations, 1 (6.7 percent) had down-to-the-left indentations, and 1 (6.7 percent) had down-to-the-right indentations.

The indentation alignment usually could not be determined for either Ochoa or Corona because too little surface area was visible, indentations were too heavily obliterated, or distinct individual indentations were absent altogether. When enough Ochoa indentations were visible, they were mostly vertically aligned (n=17, 51.5 percent) or unaligned (n=14, 42.4 percent) and rarely alternating stacked aligned (n=2, 6.1 percent). When enough Corona indentations were visible, they were mostly unaligned (n=3, 60.0 percent), sometimes vertically aligned (n=1, 20.0 percent) or aligned to form a down-to-the-left pinwheel (n=1, 20.0 percent). Examples of indentation alignments are shown in Figure 16.24.

Figure 16.24. Examples of indentation alignment: (left, CN229) vertical alignment of indentations; (center, CN213) unaligned indentations; (right, CN153) stacked indentations.

The indentation implement was typically not discernible for Ochoa sherds either because no distinct indentations were visible, which was the case for 11 sherds (22.0 percent), or because no evidence of an implement of any kind was visible, the case for 36 sherds (72.0 percent). Three sherds (6.0 percent) showed probable fingerprint impressions, an example of which is shown in Figure 16.25). Most Corona sherds showed fingerprint impressions (n=11, 73.33 percent), though just over one quarter (n=4, 26.67 percent) showed no evidence of indentation implement.

Leslie (2016a) examined several hundred Ochoa Indented sherds and concluded that the impressions were not formed through finger impressions but rather by the use of small end scrapers. Collins (1968) performed experiments with clays, showing how the impressions were rapidly and consistently formed through fingertips. This study has found limited evidence of fingerprint impressions, but no evidence of tool use. Thus, the issue of fingertip versus tool remains unresolved, although examination of several impressions of the current study found that fingertips fit perfectly within series of impressions.

Coil Metrics: Table 16.4 shows summary statistics for the sampled Ochoa and Corona sherds next to summary data retrievable from published reports whose authors used comparable methods. Mean and coefficient of variation (CV) values are ranked to highlight relationships between the different types of pottery. An important observation is that the Ochoa sample consistently has the lowest CV values, indicating relatively limited variation among the measured attributes.

Mean coil height was largest among Ochoa Indented Corrugated (9.2 mm), followed by Shivwits (6.7 mm) and Tusayan (2: Virgin Branch Pueblo) (5.9 mm). Moapa, Tusayan (1: Pueblo Bonito Mounds), Puerco Valley/Mogollon, Mesa Verde, and Cibola all fall between 5.6 and 5.5 mm. Corona Corrugated had the second smallest mean coil height (5.4 mm) and Chuska had the smallest (5.1 mm).

Figure 16.25. Arrow marks a fingerprint impression on Ochoa sherd CN 153 (NAA sample MRM808). Fingerprints were uncommon in the sample of Ochoa Indented Corrugated sherds examined during this study, but the sherds also lacked any evidence of the use of a tool as an indenting implement.

Mean coil width was largest among Ochoa Indented Corrugated (6.8 mm), followed by Mogollon pottery from the Eastern Mimbres region (6.5 mm) and then the Corona sample (6.3 mm). Tusayan (2), Shivwits, and Moapa cluster around 5.5 to 5.4 mm. Cibola (4.46 mm), Chuska (4.43 mm), Tusayan (1) (4.39 mm), and Mesa Verde (4.38 mm) all have narrower coil widths.

Indentation depth was only available for one additional comparative sample published by Neuzil (2005). Ochoa had the deepest indentations (1.5 mm), then Corona (1.0 mm), and Neuzil's sample from Bailey Ruin had the shallowest indentations (0.9 mm). Ochoa had the widest indentations (14.5 mm), too. Mesa Verde (10.5 mm), Tusayan (2) (9.8 mm), Cibola (9.7 mm), Tusayan (1) (9.51 mm), Corona (9.47 mm), and Chuska (9.38 mm) follow. Shivwits (7.7 mm) and Moapa (7.3 mm) indentations are under 9.0 mm. Indentations on Bailey Ruin Puerco Valley and Mogollon sherds are much more narrowly indented on average (4.4 mm). These data come from samples of variable sizes and were collected by various researchers, sometimes employing different techniques. Neuzil's data were initially divided by provenience but have been averaged for this comparison. Nevertheless, the quantitative comparison of metric coiling variables is enlightening.

Table 16.4. Summary of metric variables related to corrugation style.

Ware *ca. AD*	**Ochoa** **1300-1420**	**Corona** **1100-1425**	**Puerco Valley/Mogollon** **1275-1325**	**Cibola** **750-1300**	**Chuska** **750-1300**	**Mesa Verde** **750-1300**	**Tusayan(1)** **750-1300**	**Tusayan(2)** **1050-1125**	**Shivwits** **1050-1125**	**Moapa** **1050-1125**	**Mogollon (E. Mimbres)** **1150-early 1200s**
Coil height											
Mean	9.2	5.4	5.5	5.5	5.1	5.5	5.6	5.9	6.7	5.6	
Mean rank	1	9	6	8	10	7	5	3	2	4	
St. dev.	1.5	1.1	1.8	1.1	1.0	1.2	1.1				
CV	16.6	20.4	32.7	20.6	19.9	21.5	19.2				
CV rank	7	4	1	3	5	2	6				
N	34	15	297	5490	5533	322	275	236	306	189	
Coil width*											
Mean	6.8	6.3		4.5	4.4	4.4	4.4	5.5	5.4	5.4	6.5
Mean rank	1	3		7	8	10	9	4	5	5	2
St. dev.	0.7	0.8		0.6	0.6	0.6	0.7				
CV	10.8	12.9		14.4	12.7	13.8	14.9				
CV rank	6	4		2	5	3	1				
N	50	15		4978	4978	255	255	236	306	189	
Indent depth											
Mean	1.5	1.0	0.9								
Mean rank	1	2	3								
St. dev.	0.5	0.3	0.3								
CV	31.5	33.0	36.1								
CV rank	3	2	1								
N	38	15	297								

Ware	**Ochoa**	**Corona**	**Puerco Valley/Mogollon**	**Cibola**	**Chuska**	**Mesa Verde**	**Tusayan(1)**	**Tusayan(2)**	**Shivwits**	**Moapa**	**Mogollon (E. Mimbres)**
ca. AD	**1300-1420**	**1100-1425**	**1275-1325**	**750-1300**	**750-1300**	**750-1300**	**750-1300**	**1050-1125**	**1050-1125**	**1050-1125**	**1150-early 1200s**
Indent width											
Mean	14.5	9.5	4.4	9.7	9.4	10.5	9.5	9.8	7.7	7.3	
Mean rank	1	6	10	4	7	2	5	3	8	9	
St. dev.	1.5	1.4	1.5	2.0	1.8	2.1	1.7				
CV	10.1	15.0	34.1	20.4	19.3	20.5	17.9				
CV rank	7	6	1	3	4	2	5				
N	20	4	297	4246	4521	237	212	168	231	132	

*For newly collected data and Horton and Harry (2017) data, this represents the maximum coil width, or wall thickness. For Mattson (2016), this measurement came from between coils, where the wall thickness is thinnest. Even so, the Cibola, Chuska, Mesa Verde, and Tusayan material Mattson examined has thinner coil widths: the mean minimum coil width is 5.39 mm for Ochoa and 5.35 mm for Corona Corrugated.

This study examined Ochoa and Corona sherds. Corona dates come from Hayes (1981). Puerco Valley/Mogollon ware data come from work by Neuzil (2005) on Bailey Ruin (AZ P: 11:1 [ASM]) in the Silver Creek area of Arizona. Cibola, Chuska, Mesa Verde, and Tusayan (1) data come from work by Mattson (2016:33, Table 2.7) on ceramics from the Pueblo Bonito mounds, Chaco Canyon, New Mexico. Tusayan (2), Shivwits, and Moapa data come from work by Horton and Harry (2017:13, Table 4) in the Moapa Valley, Nevada, and the Mt. Dellenbaugh area of northwestern Arizona. Eastern Mimbres data come from work by Hegmon et al. (2000:228, Figure 5) at hamlets along Palomas Creek, New Mexico.

Variation in Corrugation Treatments: The signature and distinguishing characteristic of Ochoa ware is the indented corrugated decorations on vessel exteriors. The individual construction coils of vessel exteriors were not smoothed while in their plastic state, but instead were textured by pressing the coils with a fingertip or tool so that scallop-like impressions were formed over the coil below. The overall pattern is a series of semi-circular or scalloped indentations arranged in rows. Some indentations were uniform while others were irregular and haphazard. The impressions were formed during placement of the coils and moved from the lower surfaces of the vessel to the top. This is an efficient means of indenting and seems most likely based on replication studies of Ancestral Pueblo corrugated gray wares (Blinman 1993:18; Swink 2004:253) and based on the construction methods of historic Pueblo potters (Colton 1953:9; Guthe 1925:47). In some cases, however, a slight decorative elaboration was that the uppermost row of impressions below the rim was created in a horizontal pattern, sometimes leaving a fillet-like rim (see Figure 16.11).

There is considerable variation in the treatment and presentation of the indented corrugations of both Ochoa ware from the Merchant site and the small sample of Corona Corrugated sherds from Robinson pueblo (Table 16.5; Figure 16.26). The degree of obliteration often varied across a single sherd and different degrees of obliteration were probably quite variable across individual vessels.

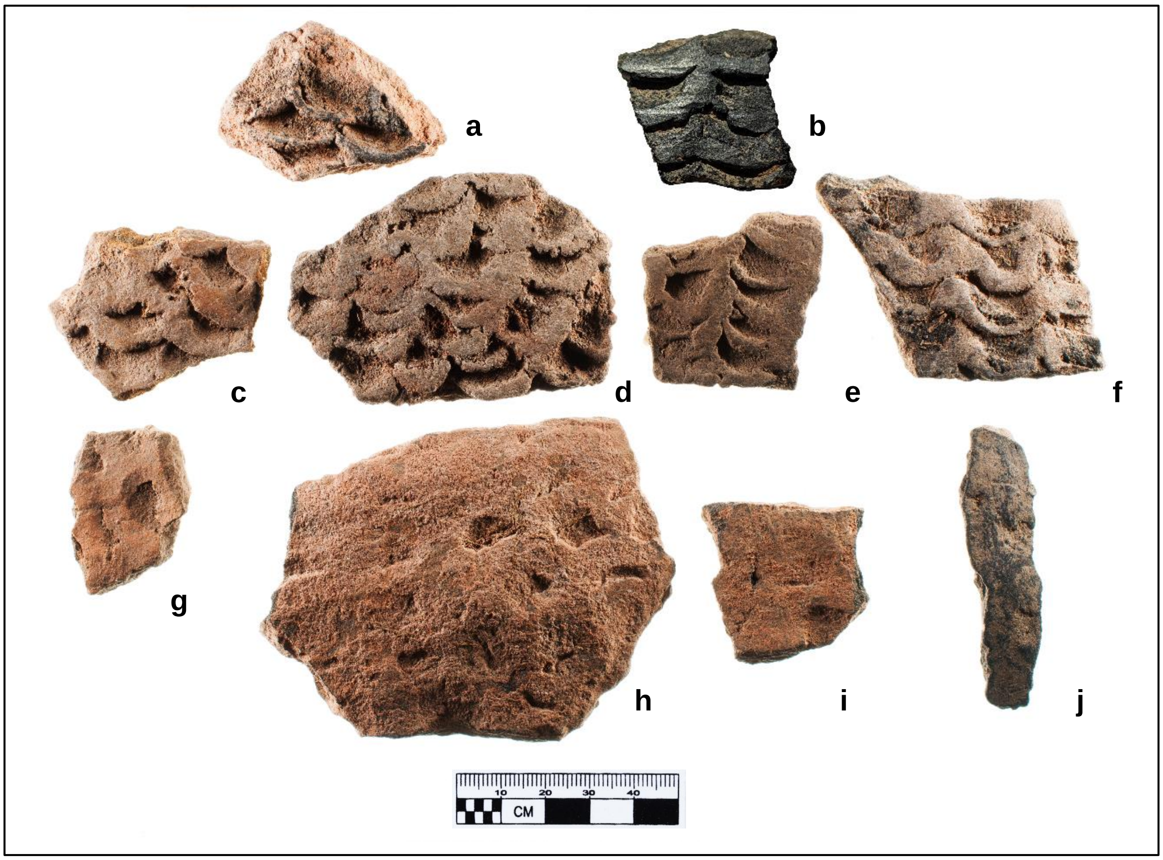

Figure 16.26. Variation in indented corrugated treatments: (a) indented corrugated (ridged); (b) wiped obliterated and polished; (c-f) wiped obliterated; (g-h) heavily obliterated; (i-j) smoothed.

Table 16.5. Summary of surface treatment counts for Merchant site Ochoa Indented Corrugated sherds and Robinson Ruin Corona Corrugated sherds

	Indeterminate		Smoothed		Indented Corrugated		Clapboard Corrugated		Flattened		Polished Obliterated		Wiped Obliterated		Heavily Obliterated		Total
	n	**%**	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**	**n**
Merchant	3	6.0	7	14.0	3	6.0					6	12.0	19	38.0	12	24.0	50
Robinson					2	13.3	1	6.7	1	6.7	3	20.0	7	46.7	1	6.7	15
Total	**3**		**7**		**5**		**1**		**1**		**9**		**26**		**13**		**55**

One corrugation type, Indented Corrugated, is characterized by raised indentations that were left in their original plastic state and were not further modified by smoothing, wiping, flattening, or otherwise compressing the raised ridges. This is one of the more visually striking forms of corrugation but is rather uncommon with only 6.0 percent of the Merchant sample exhibiting this style. It is slightly more common (13.3 percent) among Corona Corrugated.

Wiped obliterated and polished obliterated are related treatments and are the most common treatment on Ochoa ware, together accounting for half (50.0 percent) of the collection. These treatments compressed the raised indentations through smoothing or wiping while the clay was in a plastic state, creating flat corrugations that varied from somewhat deep to partially obliterated. A small subset (12.0 percent) of wiped and smoothed sherds was then lightly polished. The count and proportion of polished obliterated sherds would probably increase with additional cleaning. Wiped and polished corrugations were also the most common treatment observed among the sample of Corona Corrugated.

Heavily obliterated corrugation (24.0 percent) describes sherds with nearly obliterated indentations where only the deepest scalloped impressions can be seen. Smoothed surfaces (14.0 percent) were also common among Ochoa sherds. Only 6.7 percent of the Corona Corrugated sherds were heavily obliterated through smoothing. A fully smoothed Corona sherd would be classified as Corona Plain but no Corona Plain sherds were included in the small comparative sample. Corona Corrugated also more often exhibited unindented types involving clapboarding and flattening.

It is uncertain if these slight variations in corrugation treatments reflect different functional or social contexts. The proportion of Ochoa ware sherds with heavily obliterated and smoothed surfaces is significantly greater in extramural activity areas than rooms and middens (Figure 16.27). Cooking activities presumably took place outside of rooms, and together the presence of greater numbers of sooted sherds and sherds lacking corrugated surfaces in exterior work areas indicate that the removal of corrugations on the lower surfaces of cooking pots was an intentional technological feature.

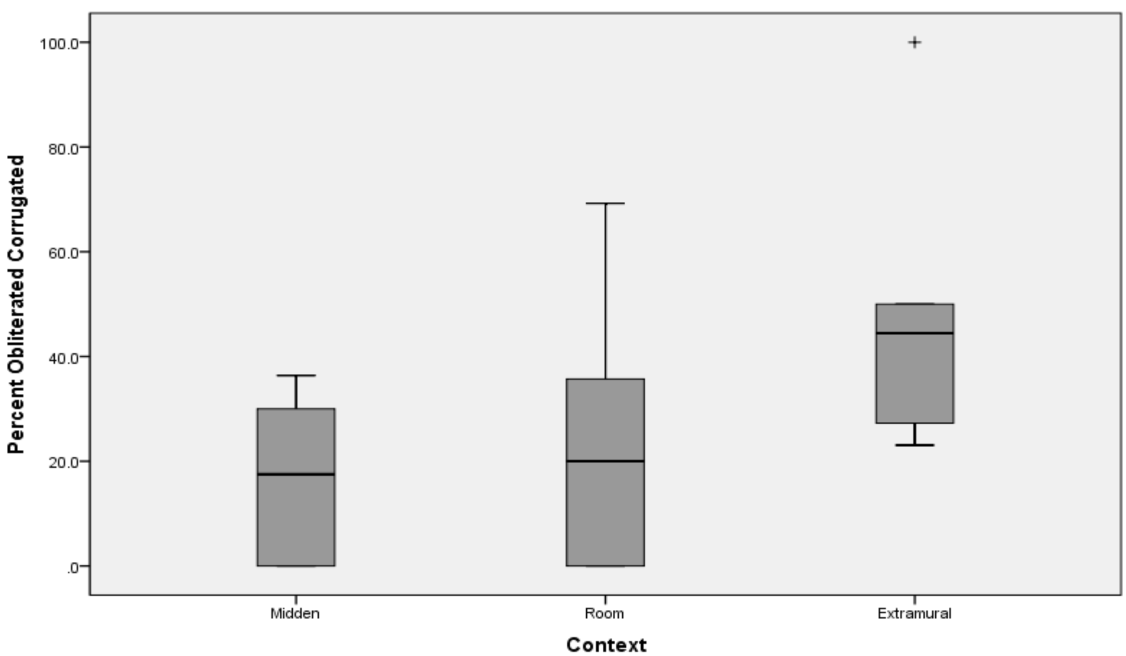

Figure 16.27. Boxplot comparing percentages of obliterated corrugated and smoothed sherds among major contexts at the Merchant site.

Discussion

The summary discussions review the manufacture of Ochoa Indented Corrugated pottery and how Ochoa Indented Corrugated sherds differ from other Southwestern corrugated ceramics.

Fashioning an Ochoa Indented Corrugated Pot: A general characterization of the building processes involved in making an Ochoa Indented Corrugated pot is as follows. The quality of locally available materials might explain some ceramic attributes and some potter choices.

How a potter begins an Ochoa Indented Corrugated pot is not clear from this sample. The sample lacked base sherds and whole or reconstructable vessels—all are needed to show coiling direction and puki use. Whatever the initial process, the potter would have to roll out coils. The potter would roll them a bit thicker than in other areas and earlier time periods. The potter may at first adhere these coils to the interior of the growing basal portion of the pot. This is the part of the pot that is expanding outward, and interior coil placement might aid in control against the forces of gravity. If this is the case and the potter does begin an Ochoa pot with interior coil placement, at some point the potter must switch to exterior coil placement. This is clear because most sampled Ochoa sherds show evidence of exterior coil application. The potter may use exterior coil placement on entire Ochoa vessels, with certain areas being partially smoothed out through abrasion either while building (i.e., the potters' hands rub out still wet and highly plastic lower indentations and coil junctures while building the upper portion of the pot) or during the finishing process (i.e., when some material is used on a slightly drier but not quite leather hard vessel to intentionally obliterate coils). Potters probably did not construct whole Ochoa Indented Corrugated vessels with interior or directly-on-top coil application.

Based on the way coils overlap preceding coils and cover the indentations of preceding coils, one can conclude that potters indent coils simultaneous with coil placement. When adding the exterior placed coils, the potter indents the exterior face of the coil by pushing deeply (mean indentation depth = 1.5 mm) and pushing straight down either with a finger or a tool aligned parallel to the coil. There was no evidence of tool use. Nevertheless, the use of a tool cannot be ruled out because fingerprint impressions were rare on Ochoa sherds—rarer than on the examined Corona sherds. Fingerprints, however, might not be visible with certain clay body properties (i.e., sticky, tacky, and/or lacking in plasticity).

It seems that parallel, U-shaped indentations are diagnostic of Ochoa. The overall effect is one of distinctive scalloping. This indentation pattern contrasts visibly with the ribbon-like effect seen on most Ancestral Pueblo gray ware utility jars from the Colorado Plateau and the nubby commonly perpendicular corrugations of some Mogollon red and brown corrugated wares. The prevalence of U-shaped indentations suggests Ochoa potters employed different motor habits than many other potters. Rather than holding the thumb, the fingers, or some tool (as an extension of the thumb or fingers) at an angle to the coil with arms out and wrists straight, an Ochoa potter would need to position the indenting implement such that the tip of the implement would parallel the coil and the force applied would be perpendicular to the coil. To achieve this, the potter would have to bend sharply at the wrist before pressing down (Figure 16.28).

Whatever the technique, the potters responsible for Merchant site Ochoa Indented Corrugated pottery used similar coils and made similar indentations. The CV ranks in table 2 indicate the coil forming and adhering process is relatively standard for Ochoa potters. That is, the sampled Ochoa Indented Corrugated sherds have the least variability in terms of coils and indentations. Later stages of the Ochoa ceramic production process exhibit less standardization. Rim forms, surface finish, and degree of interior smoothing and polishing vary, though perhaps no more than any other corrugated ceramic. Sometimes coils are indented right up to the rim lip and sometimes a wide rim fillet separates indentations from the lip. Sometimes potters left Ochoa indentations unobliterated, but more often they wiped, nearly erased, erased, or polished the indentations. Interior coil junctures were always completed obliterated, but some vessel interiors exhibit streaky polishing, and some interiors are only scraped flat.

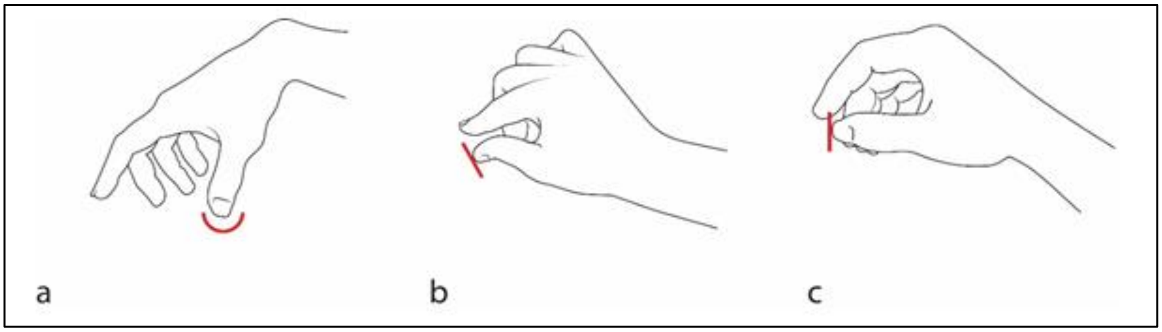

Figure 16.28. Different hand configurations and motor habits are necessary to achieve different indentation directions. In these illustrations, the indenting implement is the right thumb, and the potter is working at the close side of the vessel. Other arrangements are possible. (a) To make a parallel, U-shaped indentation, the indenting implement is held parallel to the coils and presses straight down; the wrist must be bent unless the vessel is much lower than the potter. This creates a scalloped effect. (b) To make an oblique indentation, the indenting implement is held at an angle to the coil, then the potter squishes and indents back onto the previous indentation. (c) To make a perpendicular indentation, the indenting implement is held straight up-and-down, then potter once again squishes and indents back onto the previous indentation. Oblique and perpendicular indenting creates a ribbon or ripple effect.

Variation may relate to vessel form and intended use. One might expect taller rim fillets on jars and more finely finished interiors on bowls. Larger samples and additional qualitative data from other corrugated ceramic types are necessary before one can determine how latter stages of the Ochoa operational chain compare to those of other types.

Ochoa vs. Corrugated Ceramics from Elsewhere in the Southwest: Figure 16.29 provides a series of bivariate plots that graphically illustrate the data on coil metrics (means) and the coefficients of variation (CV) of those metrics that are listed in Table 16.4. In almost every plot, Ochoa ware is very distinctive compared to other Southwestern corrugated wares.

Overall, compared to corrugated sherds from elsewhere in the Southwest, the sample of Ochoa Indented Corrugated sherds has the tallest and widest coils and the deepest and widest indentations. The sample of Ochoa Indented Corrugated sherds also exhibits less variability. This lack of variability may be a function of the small sample or may be meaningful. For example, the low Ochoa CVs could mean the sampled pottery was made by a small number of closely connected potters working in a shared community of practice, perhaps based at or near Merchant.

Ochoa does resemble Corona Corrugated and other corrugated Mogollon brown wares in terms of the colors it fires to and the prevalence of coil obliteration. The numbers show that the coils are thicker and the indentations are bigger. The indentations are also a distinct U-shape, and there seems to be no unindented type variety comparable to the unindented, semi-obliterated corrugation visible on the Corona sherds (unless the Ochoa Plain Corrugated sherds described by Leslie are found to be a true type).

Although Ochoa resembles blind, smeared, and washboard indented corrugated types of the Rio Grande Valley, comparable data for these pottery types has not yet been located. What is more, such Rio Grande pottery is built by interior coil placement (see Figure 16.23). This means that comparable metrics are not possible to collect as exterior coil junctures are not visible and indentations are not clearly differentiated. This also means that Rio Grande coil placement differs from all other pottery types discussed here, including Ochoa Indented Corrugated. Additionally, if Ochoa potters wanted to make their pottery resemble Rio Grande smeared types, then they probably would have largely erased all surfaces rather than deeply indenting and leaving many indentations visible.

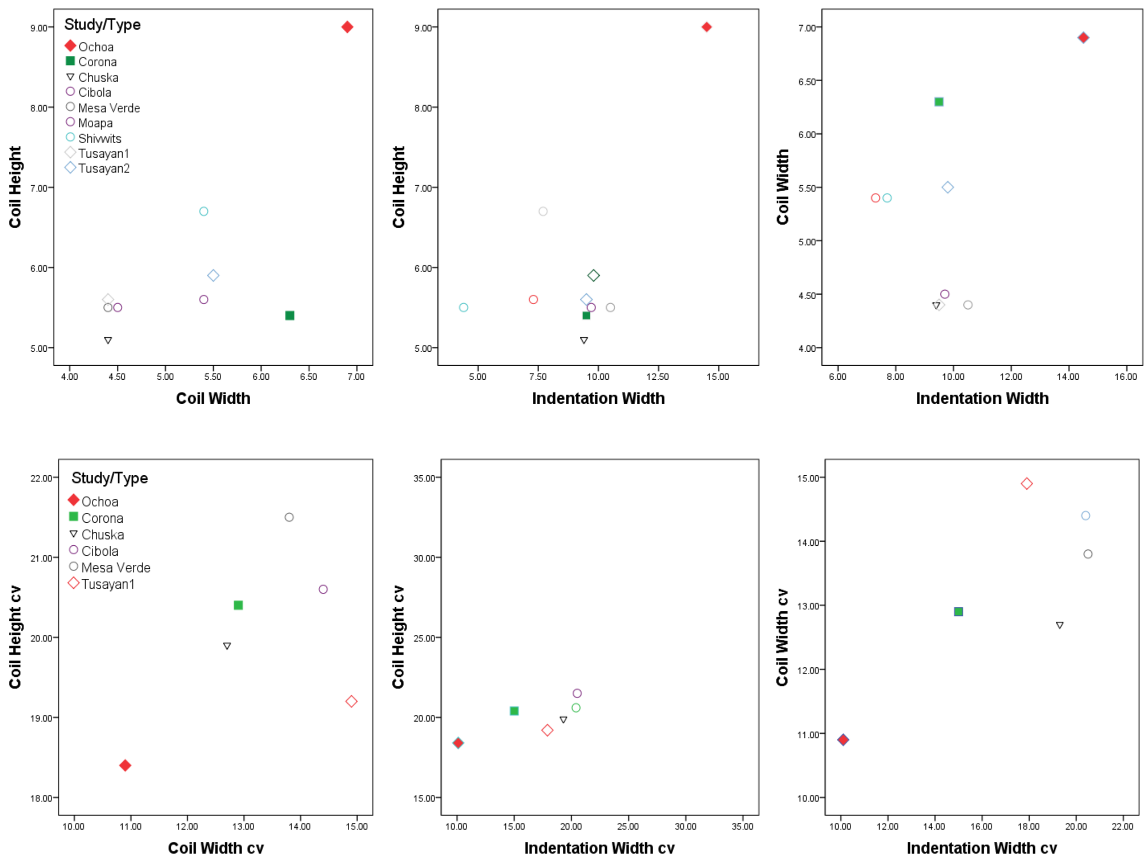

Figure 16.29. Comparison of metric variables (upper row) and the coefficients of variation of those variables recorded for Southwestern corrugated ceramics (data from Table 16.4).

Why the Similarities and Why the Differences? To evaluate the merits of all possible explanations for why Ochoa ware looks like—but not exactly like—other Southwest corrugated pottery is beyond the scope of this chapter. To adequately evaluate migration and diffusion scenarios for culture change, one must consider regional historical context and a site's social organization, trade relationships, and transport technology (Anthony 1990:895–896). Culture history factors that might be significant in this instance include the following two points regarding conditions that favor population movement and the spread of ideas, information, objects, and practices.

The Merchant site occupation begins sometime in the A.D. 1300s. This coincides with the pueblo interval (El Paso and Lincoln phases) of the Jornada region to the west and northwest, the Pueblo IV period of the northern Rio Grande, the Medio period of the Casas Grandes region, the Antelope Creek phase of the southern Plains, and the Toyah phase of central Texas. As such, Merchant and other Ochoa phase settlements were part of the widespread patterns of population movements and aggregations and accompanying developments in social and ritual organization that occurred throughout the Southwest, northern Mexico, and southern Plains during the fourteenth and fifteenth centuries. In a context where people are moving out of an area or moving around and establishing far-reaching networks, migration and diffusion are both possible.

Ochoa Indented Corrugated and corrugated Mogollon brown wares share the same basic primary shaping technique of coiling and indenting and the same secondary technique of scraping, wiping, and sometimes polishing. It is possible that the general concept of obliterated indented corrugated pottery diffused from the west to the east. For this diffusion to occur, either some examples of indented corrugated brown wares were exchanged eastward and served as templates for emulation, or potters or perhaps even non-potters communicated the process to Ochoa potters, who then executed their interpretation of obliterated indented corrugated pottery. These two scenarios allow for the flow of information in the absence of direct learning through shared practice. Transmission without interaction between potters can take place (Roux 2015). Over long distances and without objects to imitate or verbal guidance from someone deeply familiar with the construction process, the corrugation process might have altered.

That is how diffusion may have taken place. With the current comparative data, Ochoa Indented Corrugated pottery does not resemble any other corrugated pottery well enough to argue for a site unit intrusion migration to Merchant site. Although there is evidence for diffusion in the absence of population movement, one cannot rule out all migration scenarios. "Scouting expeditions" (Anthony 1990) might result in transmission of potting knowledge without direct technical guidance. Alternatively, this could be a unique example of "the founder effect" (Anthony 1990). Ochoa's distinctive U-shaped indentations do occur elsewhere in small quantities. One Corona Corrugated sherd from Robinson had U-shaped indentations, though the coils were thinner and the temper was finer than with a typical Ochoa sherd. See also Horton and Harry (2017:9–10, Figure 2 upper left sherd, figure 4 second sherd in from the left) for examples of U-shaped indentations in the Virgin Branch Pueblo region. Could a small cohort of people including parallel-indenting potters have settled at Merchant site? Is Ochoa Indented Corrugated an example of diffusion, migration, or something else?

To most Southwest ceramicists and probably most potters, past and present, Ochoa will look unique. Some of the attributes that set it apart—its larger coils and indentations—are typically considered low visibility and unlikely to convey information about social identity (Horton and Harry 2017:11). These are the same attributes that might have changed temporally given historic photographic evidence of Southwest Native American potters using thick coils. The visibility of these attributes is also difficult to assess without full knowledge of use context and audience (Mattson 2016:32). The U-shaped indentations are more conspicuous and might have actively signaled something about potters from or residents of the Merchant site or parts of the southeast Southwest. High-visibility ceramic attributes that communicate identity are more open to change (Gosselain 1998; Wobst 1977). Potters responsible for Ochoa Indented Corrugated may have deliberately decided to make scalloped ceramics when their neighbors to the west made unindented and obliquely and perpendicularly indented ceramics. Because corrugated wares blur the line between technological and decorative style, similarities and differences in coiling and indenting techniques are not simple proxies for interacting production groups.

Ochoa Ware in the Larger Picture

Ochoa Indented Corrugated is one of the more unique ceramic developments of southern New Mexico. It was a relatively short-lived tradition, appearing sometime in the early 1300s and production had ceased by the early 1400s. As revealed through the series of production, use, and compositional studies presented in this chapter, during that brief span of time Ochoa ware was a surprisingly distinctive ceramic in terms of its manufacturing attributes and its limited distribution and exchange.

In some ways, the study of Ochoa ware mirrors the lead author's experience with El Paso brownware. Several of the manufacturing and decorative attributes of El Paso brownware and Ochoa corrugated ware do not "fit" with conventional perceptions of Southwestern ceramics. It is tempting to simply write off such variations and deviations to idiosyncratic choices, random cultural practices, or some other form of non-functional choices and practices, but as learned from the past two decades of El Paso brownware research, that path leads to overgeneralized and misleading conclusions. The paste and temper recipe, form and finishing choices, and decorative attributes reflect a nexus of technological and performance characteristics that fulfilled the specific set of functional, economic, and social roles required of El Paso brownware ceramics.

The same can be said of Ochoa ware. A specific set of functional, economic, and social factors contributed to the manufacture and design of Ochoa ware. When it comes to understanding Ochoa ware, however, we are on a less secure footing than the Jornada situation, and it is difficult to untangle and isolate which aspects of Ochoa ware were conditioned by functional and economic factors and which were conditioned by its social contexts. We still know little of the overall contexts—environmental, technological, and social—of the people who manufactured the elaborately textured Ochoa vessels found at the Merchant and Salt Cedar sites.

The Functional Aspects of Ochoa Ware

The presence of sooting and distribution of sooted vessels in extramural areas confirms that Ochoa jars and perhaps some bowls served as cooking pots. Additionally, the absence of sooting on many sherds indicates that some Ochoa vessels were also used for storage, serving, and perhaps transport. What may have been transported within Ochoa jars remains uncertain, particularly considering the almost non-existent evidence of regional movement and exchange of Ochoa vessels as revealed by the compositional and distribution studies. In general, the limited range of vessel forms and consistency of manufacturing methods suggest that Ochoa vessels were designed to serve multifunctional roles. It was a standardized, utilitarian approach to making ceramics, but not one devoid of decorative flare.

The performance characteristics of corrugated ceramics merit consideration here. Experimental studies of Southwestern corrugated ceramics have observed how the presence of exterior corrugations can facilitate cooking and heat transfer, reduce the likelihood of contents boiling over the rim, increase vessel use-life, and reduce slippage and breakages, thereby facilitating movement of vessels, particularly when wet (Pierce 1995, 2005; Schiffer 1990; Stone 1986; Young and Stone 1990). It does not appear that corrugation increased vessel use-life, as seen by the quantities of broken vessels found in midden deposits and the frequency of breaks along coil junctures.

Considering the wood-poor environment of the Mescalero Plain, any gain in heat efficiency would be beneficial for cooking. However, experimental studies by Young and Stone (1990) demonstrated a lower rate of heat transfer and efficiency among corrugated ceramics. On the other hand, the lower heat transfer effectiveness of corrugation likely helps avoid boil over (Pierce 1999), particularly if corrugation is applied to the vessel neck. Given what we know from experimental studies by Young, Stone, Pierce, and others, a cooking vessel with a semi-smoothed base and a textured upper body might have been an efficient compromise to conserve fuel while increasing evaporative cooling just enough to avoid boil over and enable a slow simmer.

Aside from cooking efficiency, other performance characteristics of Ochoa corrugated ceramics might have proven useful. It is possible that the corrugated surface of Ochoa vessels served to facilitate movement and handling during the use of corrugated jars for pot watering in the gridded agricultural fields north of the pueblo (see Chapter 10). The reduced exterior slippage of the corrugated surface may have been beneficial in such tasks (see Boulanger and Hudson 2012).

The Economic Uses of Ochoa Ware

Based on the results of neutron activation analysis and thin section petrography, the sample of Ochoa ware from the Merchant site is perhaps the least compositionally variable assemblage that Miller and Ferguson have encountered in studies spanning the southeastern Southwest, southern Plains, and central Texas. This is perhaps not that remarkable when considering the isolated geographic location of the Merchant site as well as the limited sources of clay and temper material available on the Mescalero Plain. What is remarkable, however, is that there appears to have been little to no exchange of Ochoa ceramics with the inhabitants of other Ochoa phase villages, with people residing in Jornada villages around the Roswell Oasis, or with people residing anywhere outside the primary village production areas. A few sherds of Ochoa ware have been found at locations in west-central Texas and the Texas Panhandle, but the counts are exceptionally small, especially if compared to Chupadero Black-on-white, Rio Grande Glazewares, and other widely traded ceramics.

Figure 16.30 displays the present conception of Ochoa distributions. The definite provenance or production location at the Merchant site is indicated, as is the probable production area in the vicinity of the Salt Cedar site. Two possible production areas are noted, either of which could be the provenance of Ochoa Group 4 and Group 2, if the existence of the latter is confirmed through additional sampling. The small oval reflects the probable limits of Ochoa ceramic production and distribution, discounting the occasional isolated sherd. It should be noted that the distribution area is similar to that proposed by Leslie and his cohort of the LCAS, who had an intimate knowledge of the region.

For comparison and contrast, a generalized impression of the distribution of Chupadero Black-on-white during the 1300s and early 1400s is superimposed over the Ochoa ware distribution. This is a peculiar situation and is one of the most enigmatic facets of the Merchant site and Ochoa ware ceramics. Ceramics produced in other regions, such as Chupadero Black-on-white, Rio Grande Glazewares, El Paso brownware, Three Rivers redwares, and Chihuahuan polychromes, were found at the Merchant and Salt Cedar sites. A few items of marine shell and obsidian from sources to the west were also found in rooms and middens. The counts of these ceramics types and other items are rather low, but their presence does indicate that the Merchant villagers were involved in some level of exchange and interaction beyond the walls of the pueblo. Chert, chalcedony, opalite, and Alibates dolomite materials from distant sources were also brought to the Merchant site. It is likely that the materials were obtained during long-range hunts and brought back to the village and their presence does establish that Merchant villagers were traveling long distances from the village and certainly must have encountered other people in other places.

An obvious conclusion is that Ochoa ware vessels were not produced for exchange or long-distance transport. There are two larger implications of this conclusion. First, the performance characteristics of Ochoa ware corrugations apparently were not designed for long-distance transport. Second, the absence of long-distance transport and exchange is a rather rare phenomenon among the hundreds of ceramic-producing communities documented globally. The role of ceramic vessels in Ochoa phase settlement and society was very different from other Southwestern and Plains communities.

The concept of *dispersed household production* (Hagstrum 1995:288) probably best describes pottery production at the Merchant site. This mode of production falls between simple, unspecialized household production and community craft specialization. Households produce ceramics for their domestic use and for distribution to other community members, thus establishing and maintaining intra-community social relations. However, ceramics produced by dispersed household specialists are seldom exchanged with members of other communities. What is rather unique about the Merchant case is that communities of the size of the Merhant site often had community ceramic specialists that produced ceramics for exchange with other settlements.

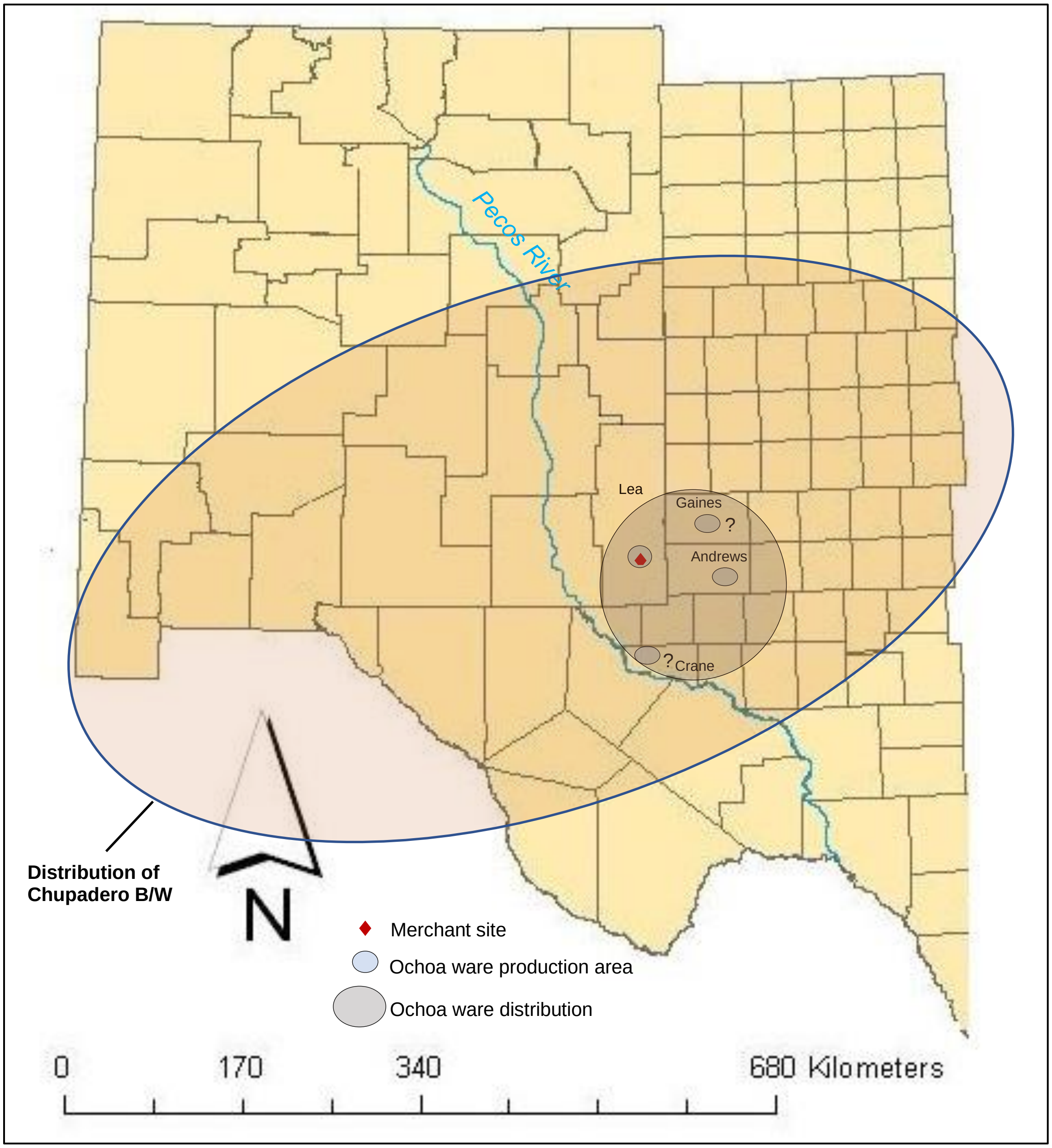

Figure 16.30. The probable and possible production areas of Ochoa ware and its geographic distribution. The distribution of Chupadero Black-on-white is displayed for comparison.

The Social Component

In the 2016 report on the remedial investigations at the Merchant site, it was proposed that the distinctive corrugation style of Ochoa ware may have served as a marker of social identity and social signaling (Miller et al. 2016) by a newly established migrant community on the Mescalero Plain. The data accumulated during the present project has led to a reconsideration of those conclusions. The specific texturing methods and finishing variants (wiped obliterated, polished obliterated) may indeed be related to social dynamics, but it is more likely that whatever those social factors were, they were *internal* rather than external. The rare exchange of Ochoa vessels with communities beyond the Merchant site indicates that the elaborate corrugations were probably not intended to convey social information beyond the village.

Ochoa corrugated ceramics have a remarkable degree of chemical and compositional homogeneity. They also have very little variation in paste recipe and forming techniques. The patterns of coiling and corrugation identified by Woodhead lend support to these conclusions, as Ochoa production seems to have been relatively more standardized based on its low CV values (see Table 16.4). These factors may all be evidence that Ochoa ware vessels were produced by small groups of closely connected potters working in close-knit communities of practice. Whatever social signals were embedded in corrugation styles and treatments were probably intended to communicate to others within that community. The growth of the eastern and southern room blocks described in Chapter 6 indicates that newcomers did settle at the Merchant site. When intracommunity relationships are prioritized, newly arrived outsiders are quickly assimilated into the learning frameworks of such communities and thus stylistic variations are inhibited and muted (Neuzil 2005). In such instances, homogeneity is the outcome of pressure to conform and, therefore, the homogeneity exhibited by Ochoa ware might not necessarily mean a small number of potters were responsible for production.

An intriguing interpretation is that the internal village dynamics of Ochoa pottery production may have been expressed through gender. Ethnoarchaeological studies of Kalinga ceramic production describe a similar situation to Ochoa ware (Graves 1994). The pottery produced within and among villages had limited paste, forming, and finish variations, but the female potters encoded slight variations of incised designs placed below the rim. Pottery was produced by females in Kalinga villages and the slight design variations were intended to convey boundary and identity to other females. The limited distribution of Ochoa ceramics may reflect the fact that women were not interacting with other social groups, both internal and external, on the scale that men were, particularly if it is assumed that long-distance hunting trips were conducted by parties of males. Thus, it may be argued that rather than community-wide social identity, the corrugated styles and surface treatments of Ochoa vessels might reflect female social identity and interaction. Male village members at Merchant and other Ochoa phase settlements probably had much wider spheres of political and social interaction and would have expressed identity via other means and media, such as painted designs on shields and arrow shafts, body art, and perhaps even arrow styles.

This may explain why so little evidence of Ochoa vessels produced in one location has been found at other locations in southeastern New Mexico and west-central Texas. Ceramic vessels were transported for several reasons, including exchange of the vessels themselves for aesthetic or functional reasons, and exchange of materials such as marine shell, pigments, ornaments, ritual plants, and dozens of other things that were safely and securely contained within the vessels. Chupadero Black-on-white containers were probably exchanged for both reasons. In the case of Ochoa ceramics, it is possible that their limited distribution is because the women potters were restricted in their interactions and thus the pots were seldom transported beyond the confines of the village. Whatever was being exchanged by Ochoa villagers – meat, hides, raw materials – apparently was the purview of males and did not involve ceramic containers.

Nevertheless, the possibility that some Ochoa vessels were used in socially dynamic contexts and broader communal gatherings cannot be ruled out. The function of smudged bowls remains unresolved. Bowl sherds with smudged and slightly polished interiors were recovered from the spoil piles associated with the two civic-ceremonial structures (Miller et al. 2016:303), suggesting these more highly finished serving vessels fulfilled possible ritual or status roles. The few smudged sherds recovered during the 2019 excavations were also from a single locality. The use-alteration study and residue analysis found no evidence of fermentation or ritual drinks, although it should be noted that smudged bowl sherds were not analyzed as part of the residue study.

The Origins of Ochoa Ware

The discussions, interpretations, and questions presented throughout the chapter ultimately lead to the question of the origins of Ochoa Indented Corrugated wares. Ochoa ware is an indigenous ware manufactured and utilized by the inhabitants of the Merchant site and what appears to be a small number of other Ochoa phase communities across the Mescalero Plain and adjacent counties of Texas. Indented corrugated ceramics were not a unique or unprecedented design innovation attributable to the Merchant site potters, but rather were produced in several locations and at several times across the prehispanic Southwest. Noting the Southwestern origin of corrugated ceramic vessels, the critical question is: from where and from whom did the inspiration and design of Ochoa corrugated ceramics derive? Did the Ochoa tradition derive from anywhere at all, but was it instead a regional development that evolved to meet the particular social, functional, and economic needs of Ochoa phase settlements? Corrugated ceramics may have offered several performance advantages to the Merchant villagers that met the functional needs of pottery vessels on the Mescalero Plain, but it is equally likely that the reasons for producing corrugated pots were related to the social information encoded in the designs. The creation of corrugated surfaces on pottery vessels is a more complex and labor-intensive endeavor than required for producing plain surfaces, and the aesthetic and symbolic aspects of Ochoa ceramics could have been important factors underlying the investment of time and labor in producing their elaborately decorated surfaces.

Pierce (1995:80) illustrates how the earliest neck-banded vessels first appeared in southwestern New Mexico around A.D. 650, spreading to the northern southwest during the 700s and reaching the northern Rio Grande Valley sometime in the late 900s or 1000s. Fully corrugated vessels appeared at around A.D. 1000 in the Puerco and San Juan areas of northwestern New Mexico, spreading south, southwest, and east and appearing in the Mogollon and Rio Grande regions of New Mexico around A.D. 1150 or 1200. Reserve Indented Corrugated pottery from the Mogollon region has several similarities to Ochoa Indented Corrugated but its production ceased around A.D. 1300.

Corona Corrugated appears in the Chupadero, Salinas, and Capitan regions of southeastern New Mexico sometime between A.D. 1150 and 1300 and continued to be produced through the early 1400s (Hayes et al. 1981; Kelley 1984; Wiseman 2004). In addition to Corona Corrugated, other variants of corrugated wares appear during this period, including Seco Corrugated in the eastern Mogollon region (Laumbach and Laumbach 2013; Schleher and Ruth 2005) and several indented corrugated wares in the Northern Rio Grande region. In an interesting departure from these trends, corrugated pottery never gained a foothold in the Jornada region.

Any of the Mogollon, Rio Grande, or Ancestral Pueblo traditions are a candidate for the inspiration of Ochoa ware. Distinct regional variations in corrugation, as well as the manufacturing process that forms the corrugations from coils, are known across the Southwest (Geib 1996; Hensler and Blinman 2002; Snow 2017). For example, prehistoric and historic potters in the Colorado Plateau usually preferred to manufacture corrugated vessels by applying new coils to the outside of previously applied coils, while in contrast potters of the northern Rio Grande often applied new coils to the inside of the previous coils (Hensler and Blinman 2002). Moreover, as noted by Habicht-Mauche (1993), migration of populations into the Rio Grande Valley during Pueblo V period led to a mixture of both manufacturing processes at Arroyo Hondo pueblo. Hegmon and others (2000) use variations in corrugated pottery to track prehistoric migrations in the Mimbres region of southwestern New Mexico.

Woodhead analyzed 50 Ochoa Indented Corrugated sherds and 16 Corona Corrugated sherds. She compared the samples with each other and with published data on corrugated wares from the Mogollon area, the Virgin Branch Pueblo area, and Pueblo Bonito, Chaco Canyon. Ochoa sherds have larger coils and larger indentations than other corrugated wares. Ochoa nearly exclusively exhibits parallel, U-shaped indentations. The coil and corrugation attributes differ from other corrugated ceramics from the Southwest.

This study does not resolve the origins of the Ochoa tradition. With the current collection of comparative data on corrugated ceramics from elsewhere in the U.S. Southwest, one can conclude the tradition was not transplanted directly to the Merchant site through site unit intrusion. If the practice was brought to Merchant site by migrants, then it was likely through a less straightforward manifestation of migration. Diffusion scenarios could also explain the appearance of Ochoa Indented Corrugated. Depending on how one interprets the evidence, Ochoa potters may have been emulating pottery or an idea of pottery from elsewhere (perhaps the Mogollon area) or Ochoa potters may have been choosing to differentiate themselves from others with their distinctively scalloped corrugation. These are two very different possibilities, but they both involve far-flung interactions and the movement of things, ideas, and very probably people. There is still much to question and much to learn about this enigmatic ceramic tradition.

Chapter 17

Flaked Stone and Ground Stone

Myles R. Miller and Tim Graves

As with most prehistoric settlements across New Mexico, flaked stone artifacts are the most common class of material recovered during surface collections and excavations at the Merchant site. A total of 9,468 artifacts has been described and analyzed to some degree during the LCAS investigations (Leslie 2016a), through Gregory's (2006) thesis research, and from the 2015 remedial investigations (Miller et al. 2016). The present study contributes another 3,879 items to that total. Leslie provided a summary of descriptive and typological attributes primarily oriented towards the assemblages of formal tools. Gregory examined raw material use among artifact classes. The 2015 fieldwork was intended to stabilize the site and evaluate its data potential five decades after the LCAS excavations. Detailed artifact analyses were not included as part of that study. So, at the inception of the present project, little was known about flaked stone technology at the Merchant site beyond the information presented in Gregory's study.

For the present study, the intent of the flaked stone analysis was twofold. First, the morphology of tool forms was cataloged in order to better compare the types with formal tools of Late Prehistoric Period settlements documented across the Plains, Southwest, and central Texas. For example, blade flakes are one of the signature traits of Toyah culture lithic assemblages in central Texas, and the assemblage of flake tools from the Merchant site was examined to determine if such tools were a prominent component of Ochoa phase technology.

The second goal of the analysis was more complex and nuanced. The Merchant site presents an intriguing context for the study of the flaked stone technology, raw material procurement, and settlement organization. In the discussions to follow, a series of debitage attribute analyses, raw material identifications using visual and ultraviolet fluorescence, and comparative data on tool forms are combined to develop a model of flaked stone tool and material use. The ultimate conclusions are that the nature of lithic reduction and material use are conditioned by the technological requirements of long-distance hunting by groups residing at a sedentary village. Additionally, the predominance of distant material types offers important insights into where the Merchant hunters were traveling to and from where they were bringing back certain materials.

The intent of the present study is to investigate the interplay of settlement, hunting, and technological strategies at the Merchant site, and presumably among other Ochoa phase villages. Fundamentally, the orientation is structured around the concept of technological organization. Subtexts under the umbrella of technological organization include resource structure, risk avoidance, raw material procurement, and settlement organization. Expanding on an earlier article by Wiant and Hassen (1985), Nelson (1991:57) defines organization of technology as:

> "..the study of the selection and integration of strategies for making, using, transporting, and discarding tool and the materials needed for their manufacture and maintenance.

> Studies of the organization of technology consider economic and social variables that influence those strategies."

Kelly (1988:717) further expands the definition as:

> "..the spatial and temporal juxtaposition of the manufacture of different tools within a cultural system, their use, reuse, and discard, and their relation not only to tool function and raw-material type and distribution, but also to behavioral variables which mediate the spatial and temporal relations among activity, manufacturing, and raw-material loci."

Simply stated, technological organization is viewed as the strategies and technological choices that reflect social and economic issues with respect to environmental conditions. Fundamental aspects of this line of study are the ways in which stone tools were designed, manufactured, repaired, recycled, and discarded among differing land use patterns.

The consideration of raw materials is a practical starting point for the study of technological organization. Andrefsky (1994) makes a reasonable case that raw material quality and abundance serve as a prime factor in conditioning tool production, but also offers the subtle rejoinder that quality and quantity of raw material may structure lithic tool technologies in a predictable manner "…*if all other variables are held constant* (Andrefsky 1994:31, emphasis added)." The qualifying statement is actually one of the more critical components of Andrefsky's raw material model. It is difficult to assess where southeastern New Mexico would best fit among the high/low raw material quality and high/low raw material abundance axes of his model. One form or another of lithic raw material is available within a few kilometers of the Merchant site and many settlements across the region. Regardless of subsistence task or mobility strategy, if a particular tool designed for a particular task required the use of fine-grained materials, such materials could be obtained without excessive effort.

Some important insights into this matter can be gained by contrasting fundamental aspects of southeastern New Mexico flaked stone technology with other regions or perhaps in a global perspective. In doing so, the first and most prominent observation is that most of the material-conserving reduction and tool production strategies common throughout the world are exceptionally rare in the region. Bifacial cores are rare, a pattern unlike many areas of western North America. Nor is there much evidence for the use of blade or microblade technologies. These tool forms are basically non-existent as are the prepared blade cores from which such tools would have been detached. Thus, while raw material conservation was influential, it does not appear to have been a primary constraining factor influencing prehistoric technological strategies at the Merchant site and elsewhere in the region.

Rather, it is proposed that a range of different task orientations is what structured the nature of flaked stone technology at Merchant site. As Tomka (2001) suggests, tool forms are structured by processing requirements, and thus the design of toolkits of Late Prehistoric groups on the southern Plains and in central Texas were less influenced by decreasing mobility and raw material availability as opposed to changes in processing requirements of large and medium game. However, tools were also used to complete a wide range of other production and maintenance tasks at the village.

The groundstone collection is reviewed in the final section of the chapter. The collection is mostly fragmentary, but a sufficient number of items were collected to allow for some quantitative analysis. The comparative study of mano length and grinding area revealed an unexpected result in that the Merchant collection falls in the range of grinding technologies associated with low agricultural dependence.

Assemblage Composition

The 2019 excavations recovered a total of 3,879 chipped stone artifacts from the nine rooms, two middens, and some extramural areas of the Merchant village. Chipped stone artifacts were assigned to general classes of debitage, cores, unretouched tools, retouched tools, and cobble tools. Some classes were further subdivided into specific tool types and forms. A technological attribute analysis was conducted on all items. The overall composition of the assemblage is listed in Table 17.1. The counts of proportions of the 2019 assemblage are compared against those of the 2015 excavations and the chipped stone tool counts provided by Leslie (2016a) for the LCAS excavations of rooms, middens, and the two pit structures.

Table 17.1. Comparison of chipped stone assemblages from three periods of work

	LCAS 1959-1965		2015		2019	
Artifact Type	**n**	**%**	**n**	**%**	**n**	**%**
Debitage and Core Total	**3**	**0.2**	**4,343**	**92.4**	**3,543**	**91.4**
Flake debitage	0	0.0	4,272	90.9	3,486	89.9
Angular debris	0	0.0	31	0.6	24	0.6
Core	3	0.2	40	0.9	33	0.9
Unretouched Tool Total	**0**	**0.0**	**148**	**3.1**	**162**	**4.2**
Utilized flake	0	0.0	147	3.1	158	4.1
Utilized flake w/ spur	0	0.0	1	<.01	4	0.1
Uniface Tool Total	**213**	**11.3**	**79**	**1.7**	**60**	**1.6**
Graver/Spur	1	0.1	0	0.0	6	0.2
Side/end scraper	20	1.1	0	0.0	0	0.0
Small end scrapers	152	8.0	79	1.7	53	1.4
Medium end scraper	1	0.1	0	0.0	0	0.0
Side scrapers	39	2.1	0	0.0	1	<.01
Biface Tool Total	**1,677**	**88.6**	**111**	**2.4**	**94**	**2.4**
Projectile Point	1,608	84.9	91	1.9	79	2.0
Small knife/scraper	9	0.5	1	<.01	11	0.2
Triangular biface	11	0.6	18	0.4	1	<.01
Oval biface	6	0.3	0	0.0	0	0.0
Leaf-shaped knife	16	0.8	0	0.0	0	0.0
4 blade bevel knife	10	0.6	0	0.0	0	0.0
Drill/Graver	17	0.8	1	<.01	3	0.1
Cobble Tool Total	**0**	**0.0**	**21**	**0.5**	**20**	**0.5**
Hammerstone	0	0.0	13	0.3	12	0.3
Plane scraper	0	0.0	4	<.01	1	<.01
Chopper	0	0.0	2	<.01	1	<.01
Tabular knife	0	0.0	2	<.01	6	0.2
Total	**1,893**	**100.0**	**4702**	**100.0**	**3,879**	**100.0**

A prior review of the LCAS and 2015 collections determined that the proportions of chipped stone artifact classes are highly skewed by the effects of selective artifact collecting (Miller et al. 2016). The LCAS crews and the other group of individuals looting the site kept the projectile points, bifaces, complete grinding tools, and decorated ceramics found while screening midden and house fill deposits. The nondescript flakes, flake tools, cores, expedient unifaces, small sherds, and thousands of animal bones were dumped in the screened backdirt deposits. The 2015 excavations of those backdirt deposits recovered large quantities of flakes and animal bones but very few formal tools, grinding tools, or large ceramic sherds. The effects of this process of selective artifact screening are best illustrated by the fact that over 92 percent of the 2015 collection consists of debitage and cores while only 4.1 percent was bifacial and unifacial tools – a stark contrast to the LCAS assemblage described by Leslie that consisted of almost 100 percent of formal tools.

The effects of selective screening bias observed in 2015 continues to be an issue in the present study. One of the intriguing findings is how closely the artifact proportions of the 2015 and 2019 collections match each other. There is less than a one percent difference among all of the major artifact classes and individual tool types. The 2015 excavations mostly took place in previously excavated and screened deposits in and around the two large pit structures and in midden areas. The 2019 excavations, in contrast, took place primarily in the lower fills and floor of rooms and a few midden layers. It was expected that the 2019 excavations in undisturbed rooms and deep midden layers would recover substantial numbers of projectile points and formal tools similar to the counts Leslie reports, but that was not the case. For example, Leslie reports a count of 198 projectile points from 12 excavated rooms, an average of 16 points per room. The 2019 excavations recovered 50 points from 9 rooms, an average of only 5.6 points per room.

It is likely that the extent of the impacts from looting across the eastern part of the site were more severe than we accounted for. We were aware that much of the area had been strip-looted and large looter pits were present in several of the excavated rooms. It appears that the deposits overlying the rooms and backwashed into the looter pits contained much of the same selectively screened artifact collections as observed elsewhere across the site.

However, relatively few formal tools were found, even in the undisturbed lower fills or floors of rooms. In contrast, relatively high numbers of informal flake tools were recovered, including several with spurs, denticulate edges, and even a few bifacial drill fragments. Small end scrapers were also common. These tools were probably used for various domestic production and maintenance tasks conducted in and around the houses. But the variety of large bifacial tools, dozens of unifacial tools, and hundreds of projectile points reported by Leslie were not encountered among the sample of excavated rooms and nearby extramural areas investigated in 2019. The tool assemblage comprising the present sample was both fewer in number and had much less variety than the tool forms reported by Leslie.

Accordingly, in addition to selective screening bias detected in 2016, we also note that there is a spatial bias to the composition of the 2019 assemblage. It appears that the intensive processing tasks involving large game, whatever those tasks may have been, were conducted in certain locations beyond the immediate extramural space of the domestic rooms. It is possible that the central plaza area was such a location, particularly since it would have afforded a central location for redistribution of meat, hides, bone, and other products. It is also possible that middens or areas around middens were game processing locations and the masses of bone, broken projectile points, and exhausted tools were tossed in the refuse deposits.

Speth (2004d) observed such spatial patterning at the Henderson site. Noting that large animals (bison, ungulates) were recovered in significantly higher numbers in non-room contexts such as plazas, Speth (2004d:341) suggests, "Given their size, bison, and possibly also antelope and deer, were almost certainly butchered in open areas such as plazas, not within the confined spaces of the room blocks (2004d:341)." He further notes that, based on utility indices, animals such as bison and rabbits that were usually procured through communal hunts were more common in plazas spaces, suggesting communal sharing of the bounty of the communal hunt.

It is assumed that the deposition of the bones of large and medium animals would be accompanied by the stone tools used to process them, as well as resharpening debris. These inferred spatial patterns are supported by the distributional data presented in Table 17.2. Only 11.7 percent of the projectile points and 16.1 percent of formal tools documented in the LCAS collections were from domestic rooms. In contrast, 41.4 and 43.3 percent of the points and tools were recovered from Middens A, B, and C.

Similar distributions are present in the 2019 data. If the volume of excavated sediment is considered, then the reality is that substantial densities of tool and points were recovered from Middens B and C in 2019. The seemingly low counts of 13 points and 22 tools from the 2019 middens excavations is due to sampling bias in that only two small units totaling 3 square meters in area and 1.8 cubic meters in volume were excavated. If a 25 square meter area (22.5 cubic meters, assuming 0.9 m depth) had been excavated in Midden B, it is estimated that 163 points and 275 tools would have been recovered. This is a substantially higher number than the 46 points and 36 tools recovered from the 93 square meters (15.8 cubic meters) excavated in the rooms of the eastern room block. These spatial patterns resulting from site formation processes are one of the reasons for the low counts of formal tools and projectile point recovered during the 2019 excavations in rooms and extramural spaces.

Table 17.2. Distribution of projectile points and formal tools among major proveniences

	Projectile Point		Formal Tool		
Context/Provenience	**n**	**%**	**n**	**%**	**Point to Tool Ratio**
12 domestic rooms	198	11.7	53	16.1	3.7
Middens	702	41.4	143	43.3	4.9
Pit Structure 1	737	43.5	118	35.8	6.2
Pit Structure 2*	57	3.4	16	4.8	3.6
Total**	1694	100.0	330	100.0	
Backdirt and Middens 2015	91		99		0.9
9 domestic rooms 2019	50		43		1.2
Middens 2019	13		22		0.6

* Artifacts in Pit Structure 2 were mostly removed by looters and avocational LCAS members without recording counts

** Totals do not match Table 17.2 because Leslie included different collections in his overall site count and his individual context counts. Artifact counts from looters were sometimes included with the counts recovered by the LCAS.

The effects of past collection bias are again demonstrated in Table 17.2 through the ratios of projectile points to tools. The LCAS collections have an average of five times more projectile points than formal tools. In contrast, roughly even proportions of projectile points and formal tools were recovered during 2015 and 2019.

In conclusion, there appears to be two factors at play in the relative counts and densities of projectile points and formal tools recovered during excavations conducted at different times and in different places at the Merchant site: (1) a modern site-wide collection bias caused by the practice of the LCAS crews and looters selectively removing projectile points and formal tools from screened deposits; and (2) a spatial bias caused by the interplay of prehistoric site formation processes involving the locations where certain activities were conducted combined with patterned artifact discard behaviors, both of which resulted in formal tools and projectile points being deposited in variable concentrations across the site.

Another significant component to the distributional patterns of Table 17.2 is the unique nature of the interior fill deposits of Pit Structure 1. Leslie describes a 12-inch thick layer of animal bone in Zone E, and the presence of massive numbers of large mammal bone was confirmed through the 2015 excavations. In addition to the bone, 737 projectile points and 118 formal tools were recovered, and those counts represent only portion of the totals since hundreds of items were removed by looters. It is becoming more apparent that not only was the mass layer of faunal bone placed in the structure as a closure deposit, but hundreds and perhaps thousands of projectile points and formal tools were also placed with the masses of bone. It is also noted that the ratio of projectile points to tools is the highest recorded among any context at the site.

Setting aside the issues of assemblage bias, several preliminary observations can be made based on the artifact counts and proportions in Table 17.1. Both the 2015 and 2019 collections are dominated by debitage, although the proportions of non-diagnostic angular debitage are surprisingly low. Cores are also surprisingly rare given the masses of debitage present, indicating that cores had probably been thoroughly reduced for both flake production and bifacial tool production. Also of interest is that informal flake tools are quite common, indicating that a wide range of tasks beyond game hunting and processing were performed in and around the domestic rooms. These and other assemblage attributes are reviewed in the following discussions.

Raw Materials

All artifacts were examined under magnification and raw material varieties were individually coded by material class, texture, and color. The multiple varieties have been combined into general raw material classes for presentation in Table 17.3.

Table 17.3. Raw material types of chipped stone artifacts

Material Type	n	%
Translucent silicified	1,744	44.9
Chert	1,570	40.5
Quartzite	307	7.9
Limestone	162	4.2
Rhyolite	30	0.8
Basalt	16	0.4
Quartz	16	0.4
Sandstone	15	0.4
Obsidian	3	0.1
Other (8 types)*	16	0.4
Total	**3,879**	**100.0**

*Siltstone, tuff, shale, petrified wood, caliche, granite, schist, mica

The immediate impression from viewing the table is that the Merchant site assemblage is dominated by two material classes. Over 85 percent of the artifacts were manufactured from cherts and translucent silicified materials. The category of “translucent silicified” does not really describe a material type but rather the appearance of several materials observed among the masses of small flakes and larger artifacts. It includes chalcedony, translucent fine-grained cherts, perhaps some opalized caliche, and other very fine-grained and often glassy-textured materials. As demonstrated through the ultraviolet (UV) light reactions described later in the chapter, it is likely that some Alibates dolomite and Panhandle opalite are included within the category and it is certain that some varieties of Edwards Plateau cherts are present within this group of material.

Part of the reason for the use of the general translucent silicified category is that is difficult to differentiate among specific materials with similar colors and textures in flakes measuring a less than 10 mm in size, a size class that accounts for 67 percent of the flake assemblage. The separation of some cherts from certain chalcedonies was difficult, even under magnification, but both groups consist almost entirely of fine grained cryptocrystalline materials. Colors and texture were monitored and the translucent silicified category was subdivided into six groups: undifferentiated tan (n=318), rose (81), white (580), yellow (58), gray (699), and red jasper (8).

The 1,570 chert artifacts were assigned to 24 varieties based on color and texture. Fourteen are rare types, each of which numbers fewer than 12 artifacts (59 total, or 3.8 percent). The most common colors are dark gray (n=155), light tan (344), light gray (346), and cream white (408). These colors account for 79.8 percent of the cherts. The remaining 16.4 percent consist of gray

(66), butterscotch (64), pinkish white (38), red (46), yellow (26), and dark brown (18) varieties. As noted for the translucent silicified varieties, some quantities of Alibates dolomite and Edwards Plateau cherts are present, but they are significantly less common than observed among the translucent types.

One variety of white chert merits further description. It may be a variety of opalized caliche or perhaps a form of fossilized bone or shell. Gregory (2006:90) describes a similar material from the Merchant site as fossilized bone. It is bright white in color and grades from medium to coarse in texture. A total of 49 artifacts were assigned to this material. This material type has two noteworthy aspects. It was the dominant material recorded among lithic artifacts at the Custer Mountain site (LA 121668; see Graves et al. 2021b), located 30 km southeast of the Merchant site. Outcrops of the material were found at the margins of the Custer Mountain site and it is definitely a local source. The other noteworthy attribute is that the material presents a strong green fluorescence to short wave UV light. This can complicate the identification of distant raw material sources because one the key features of Alibates dolomite is that it shows a similar reaction to short wave UV light. The Custer Mountain chert is not a particularly fine material and was not extensively used for bifaces and projectile points, and so the problem of confusing the material with Alibates based on UV light reactions can probably be solved by specifically noting this material type in assemblages.

Two coarse-grained materials were relatively common in the assemblage: quartzite (307, 7.9 percent) and limestone (162, 4.2 percent). Quartzite materials from the Ogallala formation were common. All of the hammerstones were made of this hard, durable material, as were several core tools, flake tools, and a few unifacial tools. A brown quartzite found in local deposits was common (42 percent of the quartzite artifacts), as were white and grey quartzites (47.6 percent) obtained from Ogallala deposits within a few km of the site or along the Pecos River valley. A small number of the artifacts (31, 10.1 percent) were made of the well-known purple Ogallala quartzite. Limestone, obtained from local outcrops, was used for flake tools and core tools.

Rhyolite, basalt, sandstone, quartz, and a few miscellaneous materials together account for less than 2.4 percent of the raw materials. These materials were obtained from Ogallala formation outcrops and the Pecos River gravels. The three obsidian artifacts represent the only igneous material obtained from distant sources. The items were submitted for sourcing (see Appendix C.4) and two were identified as Cerro Toledo rhyolite (Obsidian Ridge) and one is from the Valles (Cerro del Medio) source.

Many of these medium- to coarse-grained materials were available locally. Brown quartzite can be found in lag cobble deposits on a hill slope located 1 km south of the pueblo. Limestone boulders are present 120 m west and 580 m south of the site, and several sandstone outcrops are present directly below the site. The indurated caliche conglomerate underlying the site has cobbles of various materials. Gravel deposits with chert, quartzite, rhyolite, and basalt are exposed on another ridge slope 110 to 200 m northwest of the pueblo. However, the gravels in this deposit are less than 2.5 cm in diameter and would be mostly unsuitable for reduction. No tested cores or primary flakes were noted in this deposit.

The texture or grain size of the major raw material groups is listed in Table 17.4. Materials with fine and very fine/glassy textures are present among 86.5 percent of the flaked stone artifacts at the Merchant site. Virtually all of the translucent silicified materials (1,743 artifacts out of 1,747 or 99.7 percent) are fine and very fine textured and 98% of the chert artifacts are these two texture categories. The three igneous items with glassy textures are the obsidian artifacts. Only 192 artifacts, or 4.9 percent of the total, consist of coarse-grained and very coarse-grained limestone, quartzite, and sandstone materials.

Table 17.4. Raw material texture by material class

Material		Very Fine/ Glassy	Fine	Medium	Coarse	Very Coarse	Total
Translucent	Count	47	1,696	3	0	1	1,747
	% within material class	2.6%	97.2%	0.2%	0.0%	0.1%	
Chert	Count	10	1,527	28	3	0	1,568
	% within material class	0.6%	97.4%	1.8%	0.2%	0.0%	
Igneous	Count	3	24	24	1	2	54
	% within material class	8.9%	42.9%	42.9%	1.8%	3.6%	
Limestone	Count	0	16	56	73	21	166
	% within material class	0.0%	9.6%	33.7%	44.0%	12.7%	
Other	Count	0	2	0	0	3	5
	% within material class	0.0%	40.0%	0.0%	0.0%	60.0%	
Quartzite	Count	6	25	218	69	6	324
	% within material class	1.9%	7.7%	67.3%	21.3%	1.9%	
Sandstone	Count	0	1	1	10	3	15
	% within material class	0.0%	6.7%	6.7%	66.7%	20.0%	
	Count	66	3,291	330	156	36	3,879
Total	%	1.7%	84.8%	8.5%	4.0%	0.9%	100.0%

While not unprecedented, the overall proportions of high-quality materials at the Merchant site are noteworthy because they have seldom been observed at other Formative Period settlements in southeastern New Mexico. Many of the materials were procured at distant locations ranging from the Pecos River, the Ogallala caprock, the Edwards Plateau, the Texas Panhandle, and perhaps areas to the west in the Guadalupe and eastern Sacramento Mountains (Kremkau et al. 2013). There was a specific emphasis on obtaining high quality materials and using them to produce a range of tool forms. The next series of analyses focus on the reduction stages and strategies identified among the debitage assemblages of these material groups.

Tools

A total of 336 tools were classified among the 3,879 artifacts collected during the 2019 excavations. A wide variety of tool classes was noted, including unretouched flake tools, unifaces, bifaces, and cobble tools (Table 17.5). Several variants within these classes include gravers and perforators (tools with spurs), morphological types of scrapers and bifaces, and a few types of cobble tools. As discussed earlier in the chapter, the counts and relative proportions of the general and specific tool types listed in the table are biased to an unknown and probably unresolvable degree due to the combination of prehistoric spatial differences in tool use and discard combined with the selective collection of formal tools during the looting of the site in the modern era.

Nevertheless, an appraisal of tool variability leads to an impression that perhaps the component of formal bifacial tools at the Merchant site has been overemphasized while, in turn, the number and variety of informal tools has been underappreciated. Nearly half of the tools are unretouched flake tools, and another 18 percent are unifacial tools that are essentially flake tools with more formal edge shaping and preparation and more intensive use. Six percent of the tools are large cobble tools including hammerstones and tabular tools. A brief review of the tool classes and types is presented below. A discussion and photographic presentation of tools from the 1959–1965 LCAS excavations and 2015 remedial excavation program is provided in Miller et al. 2016.

Table 17.5. Tool forms

Tool Class and Type	Number	Percent of tools
Unretouched Tool Total	**162**	**48.2**
Utilized flake	158	47.0
Utilized flake w/ spur	4	1.2
Uniface Tool Total	**60**	**17.9**
Graver/Spur	6	1.8
Small end scrapers	53	15.8
Side scrapers	1	0.3
Biface Tool Total	**94**	**28.0**
Projectile Point	79	23.5
Small biface/ knife	3	0.9
Triangular biface	9	2.7
Perforator/Graver	3	0.9
Coble Tool Total	**20**	**6.0**
Hammerstone	12	3.6
Plane scraper	1	0.3
Chopper	1	0.3
Tabular knife	6	1.8
Total	**336**	**100.0**

Flake Tools (modified flakes, utilized flakes)

Non-retouched or unmodified flake tools are the most common type in the 2019 tool assemblage, accounting for nearly half (n=162) of the flaked stone tools. These are flakes with evidence of use-wear on one or more margins but without further modification or shaping through flaking or retouch. They are the most expedient type of tool but served multiple functions and often were selected for their sharp edges. Use wear ranges from barely visible microflaking and abrasion to heavily used edges with multiple microflakes, abrasion, and rounding.

Two variants of flake tools were identified: flake blades and spurred pieces. The presence of blade flakes is of interest for comparisons of Ochoa phase assemblages with those typical of the Toyah phase technocomplex of central Texas (Johnson 1994; Mauldin et al. 2012; Rickliss 1994). Using the standard definition of a blade as having a length measuring two or more times the width of the tool, a total of only 10 blade flakes was identified among the flake tools (Figure 17.1), representing 6.2 percent of the flake tools and 3 percent of all tools. No single platform or blade cores were recovered, and it appears that blade tools were a minor component of the Ochoa phase assemblage from the Merchant site. Collins describes (1968:209) a cache of eight blade flakes at the Adobe Mound site, but otherwise blade flake tools do not appear to be a primary component of Ochoa phase tool assemblages as they are among the Toyah phase tool kits of central Texas.

Tools with spurs are another variant of both flake tools and unifacial tools (Figure 17.2). Spurs are a general descriptive term that describes any form of projection with evidence of use wear. The tool form is often described as a graver or perforator, but such functional categories are difficult to verify with the present examples. Some unifacial tools with spur projections were multifunctional tools.

Figure 17.1. The collection of all blade flake tools.

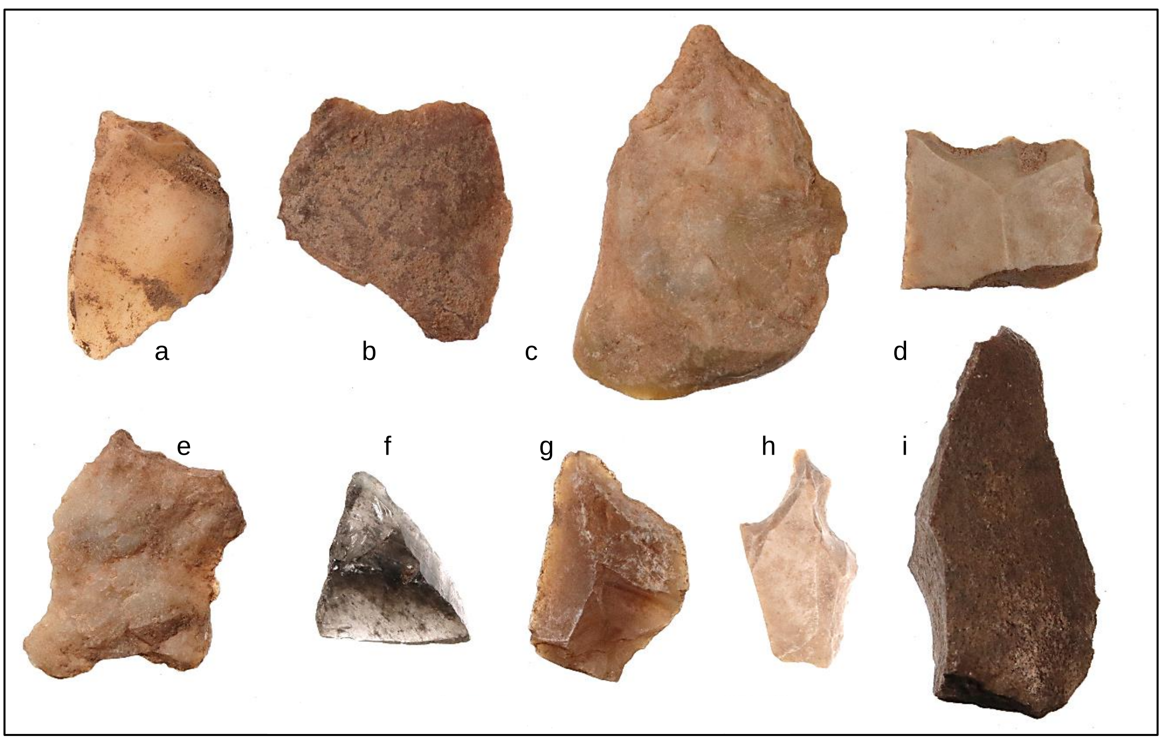

Figure 17.2. Unretouched flake tools (a, b, d, e, f, i) and unifacial tools (c, g, h) with spurs. Scale is same as displayed in Figure 17.1.

Unifaces

Unifaces are flake tools with shaping along one or more facets along with a prepared working edge created by continuous flake removals. The class of unifacial tools consists predominantly of different forms of scraper tools as well as gravers or perforators with flaked spurs or projections. Examples of unifacial tools with spurs are shown above in Figure 17.2 (c, g, h); Figure 17.2 displays examples of unifacial scraper tools.

Two general types of unifacial scrapers are present. The most common type identified in the tool assemblages from the 1959–1965 LCAS excavations and the 2015 and 2019 investigations are steep-sided end scrapers. The second type are side scrapers with more acute edge angles. One of the unifaces measures 6.46 cm in length and has a prepared surface along one entire margin and resembles a bifacial knife.

Figure 17.3. Unifacial tools.

Bifaces

The 94 bifaces include projectile points, knives, and perforators/gravers. If the 79 projectile points are excluded from consideration, the number of bifacial tools recovered from rooms is very small and has little variability in form and shape. The most common bifacial tool is a small knife with two bilateral shaped and bifacially flaked edges (Figure 17.4, a-d). In some cases, a third edge was formed, creating a bifacial scraper (Figure 17.4, e). Several of the bifacial tools were fragments, including three small bifacially flaked drill or perforator tips.

Projectile points comprise the most common form of bifacial tool. The collection of projectile points is reviewed later in the chapter as part of the discussion of raw material procurement and transport.

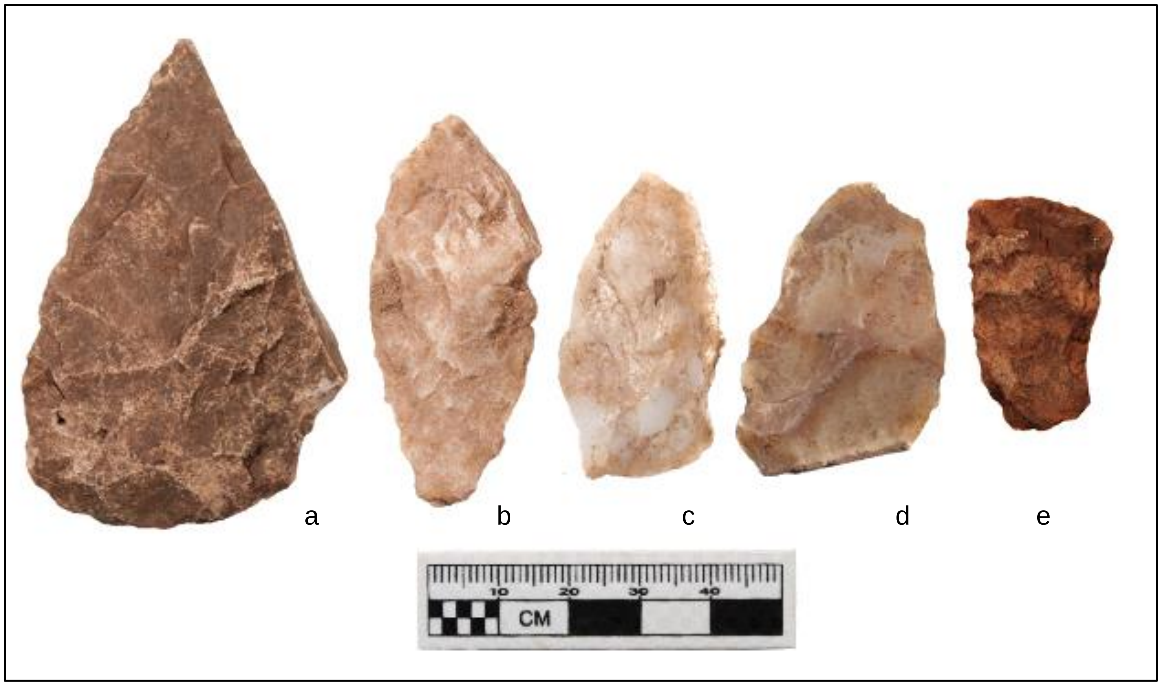

Figure 17.4. Bifacial tools: (a-d) knifes, (e) scraper.

Cobble Tools

Cobble tools include hammerstones, large plane scrapers, and tabular knives (Figure 17.5). The latter form is also called an agave knife, but in the case of the Merchant site such tools may have served other functions such as chopping or cleaving tools.

Figure 17.5. Cobble/Core tools.

Cores

The collection of cores was not particularly informative, mostly owing to the low number of specimens and the minimal variation among those specimens (Table 17.6). Multiple platform and nodular cores are the most common types.

Table 17.6. Core types by material class

Material		Tested Nodule	Single Platform	Multiple Platform	Total
Translucent	Count	0	0	2	2
	% within material class	0.0%	0.0%	100.0%	
	% within core type	0.0%	0.0%	8.3%	6.1%
Chert	Count	4	1	15	20
	% within material class	20.0%	5.0%	75.0%	
	% within core type	50.0%	100.0%	62.5%	60.6%
Igneous	Count	0	0	3	3
	% within material class	0.0%	0.0%	100.0%	
	% within core type	0.0%	0.0%	12.5%	9.1%
Limestone	Count	1	0	0	1
	% within material class	100.0%	0.0%	0.0%	
	% within core type	12.5%	0.0%	0.0%	3.0%
Quartzite	Count	3	0	4	7
	% within material class	42.9%	0.0%	57.1%	
	% within core type	37.5%	0.0%	16.7%	21.2%
Total	Count	8	1	24	33
	%	24.2%	3.0%	72.7%	100.0%

The low numbers of cores, particularly among certain materials, reveals something about the combination of reduction, spatial patterning of tool production and discard, and other factors. Only two cores of translucent silicified (chalcedony) material are present in the collection as opposed to the 1,694 flakes of this material, which translates to rather exceptional flake-to-core ratio of 847:1 and is a fact that requires some explanation. In contrast, 22 chert cores were recovered and the flake-to-core ratio for this material group is only 67:1. Three ratios of flakes, cores, and tools are presented in Table 17.7 with comparative data from four villages in the Roswell Oasis (Henderson and Fox Place) and two in the Tularosa Basin (Madera Quemada pueblo and Sacramento pueblo).

Table 17.7. Comparison of flake and core ratios

Site	Flake to Core Ratio	Flake to Tool Ratio	Tool to Core Ratio
Merchant total	114.1	11.2	11.1
Translucent Silicified	**847.0**	**35.3**	**24.0**
Chert	66.9	7.0	8.7
Fox Place	16.1	9.4	1.6
Henderson pueblo	14.4	1.4	6.8
Madera Quemada pueblo	27.8	4.9	5.7
Sacramento pueblo*	65.3	4.3	13.4

*Sacramento pueblo is located in an area where high-quality materials are scarce and the high flake to tool ratio reflects the thorough reduction of chert cores brought to the site.

The ratios calculated for the other sites and for chert at the Merchant site are generally similar. However, the ratios for the translucent silicified material class indicate that this material has disproportionately greater quantities of flake debitage compared to cores and tools than settlements of comparable age and size. A much greater ratio of finished tools to cores is also represented among the translucent silicified material. These observations regarding the rarity of cores are one of the first clues regarding the orientation and intensity of flaked stone reduction at the Merchant site.

Debitage Analysis

Debitage analysis examined the class of 3,486 non-utilized flakes. A few questionable items like a shard of mica and some possible small FCR fragments were removed from the sample. Aside from recording material type, angular debitage was not included in the debitage attribute analysis.

Angular debitage (also called non-diagnostic shatter, debris, among other terms) does merit some attention since it is surprisingly rare among both the 2015 and 2019 assemblages; the ratios of flakes to angular debitage for the two collections are 138:1 and 145:1. Such low proportions of angular debitage have been identified with late-stage biface thinning and reduction in experimental knapping studies, especially when non-brittle materials are used (Amick and Mauldin 1997; Ahler 1986; Flenniken 1981; Tomka 1989). The exceptionally low counts of angular debitage probably reflect the dominance of high-quality material and controlled flaking of such material during the later stages of tool production at the Merchant site and thus reveals the first clue into the nature of chipped stone technologies at the site.

The flake analysis focused on material, cortex, platform type, dorsal scar pattern, and dorsal scar number. Except for material type, these attributes could not be measured or reliably measured on partial flakes, which reduced the sample sizes in some situations. Cortex, dorsal scar pattern, and dorsal scar count were recorded only on complete flakes (n=972, 27.9 percent) with a platform and distal termination. Platforms were recorded on complete flakes and the 1,339 (38.4 percent) proximal fragments. Distal fragments (1,175, 33.7 percent) are similar to angular debitage in that they provide information on material types but were not included in the attribute studies.

A breakdown of flake completeness by major material categories is provided in Table 17.8. In this and forthcoming crosstabulations, adjusted residual values are included in each cell along with the counts and row or column percentages. The residuals are the difference between the observed and expected cell values under a null model assuming that the two variables are independent (Agresti 2002). The adjusted residuals normalize the values so that they have a mean of 0 and standard deviation of 1. Deviations are converted to Z scores, and thus an adjusted residual value greater than +1.96 (or +2.0 to round off the value) indicates that the number of cases in the cell is significantly higher than expected at the 0.5 significance level. Conversely, an adjusted residual of -1.96 (or -2.0) indicates that the cell value is significantly lower than expected. The utility of these measures is that they account for sample size effects in both the rows and columns and provide a simple yet robust appraisal of significant patterns across multiple crosstab cells.

A review of the adjusted residuals (AR) in the table finds that the complete flakes are significantly more common among the group of translucent silicified materials and present in significantly lower counts and proportions among limestone and quartzite. This is not a particularly surprising finding, but it is important because the separation of the translucent silicified group from other material groups is manifested throughout the attribute analyses to follow.

Individual Flake Attribute Analysis and Stage Reduction Typologies

Andrefsky (2001) reviews the three primary approaches to debitage analysis. *Aggregate or mass analysis* (Ahler 1989b; Ahler and Van Ness 1985; Stahle and Dunn 1982) involves the division or grouping of large collections of debitage by certain criteria and then comparing the relative proportions of those divisions among certain criteria such as reduction patterns or sites. The proportions are determined by the count or weight of items in each division. Most aggregate analyses include a size variable, usually measured by nominal categories of size grades.

A second approach is *debitage typological analysis*. In this approach, individual pieces of debitage are classified by types that are assumed or inferred to have technological or functional meanings. Examples included pressure flake, biface flake, hard hammer flake, core flake, and other terms. Andrefsky (2001:6) notes that the benefit of such an approach is the "immediate behavioral inference gained" from recognizing a specific reduction pattern or technology in a single piece of debitage. The categories of biface flake and core flake utilized by Vierra in several studies of Southwestern lithic technologies (1993, 1994, 2005) would fall under this approach.

Table 17.8. Flake completeness by material group

Material		Complete	Proximal Fragment	Distal Fragment	Totals
Translucent	Count	519	631	544	1694
	% within material group	30.6%	37.2%	32.1%	
	Adjusted Residual	**3.5**	-1.4	-1.9	
Chert	Count	356	526	455	1337
	% within material group	26.6%	39.3%	34.0%	
	Adjusted Residual	-1.3	0.9	0.3	
Igneous	Count	9	20	12	41
	% within material group	22.0%	48.8%	29.3%	
	Adjusted Residual	-0.9	1.4	-0.6	
Limestone	Count	26	49	63	138
	% within material group	18.8%	35.5%	45.7%	
	Adjusted Residual	**-2.4**	-.07	**3.0**	
Quartzite	Count	62	113	101	276
	% within material group	22.5%	40.9%	36.6%	
	Adjusted Residual	**-2.1**	0.9	1.1	
	Count	972	1339	1175	3486
Totals	%	27.9%	38.4%	33.7%	100.0%

Boldface red text denotes significantly higher counts and proportions at the 0.5 significance level; boldface black text indicates significantly lower counts and proportions at the 0.5 significance level

The third approach is *attribute analysis*. This method involves the measurement or observation of specific attributes or attribute states on collections of debitage. A variety of attributes have been measured, ranging from metric dimensions of flake size, weight, and platform width to categorical variables that include platform type, dorsal cortex, flake termination, and many more options (see Magne 1989; Magne and Pokotylo 1981). In contrast to typological analysis described above, attribute analysis examines the distributions of one or more attributes across the entire assemblage or sample of debitage. It differs from aggregate analysis in that the attributes are not confined to size or weight grades. The most common forms of attribute analyses have focused on platform characteristics, dorsal cortex, and the morphology of the dorsal surface of flakes.

As Andrefsky (2001:13) states in his introductory overview of debitage analysis, "There is no ultimate kind or level of debitage analysis….Instead, it is apparent that different techniques will provide different kinds of information about the overall site assemblage." Each of the approaches described above has inherent strengths and biases in the context of particular raw material types and availability, settlement systems, and technologies (as well as the constraints of laboratory time and funding), and each approach has been the subject of numerous criticisms based on experimental, archaeological, and theoretical grounds. The debates have been reviewed in several publications and do not need to be rehashed here (see Andrefsky 2001 for a thorough review).

For the present study of debitage from the Merchant site, the attribute analysis method is the preferred approach. The approach is based on observations of individual flake attributes within a general conception of lithic reduction stages and overall orientation. In this approach, specific attributes of individual flakes such as size or platform type are monitored in order to assign them to a general reduction stage associated with a particular reduction method, strategy, or trajectory.

The efficient application of this approach depends on the ability of the researcher to isolate a small number of independent attributes that reliably and consistently convey relevant technological information (Andrefsky 2001; Shott 1994). For example, surveying the literature on debitage analysis, Magne and Pokotylo (1981:36; Table 6) identify upwards of 38 variables used by various researchers. Based on discriminant function analysis of debitage experimentally produced during various reduction stages, Magne (1985; see also Magne and Pokotylo 1981) concludes that reduction stage can be predicted with 70-100% accuracy on the basis of four attributes: platform scar count, dorsal scar count, cortex cover, and weight. For flakes having intact platforms, platform type (count of flake facets) was determined to be the most powerful discriminator. Dorsal scar count was determined to be the most powerful discriminating variable for medial-distal fragments lacking platforms.

These attributes are then used to identify reduction stages. Building on the study of Collins (1975), Magne (1985) identifies four reduction stages: early stage reduction subsumes various initial processes of core reduction, middle stage reduction is viewed as the initial stages of tool production or blank production, and late stage reduction includes the final shaping, finishing, and maintenance of tools. The fourth stage - biface thinning - is viewed as a variant of late stage reduction. This scheme is useful as an analytical construct for several reasons. First, its relatively well-defined stages are based on explicit experimental observations and represent mutually exclusive classes. Independent assessments of Magne's stage classification scheme (Bradbury and Carr 1995; Carr and Bradbury 2001; Shott 1994) have produced similar results. Second, most studies have found that it is difficult to differentiate between the debitage produced during the final shaping and finishing of tools and that produced during maintenance and resharpening of tool margins and edges, regardless of whether individual flake attributes or size grades are examined (Ahler 1989b; Mauldin and Amick 1989; Prentiss 1998). Thus, for convenience, these reduction processes can be subsumed under the category of late stage reduction. Third, depending on the functional tool requirements of prehistoric groups, the presence/absence or differing proportions of reduction stages present among debitage assemblages will vary according to settlement type, technological organization and raw material availability. The reduction stage classification can be used in combination with other artifact data to examine site function and assemblage formation.

A review of the literature on debitage analysis finds that many studies have effectively integrated combinations of individual flake attributes and flake sizes or size grades (a variant of mass analysis) to interpret patterns of lithic reduction under both experimental and archeological conditions. The operative word here is "combinations." Carr and Bradbury (2001:134) conclude that "no single attribute can reliably classify all the individual flakes in an assemblage as to reduction type. However, certain attributes occur more commonly with one type (of reduction) than in others." Based on extensive experimental data, Carr and Bradbury (2001; see also Bradbury 1998; Bradbury and Carr 1995, 2005) demonstrate the utility of combining mass analysis and individual flake analysis to provide multiple lines of corroborative evidence. They note that convergence of multiple lines of evidence or multiple correlations among variables believed to represent similar forms of lithic reduction can increase the confidence in our recognition of patterns and subsequent interpretations. "If all lines of evidence suggest the same pattern of reduction for the flake debris, then inferences are strengthened, and therefore conclusions based on these data are much more likely to be correct [Carr and Bradbury 2001:129]."

This is the fundamental point and pursuit of the discussions to follow. The following series of analyses, the correlations of individual flake attributes and sizes are examined by material types. Five variables considered the most robust and reliable indicators of reduction method through both experimental and archaeological studies are examined. These variables can identify late stage core reduction and tool production versus early stage core reduction and informal tool production, particularly when used in combination. The variable are platform type, dorsal cortex, dorsal scar pattern, dorsal scar number, and flake size.

Attribute Analysis of the Merchant Flake Assemblage

The morphology of striking platforms on flakes has proven to be a strong indicator of types of reduction and tool production. Cortical and single facets are generally produced during core reduction and as part of flake tool production (Carr and Bradbury 2001); multifaceted platforms (2 or more flake facets) and crushed or ground platforms are more often produced during late stage reduction through pressure flaking, soft hammer retouch, and bifacial thinning, and other forms of tool production or maintenance (Dibble and Whittaker 1981; Magne 1985; Morrow 1984; Odell 1989; Parry and Kelly 1987; Shott 1994; Whittaker and Kaldahl 2001). Cortical and single facet platforms are almost always the most common types observed among lithic assemblages in southern New Mexico, simply by the fact that most reduction involved hard hammer percussion of nodules and cores. The proportions of cortical platforms is also partially conditioned by nodule size.

Table 17.9 displays the distribution of platform types by the major material categories at the Merchant site. As observed in numerous analyses across the southern Southwest, medium and coarse-grained materials have significantly higher proportions of cortical platforms, reflecting the larger nodules sizes and less intensive reduction of such nodules to produce core tools and flake tools. However, in the case of the Merchant assemblage, multifaceted platforms are essentially non-existent among these materials. The translucent silicified material group shows a very significant association with multifaceted flake platforms, while the chert category is relatively balanced with no significant variations. The presence of lipped platforms was also monitored but proved to be uninterpretable. Lipped platforms were observed on 122 flakes (5.2 percent) and exhibited no patterning among material types or sizes.

Table 17.9. Platform type on complete flakes and proximal fragments by material group

		Flake Platform Type					
Material		**Cortical**	**Single Facet**	**Multifaceted**	**Ground**	**Collapsed**	**Totals**
Translucent	Count	40	865	223	4	33	1165
	% within material group	3.4%	74.2%	19.1%	0.3%	2.8%	
	Adjusted Residual	**-9.8**	1.4	**6.3**	1.3	-0.4	
Chert	Count	89	657	114	1	28	889
	% within material group	10.0%	73.9%	12.8%	0.1%	3.1%	
	Adjusted Residual	0.9	0.8	-1.8	-0.8	0.4	
Igneous	Count	8	20	0	0	0	28
	% within material group	28.6%	71.4%	0.0%	0.0%	0.0%	
	Adjusted Residual	**3.5**	-0.2	**-2.2**	-0.2	-0.9	
Limestone	Count	31	44	0	0	0	75
	% within material group	41.3%	58.7%	0.0%	0.0%	0.0%	
	Adjusted Residual	**9.7**	**-2.8**	**-3.6**	-0.4	-1.5	
Quartzite	Count	49	116	2	0	8	175
	% within material group	28.0%	66.3%	1.1%	0.0%	4.6%	
	Adjusted Residual	**8.9**	**-2.1**	**-5.2**	-0.6	1.3	
	Count	217	1702	339	5	69	2332
Totals	%	9.3%	73.0%	14.5%	0.2%	3.0%	100.0%

Boldface red text denotes significantly higher counts and proportions at the 0.5 significance level; boldface black text indicates significantly lower counts and proportions at the 0.5 significance level

The attribute of dorsal cortex has been used in innumerable analyses of debitage. The terminology, classification methods, and interpretations of dorsal cortex have been critiqued in several studies. There are problems involving consistency of nomenclature, particularly the use of the nominal and poorly-defined categories of terms primary, secondary, and tertiary flake (Sullivan and Rozen 1985). Some have noted that cortical flakes can be removed at any point along the reduction sequence (Jelinek et al. 1971), while other studies have demonstrated that cortex remnants among flake assemblages are highly conditioned by nodule size, with series of flakes detached from smaller nodules having higher proportions of cortical specimens than series of flakes resulting from the reduction of large nodules (Fish 1981). Jeter (1980) notes that the attribute can only be accurately measured on complete flakes, which can impose another form of bias.

Nevertheless, the attribute does provide a general measure of reduction intensity, particularly if it is consistently recorded and evaluated in the context of other attributes. It is not useful for discriminating between core and bifacial reduction techniques, but general correlations have been identified linking the amount of dorsal cortex and reduction stage (Magne and Pokotylo 1981; Mauldin and Amick 1989; Shott 1994; Tomka 1989).

For the present study, the categories of primary, secondary, and tertiary were avoided. Instead, seven categories of dorsal cortex were recorded (100 percent, five increments of 20 percent, and 0 percent). For clarity of presentation, these have been collapsed into two general groups, cortical flakes (1 to 100 percent dorsal cortex) and non-cortical flakes (0 percent cortex), and the data is displayed in Table 17.10. Over 83 percent of the entire assemblage of complete flakes has no cortex, and thus the reason for collapsing the six cortical groups into a single group. It is also noted that the igneous group in this and the following tables is represented by only nine artifacts and the significance of the adjusted residuals for this group may be discounted on the basis of such a small sample size.

Table 17.10. Cortical vs. non-cortical complete flakes by material group

Material		0% Cortex	1-100% Cortex	Totals
Translucent	Count	491	28	519
	% within material group	94.6%	5.4%	
	Adjusted Residual	**10.0**	**-10.0**	
Chert	Count	279	77	356
	% within material group	78.4%	21.6%	
	Adjusted Residual	**-3.2**	**3.2**	
Igneous	Count	4	5	9
	% within material group	44.4%	55.6%	
	Adjusted Residual	**-3.2**	**3.2**	
Limestone	Count	8	18	26
	% within material group	30.8%	69.2%	
	Adjusted Residual	**-7.3**	**7.3**	
Quartzite	Count	29	33	62
	% within material group	46.8%	53.2%	
	Adjusted Residual	**-8.0**	**8.0**	
	Count	811	161	972
Total	%	83.4%	16.6%	100.0%

Boldface red text denotes significantly higher counts and proportions at the 0.5 significance level; boldface black text indicates significantly lower counts and proportions at the 0.5 significance level

The most striking pattern in the table is the exceptionally high proportion of non-cortical flakes among the translucent silicified materials, 16 percentage points higher than chert and more than double any other material. The AR values confirm that the proportion of non-cortical flakes among the translucent silicified materials is highly significant, while every other material class, including chert, has significantly lower proportions of cortical flakes. Nearly 95 percent of the complete flakes of translucent silicified materials have no dorsal cortex, a rather exceptional proportion among flake assemblages in southern New Mexico.

Two variables that describe the nature of flake scars on the dorsal surfaces of complete flakes were recorded. Greater numbers (3 or more) of scars on dorsal flake surfaces has been shown to be a relatively strong discriminator of late stage core and bifacial reduction (Magne 1985; Magne and Pokotylo 1981; Odell 1989; Shott 1994), although Mauldin and Amick (1989) caution that the number of dorsal scars may be partially dependent on overall flake size. A greater focus on core reduction has been shown to correlate with greater numbers of dorsal flake surfaces consisting of cortex or a single flake scar or two (Carr and Bradbury 2001). The pattern of flake scars has proven less consistently diagnostic (Mauldin and Amick 1989). However, the presence of converging dorsal scar patterns has been found to correlate with bifacial reduction and has been used in combination with other attributes to temporally differentiate between the bifacial and core reduction technologies relating to Archaic and Ancestral Pueblo occupations in northern New Mexico (Chapman 1977, 1982).

Table 17.11 and 17.12 display the dorsal scar variables and their distributions among the primary material classes. The pattern consistently seen among the preceding attributes is again manifested among the dorsal scar variables, namely that attribute states associated with more intensive reduction and bifacial tool production are manifested in significantly higher counts and proportions in the translucent silicified material group. Flakes with four or more dorsal scars and converging dorsal scar patterns were observed in significantly higher proportions in the debitage collections assigned to the translucent silicified material group. Surprisingly, the core reduction and early stage reduction indicator of 0-1 dorsal scars is significantly higher among the chert group, in addition to the coarser-grained limestone and quartzite groups.

The final debitage analysis reviews flake sizes, including continuous measurements of flake lengths and interval size categories, also known as flake size grades. Experimental analyses have identified strong and consistent correlations between late stage reduction and greater quantities or proportions of small debitage measurements and size grades (Ahler 1989a, 1989b; Baumler and Downum 1989; Mauldin and Amick 1989; Prentiss 2001; Stahle and Dunn 1982), although these studies have also observed that some amount of small debitage is produced during all stages of the reduction process. Moreover, the size grades of debitage produced during shaping and resharpening (retouching) of edges on tools is almost entirely small (Baumler and Downum 1989).

Size grades were divided into five increments. The first increment is flakes less than 6.25 mm in maximum dimension (length of width), a measurement equal to ¼ inch mesh screen. The next increment is 6.25 to 9.9 mm, followed by two increments of 10 mm, and a final group of flakes measuring 30 mm or greater. Table 17.13 displays the distribution of the size grades among the material groups.

The immediate impression is that the majority of flake debitage recovered from rooms and middens is exceptionally small. Almost 92 percent of the unutilized flakes measure less than 20 mm and 98.3 percent of the silicified translucent flakes are smaller than 20 mm. The translucent silicified group also has significantly higher proportions of the two smallest size grades. Chert again appears to have an intermediate status between the translucent silicified and coarser-grained materials which show significantly higher proportions of the two largest size grades.

Flake sizes are also examined through the continuous variable of flake lengths measured on complete specimens (Figure 17.6). The distribution of size grades evident in Table 17.13 is visually apparent in the boxplots of the figure, with the translucent silicified and chert groups having much smaller flake sizes than limestone and quartzite (note again that the igneous group consists of only nine artifacts, three of which are small obsidian flakes). The mean flake length of the translucent silicified group is 0.87 cm (st dev .345) and the mean flake length of chert is 1.09 cm (st dev .554). An independent samples t-test assuming unequal variances determines that the translucent silicified flakes are significantly smaller than the chert flakes (t = -6.606, df = 542, p = <.001).

Table 17.11. Number of dorsal scars on complete flakes by material group

Material		0-1 Scars	2-3 Scars	4+ Scars	Totals
Translucent	Count	38	254	227	519
	% within material group	7.3%	48.9%	43.7%	
	Adjusted Residual	**-6.3**	1.5	**2.9**	
Chert	Count	61	164	131	356
	% within material group	17.1%	46.1%	36.8%	
	Adjusted Residual	**2.3**	-0.3	-1.3	
Igneous	Count	2	6	1	9
	% within material group	22.2%	66.7%	11.1%	
	Adjusted Residual	0.7	1.2	-1.8	
Limestone	Count	10	12	4	26
	% within material group	38.5%	46.2%	15.4%	
	Adjusted Residual	**3.7**	-0.1	**-2.6**	
Quartzite	Count	23	18	21	62
	% within material group	37.1%	29.0%	33.9%	
	Adjusted Residual	**5.5**	**-2.9**	-0.9	
	Count	134	454	384	972
Total	%	13.8%	46.7%	39.5%	100.0%

Boldface red text denotes significantly higher counts and proportions at the 0.5 significance level; boldface black text indicates significantly lower counts and proportions at the 0.5 significance level

Table 17.12. Dorsal scar pattern on complete flakes by material group

		Dorsal Scar Pattern				
Material		None	Unidirectional	Bidirectional	Converging	Totals
Translucent	Count	4	104	166	245	519
	% within material group	0.8%	20.0%	32.0%	47.2%	
	Adjusted Residual	**-6.1**	-1.9	-1.4	**5.6**	
Chert	Count	21	82	135	118	356
	% within material group	5.9%	23.0%	37.9%	33.1%	
	Adjusted Residual	1.4	0.3	**2.0**	**-2.8**	
Igneous	Count	1	2	4	2	9
	% within material group	11.1%	22.2%	44.4%	22.2%	
	Adjusted Residual	0.9	0.0	0.7	-1.0	
Limestone	Count	6	8	8	4	26
	% within material group	23.1%	30.8%	30.8%	15.4%	
	Adjusted Residual	**4.5**	1.0	-0.3	**-2.5**	
Quartzite	Count	13	22	17	10	62
	% within material group	21.0%	35.5%	27.4%	16.1%	
	Adjusted Residual	**6.3**	**2.5**	-1.1	**-3.8**	
	Count	45	218	330	379	972
Totals	%	4.6%	22.4%	34.0%	39.0%	100.0%

Boldface red text denotes significantly higher counts and proportions at the 0.5 significance level; boldface black text indicates significantly lower counts and proportions at the 0.5 significance level

Table 17.13. Complete flake size grades by material group

Material		<6.25 mm	6.25-9.9 mm	10.0-19.9 mm	20.0-29.9 mm	30.0+ mm	Totals
		Size Grades					
Translucent	Count	98	288	124	9	0	519
	% within material group	18.9%	55.5%	23.9%	1.7%	0.0%	
	Adjusted Residual	**4.0**	**4.1**	**-2.7**	**-5.8**	**-5.5**	
Chert	Count	41	175	113	24	3	356
	% within material group	11.5%	49.2%	31.7%	6.7%	0.8%	
	Adjusted Residual	**-2.1**	-0.1	**2.2**	1.0	**-2.7**	
Igneous	Count	2	4	1	1	1	9
	% within material group	22.2%	44.4%	11.1%	11.1%	11.1%	
	Adjusted Residual	-0.6	-0.3	-1.1	0.7	1.6	
Limestone	Count	0	5	7	8	6	26
	% within material group	0.0%	19.2%	26.9%	30.8%	23.1%	
	Adjusted Residual	**-2.1**	**-3.1**	-0.1	**5.5**	**6.5**	
Quartzite	Count	1	8	23	14	16	62
	% within material group	1.6%	12.9%	37.1%	22.6%	25.8%	
	Adjusted Residual	**-3.0**	**-5.9**	1.7	**5.9**	**11.7**	
	Count	142	480	268	56	26	972
Total	%	14.6%	49.4%	27.6%	5.8%	2.7%	100.0%

Boldface red text denotes significantly higher counts and proportions at the 0.5 significance level; boldface black text indicates significantly lower counts and proportions at the 0.5 significance level

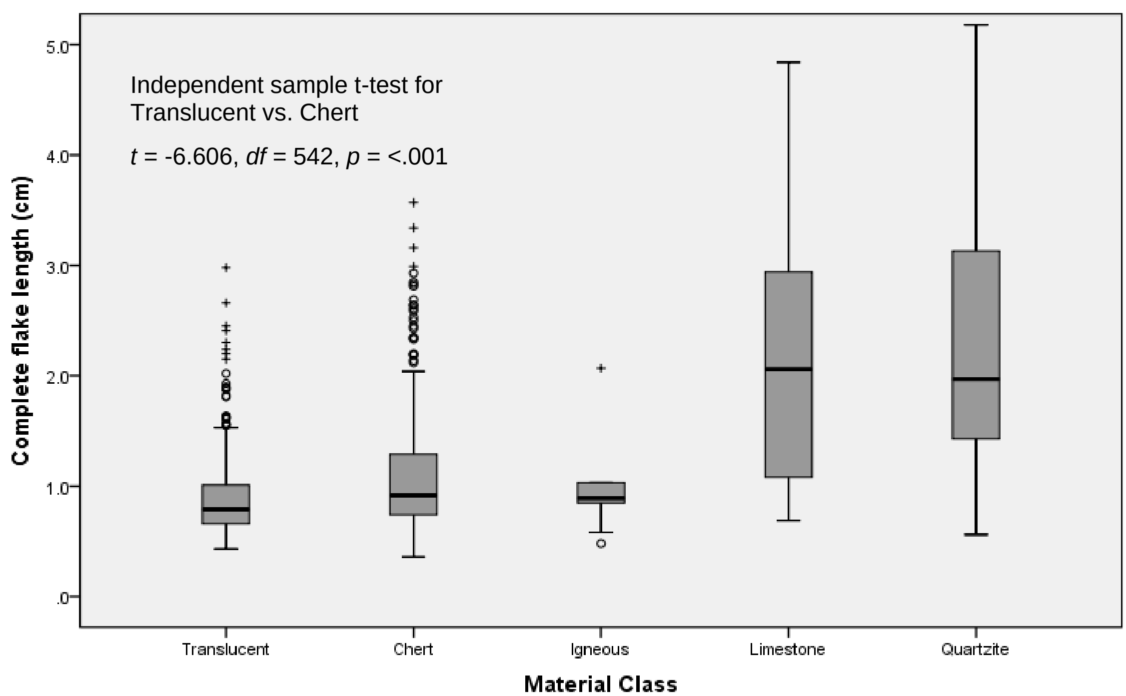

Figure 17.6. Boxplots comparing lengths of complete flakes by major material groups.

Reduction Characteristics of Individual Raw Material Types

The series of debitage analyses presented so far reveal a consistent and statistically robust trend manifested across every variable. Flake debitage of translucent silicified materials has significantly higher proportions of complete flakes, multifaceted platforms, non-cortical flakes, flakes with four or more dorsal scars and converging dorsal scar patterns, and flake size grades smaller than 6.25 and 9.9 mm. The flake debitage of igneous, limestone, and quartzite materials are nearly the mirror opposite, with significantly lower proportions across all of these variables and significantly higher proportions of cortical platforms, cortical flakes, dorsal scar counts of 0-1, and larger flake size grades. Flakes of the various chert types occupy somewhat of a middle zone between the translucent silicified and medium/coarse-grained materials. The conclusions drawn from the analysis is translucent silicified materials were much more commonly used for late stage reduction, cherts were used for intermediate tool production through early and middle stages of reduction, and medium/coarse-grained materials were predominately used in core reduction to produce expedient tool forms.

There is nothing new or revolutionary about these observations, as the correlation between fine-grained materials and late stage or intensive reduction has been observed in virtually hundreds of analyses of prehistoric lithic assemblages. However, while the relationship between high quality material and late stage and bifacial reduction, tool production, and tool edge maintenance appears to be present in the Merchant site debitage assemblage, there is also a component of intermediate tool manufacture that should not be ignored.

The small flake sizes, rarity of cores, and other attributes of the translucent silicified materials may be related to small nodule sizes, but in the sense that many of these materials are from distant sources and were transported to the site as decortified cobbles, partially reduced cores, and bifaces and tools. Conversely, the locally obtained cherts and other materials were used to produce the component of flake tools, unifaces, spurred tools, and cobble tools. If such patterning can be identified, it may reveal larger domains of hunting ranges and material procurement.

Accordingly, the specific material types merit a closer examination. A subset of the flake debitage of 19 material types was selected and is described in Table 17.14. Material types with fewer than 20 artifacts were eliminated because of the effects of small sample sizes on proportional data. This had a negligible effect on the overall sample size and variability of the data, as 19 material types remained in the analysis and those materials include 3,379, or 97 percent, of the 3,486 flakes of the total assemblage.

To reduce and simplify the dimensionality of the data presentation, the proportional attributes were input into a principal components analysis, the results of which are presented in Table 17.15. Two principal components were derived that cumulatively account for 75 percent of the variance of the data set. Principal Component (PC) 1 has high loadings on single flake and multifaceted platforms, non-cortical flakes, converging scar patterns, dorsal scar counts of 4 or more, and very small flake sizes, as well as negative loadings on cortical platforms and dorsal scar counts of 0-1. This combination of component loadings differentiates between early and late stage reduction. PC 2 is more difficult to interpret, but with high or moderate loadings on complete flakes, multifaced platforms, and dorsal scar counts of 4 or more, and negative loadings on single flake platforms and very small flake sizes, it seems to reflect biface thinning and/or tool edge production.

Table 17.14. Refined set of raw material types with sample size N>20 used in the comparative analyses

Material Class	Material Code	Description	n	Comment
Chert	205	Gray mixed	38	
Chert	206	Dark gray	103	Includes regional gray cherts?
Chert	207	Light tan	304	Includes regional tan cherts?
Chert	215	Light gray	321	
Chert	223	White/cream	367	Includes Custer Mtn white
Chert	224	Butterscotch	61	
Chert	227	Pink to pink-white	31	
Chert	228	Red	40	
Chert	230	Yellow	24	
Translucent	300	Tan/Brown	305	
Translucent	301	Rose	76	
Translucent	302	White	571	
Translucent	303	Yellow	57	
Translucent	304	Gray	675	
Rhyolite	410	Red	25	Pecos gravels
Limestone	520	White and tan	134	Local
Quartzite	610	White and gray	124	Pecos and Ogallala
Quartzite	613	Brown	100	Local outcrops
Quartzite	614	Purple	23	Ogallala formation
Total			**3,379**	

Table 17.15. Principal components analysis of debitage attributes on the subset of raw materials

	Initial Eigenvalues		
Component	**Total**	**% of Variance**	**Cumulative %**
1	5.182	57.589	57.589
2	1.517	16.853	74.442
3	.954	10.605	85.046

Component Matrix[a]

	Principal Component	
	PC 1	PC 2
Complete flake	.400	.774
Cortical platform	-.919	.171
Single flake platform	.579	-.643
Multifaceted platform	.720	.436
Non-cortical flake	.979	-.060
Dorsal scar count 0-1	-.802	-.149
Dorsal scar count 4+	.616	.312
Dorsal scar pattern converging	.875	-.049
Flake length < 10 mm	.761	-.400

a. 2 components extracted at Eigenvalue >1.0

Figure 17.7 displays a bivariate plot of the PC scores of the nineteen material types. As with any such analysis, there is some amount of unsystematic variation. For example, the small number of rhyolite flakes fall within the intensive reduction area of PC 1, but that is just a chance event because the small collection of nine complete rhyolite flakes happened to be small flakes without cortex and having single facet platforms.

Setting aside the major outliers, the typical partition of fine-grained as opposed to medium/coarse-grained materials is evident in the plot. Quartzites and limestone have negative scores on PC 1, indicating less intensive reduction. A few cherts also have negative scores on PC 1. Of additional significance is that the group of translucent silicified material types and a couple chert types have high positive scores on both PC 1 and PC 2, indicating these materials were used for more intensive late stage reduction combined with biface production.

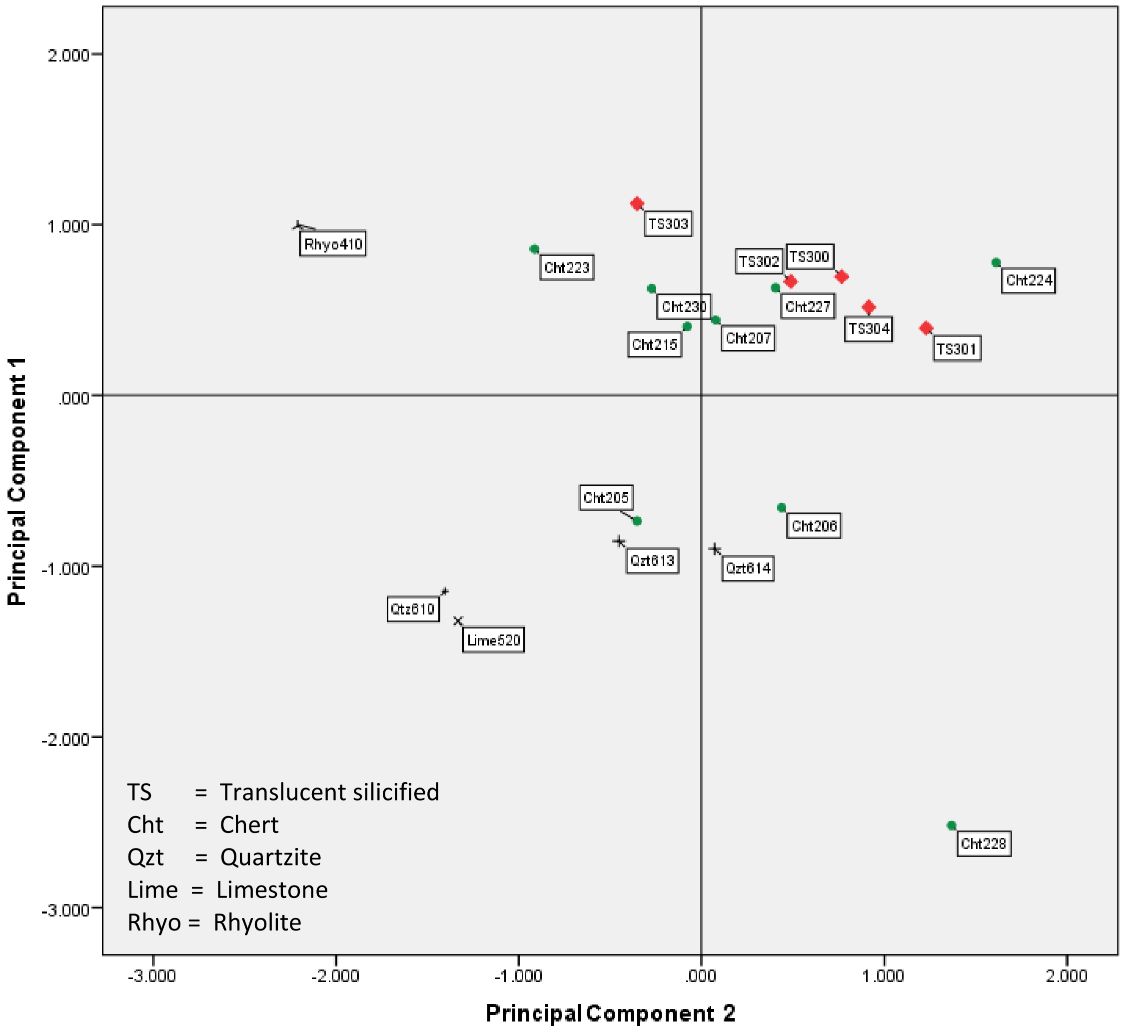

Figure 17.7. Plot of material types on Principal Components 1 and 2. Translucent silicified types are marked with red symbols, cherts in green symbols, and the igneous, limestone, and quartzite material is noted by black symbols.

These trends are evident in the distribution of tool classes by materials (Figure 17.8). For clarity of presentation the unifaces were combined with the category of flake tools. Twenty-five points representing Archaic or Early Formative types and a small number of non-diagnostic point tips were removed from the data used in this figure. While they certainly were part of the tool inventory and occupational history of the site, these points were scavenged tools and were not part of the procurement and reduction cycle that is the focus of the study. Of interest is that half of the subset of Archaic and Early Formative points are chert dark gray variety 206 and light tan variety 207 that are thought be chert types available in the Pecos Valley, Roswell Oasis, and other areas of southeast New Mexico.

Three general trends are apparent in the figure. Limestone and quartzite were used predominantly for cobble tools and flake tools while igneous and chert material to produce flake tools and some bifaces. Translucent silicified material were roughly evenly divided among flake tools and bifaces.

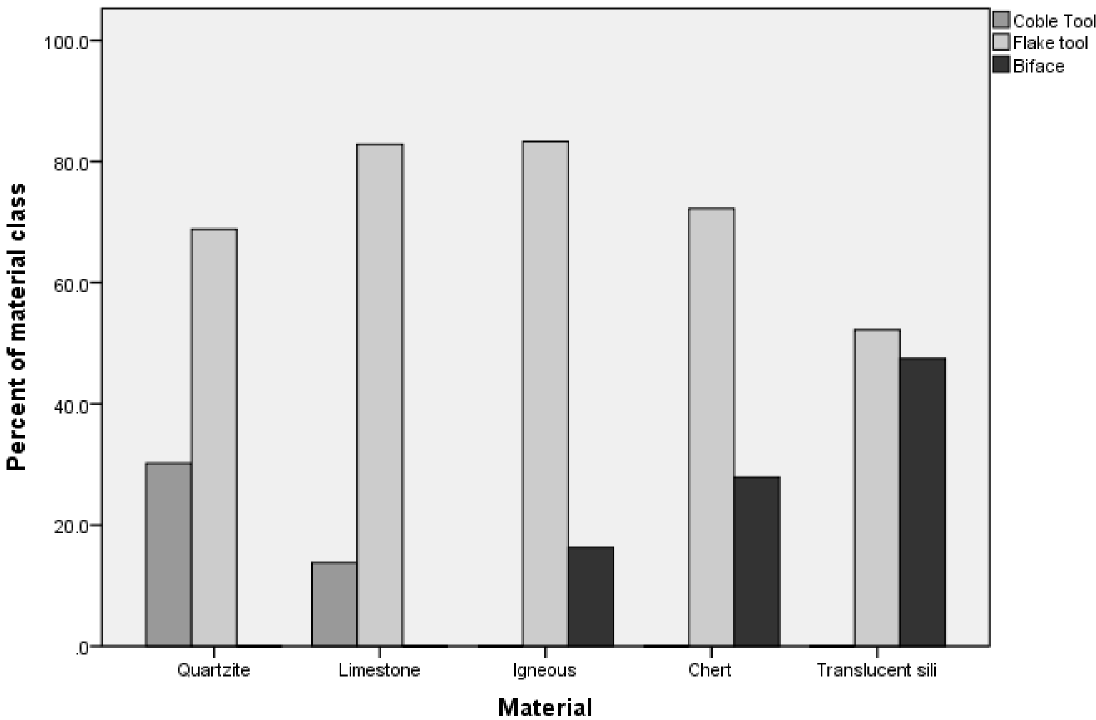

Figure 17.8. Proportions of tool classes by material class.

The next phase of the analysis was intended to examine the distributions of the individual material types among the tool classes. At this point we were confronted by a problem – the sample sizes of tools for most of the translucent silicified material types among the tool categories were too small for such analyses. While translucent silicified materials account for 49 percent of the debitage, they are present among only 14 percent of the tools. Chert accounts for 38 percent of the debitage but is represented among 56 percent of the tools. The medium/coarse-grained materials constitute less than 13 percent of the flakes but are nearly 30 percent of the tools. These are somewhat unexpected findings in the context of conventional models of lithic procurement and tool production that assume greater numbers of tools, and particularly formal tools, will be represented among the highest quality raw material types.

So clearly there is some disjunction between the amounts of debitage, the debitage attributes, and types of reduction represented by those attributes when compared to the numbers of tools among the major material classes and types. These patterns are further explored in the comparisons of debitage to tool and debitage to flake tool ratios presented in Figure 17.9.

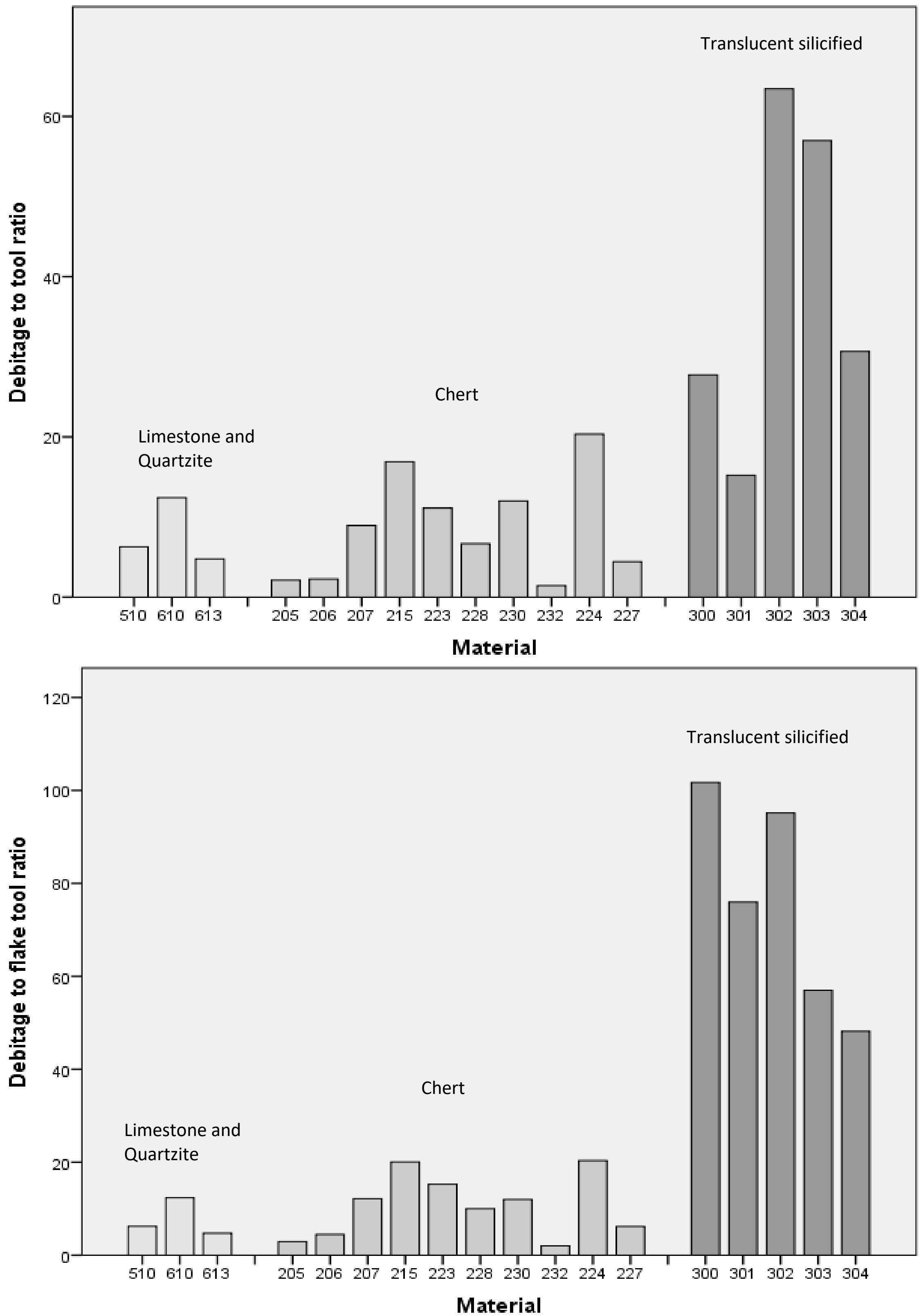

Figure 17.9. Debitage to tool ratios (upper panel) and debitage to flake tool ratios (lower panel).

The upper panel displays the ratios of debitage to all tools, including projectile points. Several of the translucent silicified material types have substantially higher ratios, indicating that hundreds of flakes of these materials were present but few tools were identified. The average ratio for the five translucent silicified groups is 38.8 flakes per tool as opposed to 8.6 and 7.8 flakes per tool for the group of cherts and the limestone/quartzite materials. These patterns are even more impressive when the ratios of debitage to flake tools (including unifaces) are examined (Figure 17.9, lower panel). The translucent silicified materials have debitage to flake tool ratios four to five times higher than cherts, limestone, and quartzites. The average ratio for the five translucent silicified groups is 75.6 flakes per flake tool as opposed to 10.5 and 7.8 flakes per flake tool for chert and limestone/quartzite materials.

Two conclusions are drawn from these analyses. The first conclusion reflects the conventional observation in lithic analyses that finer grained materials were used to produce flake tools and formal tools, while local materials of secondary quality were used as core tools and to make some flake tools. The second observation is counter-intuitive to this conventional wisdom, in that some of the highest quality siliceous material is manifested in hundreds of flakes but is comparatively absent among flake tools and formal tools. The mass quantities of translucent silicified debitage establish without doubt that intensive reduction of those materials took place and that quantities of tools were manufactured. However, those tools were rarely found in the lithic assemblages collected in 2015 and 2019.

One possibility is that the underrepresentation of tools made of translucent silicified materials is due to the collection and spatial biases reviewed in the chapter introduction. Nicely formed and finished tools of visually appealing siliceous materials were favored by looters and collectors, and the removal of such tools from the site would have reduced the counts and proportions of unifaces, bifaces, and projectile points. However, several of the local and regional cherts are fine-grained siliceous materials and thus it would be expected that collection biases would be evenly distributed across material types. The focus of the excavations in rooms and middens may have biased the assemblage towards those contexts as opposed to plaza or extramural spaces where formal tools were used. Again however, such spatial biases should be somewhat evenly manifested across tool forms.

Other factors suggest that the counts and proportions may not be overly biased. Quantities of resharpening debitage were observed, establishing that tools were used and rejuvenated around the rooms. The almost complete absence of cores of translucent materials is another factor. Cores were rarely collected by the LCAS crew or looters (as listed in Table 17.1, note that the LCAS excavators collected only three cores). Cores were not subject to selective collector bias and the rarity of translucent silicified cores is related to reduction and other factors rather than collection bias.

Raw Material Sourcing and Technology at the Merchant Site

The observations on material types, reduction intensity and type, and tool forms revealed through the series of analyses presented to this point reveal a counter-intuitive or counter-empirical conclusion that tools are represented in disproportionately lower numbers among the highest quality raw materials. This finding necessitated a deeper probe that considers the sources of the materials under study. The explanation for the unexpected analysis observations lies in the origin and sources of the materials.

Relationship of Material Type to Ultraviolet Fluorescence

Many of the material types appeared to be non-local. However, it is difficult to consistently classify any material types on assemblages of flakes measuring less than 5 or 10 mm, much less attempting to identify whether such materials were obtained from local or distant sources. Ultraviolet light fluorescence (UVF) offered a means of identifying possible and probable material types from relatively distant sources on the southern Plains.

The use of UVF as a sourcing method began in the late 1980s and early 1990s with investigations of Knife River Flint in the northern Plains (Ahler 1991; Church 1990) and Edwards Plateau chert in the southern Plains and Texas (Hofman et al. 1991). Hillsman (1992) reviewed the potential of UVF sourcing, noting the inconsistencies in describing the different color reactions. A comprehensive review of UVF material identification is provided in the Fort Bliss Lithic Sourcing Project summary report (Church et al. 1996). A variety of materials from west Texas and southern New Mexico were examined and a compendium of previous studies was presented. Church and his colleagues note that the UVF responses of cherts and other materials are quite variable, and the analyst's perception of the colors and intensities of the reactions are equally as variable and subjective. They conclude that the method should be used only with caution in attempting to identify specific material types.

Despite the issues with accuracy and reliability, there is a sufficiently consistent trend of Edwards Plateau producing orange and yellow responses and the white varieties of Alibates dolomite and Tecovas jasper have strong light green reactions upon exposure to UV light (Church et al. 1996; Hofman et al. 1991; Hillsman 1992). The use of UVF to identify these distant materials has been successfully integrated with previous studies of flaked stone raw materials in southeastern New Mexico (Hamilton 2016; Speth and Newlander 2012; Clark and Speth 2022; Wiseman et al. 2002).

Considering the cultural and geographic context of the current study, it is unlikely that material types with fluorescent properties from distant locations other than the Edwards Plateau and Texas Panhandle are present in significant quantities among the lithic artifacts from the Merchant site and, if so, their numbers are small enough that they do not cause undue bias in the statistical analyses to follow. However, it is acknowledged that some degree of error is present. For example, the discovery that cherts or fossilized shell from the Custer Mountain source have strong green reactions to UVF (Figure 17.10. upper panel) can lead a misidentification of those materials with the Alibates and Tecovas sources.

Flaked stone artifacts were inspected under UV light using a neutral black background. All tools, cores, and a sample of debitage were individually coded and debitage assemblages were also subjected to a mass analysis by provenience. Separate long-wave and short-wave UV units were used. The color of the fluorescent reaction (or absence of a reaction) and percentage of the surface reacting was recorded. Some artifacts displayed a strong reaction across the entire surface (Figure 17.10, lower panel), while others were spotty (< 50 percent of the surface) or only had trace or faint reactions. Minor variations in color were not recorded. Most of the reactions were surprisingly consistent in terms of color, with the exception of orange and yellow colors that tended to blend together.

The faint and trace reactions are minor occurrences of a few inclusions or grains in an artifact and are not included in the analyses to follow. In general, the reactions come down to a few color categories. The reactions to long-wave UV light identified orange and yellow reactions that probably identify Edwards Plateau chert. A small number of eight faint green reactions were observed but the sample is too small for further consideration. The short-wave reactions were more complex and variable, including light green, white-gray, and orange and yellow colors.

Some degree of caution is warranted when considering the analyses to follow. First, there is some potential for certain artifacts to be misidentified as Edwards Plateau cherts or Alibates dolomite on the basis of color response because many color reactions are not specific to a single material source. Indeed, the discovery that Custer Mountain chert presents a strong green response to short-wave UV light can complicate the identification of Alibates dolomite and Tecovas chert, each of which are also known for strong green reactions. To avoid such confusion, the Custer Mountain material was either assigned a new subcode to track its presence or was removed from certain analyses. On the other hand, several major stone material sources do not react to UV light at all, and therefore the presence of such materials will not be detected during UVF analysis. For example, the red variety of Alibates dolomite does not react to either short or long-wave UV light, while the white variety shows has a strong response to short-wave UV light.

Figure 17.10. Short-wave ultraviolet light reactions of select materials. Upper panel, collection of Custer Mountain chert or fossilized shell flakes (white chert material type 223a) showing a strong light green response to short-wave UV light; lower row, biface of white translucent silicified material type 302 viewed under natural and short-wave UV light. The material has been identified as opalite from the Texas Panhandle (Lintz 1998) and the very bright green UVF response is typical of such material.

Second, there is admittedly some degree of subjectivity and error involved in both the assignment of small flakes to specific material codes and during the coding of UV light responses. A couple thousand flakes smaller than 10 mm were assigned to multiple material types and colors, and some degree of analyst variability and classification error should be expected in such an analysis. Subtle variations in the color responses to UV light recorded among such small flakes might also be expected. When combined, these two factors contribute to a certain degree of error in raw material source identifications, and one that is difficult to quantify or rectify without employing a massive, intensive analysis using microscopic, geochemical, and UVF studies (see Wiseman et al. 2002 for a similar conclusion).

Although there is some degree of unquantifiable error in the visual and UVF classification of raw materials, that does not negate their utility. There is an impressive degree of consistency and statistically robust patterning of material type assignments throughout the assemblages, and this consistency confirms that important correlations are being tracked through different analyses. The basic intent of this study is not to identify an absolute or precise measurement of how much of chert type A or chalcedony type B is present, but rather to evaluate how the trends of statistically greater or lesser quantities of chert A and chalcedony B track across tool types and other variables.

With all that being said, the analysis results are quite remarkable. Under long-wave UV light, 764 of the 1,785 individual artifacts examined showed some form of fluorescence, a response rate of 42.8 percent. Eliminating the 66 trace and rare green or white reactions results in a response rate of 39.1% for orange and yellow colors, indicating that nearly 4 out 6 items may have been made of Edwards Plateau chert. Among the 1,230 individual artifacts examined under short-wave UV light, 252 (20.5 percent) had a strong light green response, 233 (18.9 percent) an orange-yellow reaction, and 87 (7.1 percent) had a grey-white response. Thirty of the chert artifacts with a green response were assigned to the Custer Mountain source and it is possible that additional items from this source are present among the group of green UV responses but were not identified visually.

The identification of Edwards Plateau chert based on long-wave UVF responses is considered to be the most reliable. Strong and moderately strong responses to long-wave UV light ranging from yellow to orange were observed and very few UVF responses of other color spectra were noted. Additionally, most of the artifacts that had a strong orange-yellow response exhibited the response over most of the artifact surface exposed to the UV light source. A few cherts and chalcedonies from southern New Mexico exhibit weak yellow UVF responses (Church et al. 1996), but none express the consistently strong response of Edwards Plateau types.

Short-wave UVF responses show a much greater range of variation in colors, intensity, and coverage. Many artifacts had partial or trace responses, as well as partial coverage where the response was spotty. Strong green responses across most of the artifact are considered a reliable means of identifying Texas Panhandle sources such as Alibates dolomite, opalite, or Tecovas jasper but may also indicate the presence of the Custer Mountain source. A small subset of artifacts assigned to chert type 207 had a gray-white response to short-wave UV light. The source of these materials is uncertain, although Hillsman (1992) notes that some Edwards Plateau cherts exhibit gray-white responses.

Turning now to the relationship between UVF responses and material types, the frequency of UVF responses among material types was examined and the adjusted residuals were used to identify significantly higher or lower proportions of color responses. The results have been incorporated into Figure 17.11, which is a modified version of Figure 17.7 with limestone, quartzite, and rhyolite removed in order to specifically focus on cherts and translucent silicified material types. The statistically significant negative and positive responses to UV light among the 14 materials are color-coded in the figure.

Four of the translucent silicified types (TS 300, 301, 302, 304) and one chert (Cht 207) have proportional UVF responses that are significantly higher than other types. These materials also occupy the upper right quadrant of the plot that identifies late stage reduction and biface production. In contrast, most of the other cherts have significantly lower UVF response rates and are plotted in quadrants that identify core reduction and early stage reduction or non-bifacial tool production. The UVF and material studies reveal that raw material types with higher proportions of late stage and bifacial reduction also have higher proportions of raw materials presumably obtained from relatively distant locations in the savannahs of central Texas and Texas Panhandle plains. These material types are also underrepresented in tool assemblages.

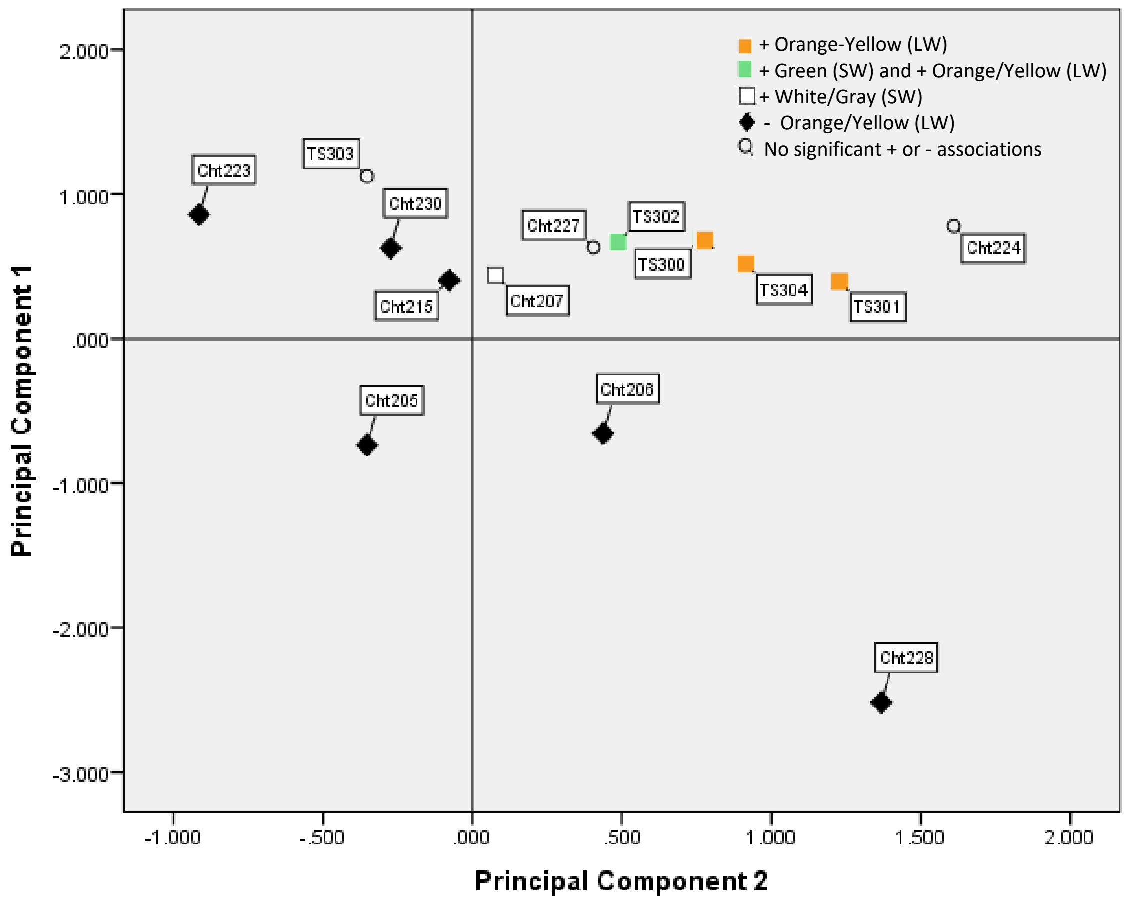

Figure 17.11. Plot of cherts and translucent silicified material types on principal components 1 and 1 with reactions to UV light indicated. SW=short-wave UVF; LW=long-wave UVF.

The summary conclusion of the UVF sourcing analysis is that statistically significant proportions of translucent silicified materials were obtained from distant sources and were transported back to the Merchant site. These materials were intensively reduced to produce projectile points, bifaces, and some unifacial and flake tools. This is further corroborated by the fact that an impressive proportion of the small number of bifaces and points recovered through excavation exhibited responses to UV light. This is particularly evident among the Late Formative period projectile points, the majority of which are displayed in Figures 7.12 through 7.15 (recalling that 25 non-diagnostic fragments and points from earlier periods were previously removed from the analysis). Of the 54 Late Formative arrow points and fragments, 45 (83.3 percent) showed a green, orange-yellow, or gray-white response to short-wave or long-wave UV light. Of the sample of 35 points that were assigned to the Fresno, Washita, Harrell, or Toyah types (Figures 7.12 – 7.15), a UVF response was recorded on 30 specimens (85.7 percent).

In noting these high UVF response rates, we should not lose sight of the fact that the overall counts of projectile points and other tools made of translucent silicified materials are very small. Accordingly, the second conclusion is that many points and tools were either taken away from the site during the long-distance hunting trips or deposited in special contexts. In some situations, those tools were returned to the site in one form or another. One means of examining this by assessing the amount of retooling or replacement of projectile points. The 54 points include 16 complete or mostly complete points, 27 basal or basal-medial portions, and 11 tip fragments. These sample numbers are small and there is no statistically robust patterning of material types or UVF responses among these completeness categories. However, the fact that 50 percent of the specimens are basal fragments and were presumably returned to the site attached to the arrow shaft for refitting does suggest that both broken points and new supplies of materials were returned to the village.

Unfortunately, there is no data on specimen completeness for the thousands of projectile points documented by the LCAS. The only data available are the type assignments determined by Leslie and a sample of the best and most complete specimens illustrated in photographs (Leslie 2016a) and therefore the numbers of broken or complete points discarded or deposited in middens and the ritual deposits of Pit Structure 2 cannot be determined.

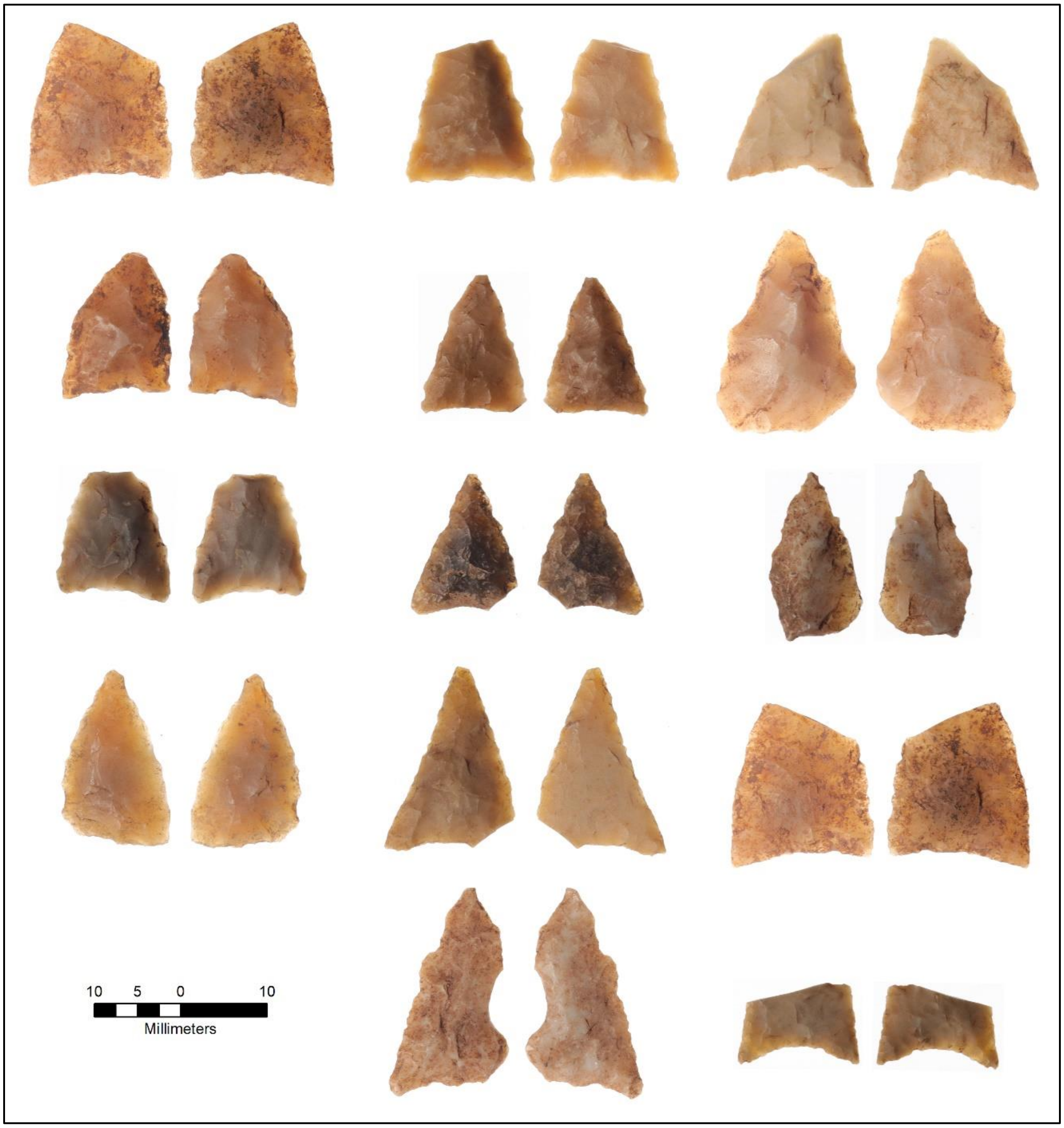

Figure 17.12. Unnotched arrow points (Fresno style).

Figure 17.13. Side-notched arrow points (Washita style).

Figure 17.14. Side and basal-notched arrow points (Harrel style).

Figure 17.15. Side-notched and deep basal-notched arrow points (Toyah style).

The Organization of Raw Material Procurement and Technology at the Merchant Site

The preceding analyses identify three components of flaked stone technology at the Merchant site. One component involved the production of cobble tools and large, strong flake tools out of durable, medium and coarse-grained materials such as limestone and quartzite. The second component was the production of flake tools through core reduction to produce flakes, some of which were further modified and maintained as unifacial scrapers, gravers, and drills. Local or regional materials were often used for these tool forms. The third component was the production of projectile points, bifaces, and some unifacial tools for game hunting and processing. These tools were commonly made from materials procured from distant sources.

First, we examine the so-called expedient component of core reduction, cobble tools, and durable flake tools. Expedient core technologies are generally associated with increasingly sedentary occupations with access to abundant raw materials (Baumler 1988; Parry and Kelly 1987; Teltser 1991). This model is proving increasingly unwieldy as an explanation of flaked stone technological choices in the Jornada region to the west of the Merchant site (Miller 2007). During the transitional centuries between the Late Archaic and early Formative periods, the decreasing emphasis on hunting and distant logistical forays resulted in a corresponding reduction in the need for preferred materials such as fine-grained cherts and chalcedonies for production of bifaces and formal processing tools. The reduction or elimination of the logistical hunting component of Late Archaic settlement resulted in a corresponding decrease in the need for fine-grained materials to manufacture maintainable bifacial tools. Moreover, the reduced logistical mobility and termination of long-range hunting forays also reduced access to distant and varied raw material sources. The combined effect was a noticeable reduction in bifacial technologies and attendant decline in the use of fine-grained raw materials and raw material diversity among Formative period lithic assemblages. Surely if long-range game hunting had continued to play a major role in regional subsistence economies, then bifacial technologies would have been maintained as would the need to acquire suitable materials.

Moreover, the growing dependence on plant foods and bulk processing of such foods created new requirements for tool design, resulting in the selective acquisition and use of more durable, coarse-grained materials for processing cacti and other plant materials. Other functional uses of tools are seldom considered, but we should acknowledge that increasing sedentism and village life led to a new range of production and maintenance roles for stone tools. For example, construction of residential structures and their roofing elements probably required more intensive preparation of wood, fiber, and other material. Stone digging tools or wooden tools shaped by stone tools may have been needed to dig adobe borrow pits and storage pits. It is likely that large woodworking or digging tools such as flake adzes made of rhyolite and quartzite were used, but these tools have not been recognized due to our inability to distinguish edge wear on such hard, coarse materials (Foix and Bradley 1985).

Accordingly, when it comes to the Jornada region, Miller (2007) proposes that the argument is perhaps best phrased not in terms of a shift to an expedient core technology that accompanied increasing sedentism, but rather a shift away from a minor bifacial component that accompanied a decrease in large and medium game hunting. Core technologies and the use of expedient cobble and flake tools occurred through most of the prehistoric sequence of southern New Mexico; what differs during later periods is that the formal tool production and particularly bifacial reduction decreases markedly while expedient tools shift from fine to coarse materials in order to meet the new set of processing and maintenance requirements. These factors explain the apparent chronological changes in raw material quality observed in dozens of studies of Jornada lithic technology. Moreover, the concept of raw material quality is a rather subjective term, essentially based on perceived textural and flaking qualities rather than performance characteristics for specific extractive and processing tasks. If the hard, durable, and coarse working edges typical of rhyolite or quartzite flakes were required for stripping agave leaves and fibers or working wood to construct jacal shelters, then the glossiest of cryptocrystalline cherts and obsidians may have been of poor quality for such tasks. Thus, perhaps the term "quality" could be reconsidered in favor of terms such as "fitness" or "utility." Thus, the selection of certain materials for production of durable tools at the Merchant site is viewed as a rational decision that reflects the intended uses of the tools.

The bifaces and formal tools are the next component examined, and these technological components at the Merchant site, as well as several settlements in the Roswell Oasis, reflect a much different context than the desert Jornada. While the bulk of animal protein and fat in the desert Jornada was obtained through communal or individual rabbit hunts, bison and other large or medium game were the primary focus of hunting at the Merchant site, and those hunts usually involved journeys of significant distances.

Hunter-gatherer groups that practice logistic mobility apportion periods of down time for retooling sessions to rejuvenate and produce tools for anticipated hunts (Binford 1979; Keeley 1982; Kelly 1988; Kuhn 1989, 1994; Nelson 1991; Sellet 2004; Torrence 1989). The process of retooling can take two forms: a gradual and continual "make and mend" replacement of tools as they break or wear out, or more intensive "gearing up" where a surplus of tools is prepared for planned hunts (Binford 1979; Kuhn 1989; Hofman 1992). It has been proposed that each process has different raw material provisioning and conservation requirements; the former requiring relatively continual access to raw material and the latter requiring a large quantity of material from a local source or quarry. The second assumption may not be entirely valid, as Speth (2018) demonstrates that most tool production requirements can be met by surprisingly small quantities of 10 kg or so of material.

Differences in encounter and ambush hunting practices may also be indicated by different strategies of retooling. Hofman (1992) makes the distinction between Late Prehistoric bison hunters who "geared up" only once or twice a year in anticipation of seasonal herd movements, the location and timing of which were well-known, and Folsom hunters who, living off a steady series of hunts, needed to continually maintain their toolkits. It is likely that former situation would best reflect the organization of hunting at the Merchant site and presents a different situation than conventionally noted among mobile hunter-gatherer groups.

A means of recognizing logistically-organized curation and retooling practices is by the presence of non-local materials among formal or more intensively utilized tool classes and the use of local materials for expedient tools (Andrefsky 1994; Bamforth 1986, 1991; Brantingham et al. 2000; Kuhn 1991, 1993). Wide-ranging foraging or logistical procurement of game has been linked to increased tool resharpening and evidence of artifact transport in the form of non-local materials (Blades 2000; Kuhn 1993; Stiner and Kuhn 1992). Similar patterns of tool manufacture, discard, and off-site transport have been identified in Folsom assemblages. Bamforth (1986:48) observed that Paleo-Indian hunter-gatherers residing at the Lubbock Lake site "relied on a toolkit with two distinct components: a basic component of more curated tools made from high quality, non-local material and a specialized and more expedient component made from local material." Sellet (2004) estimates that 38 Folsom points had been successfully manufactured at the Agate Basin site, yet only three were left at the site, leading him to infer that the remainder had been transported from the site. Sellet's description has a striking similarity to the situation with translucent silicified materials at the Merchant site.

These conventional interpretations seem to fit nicely with the Merchant data, but perhaps they fit too nicely and thus lead to oversimplified explanations. Several studies have presented findings that are contradictory or counter to the expectations derived from models based solely on the interplay of settlement mobility and raw material provisioning. Bamforth (1991, 2002, 2003) and Bamforth and Becker (2000) present related arguments that material provisioning should be considered as only one of several potential sources of variation affecting assemblage formation. In discussing the interplay among the various factors contributing to chipped stone assemblage variability, Kelly (1988:719) makes the critical point that "Stone tool production and use are not responsive to logistical and residential mobility per se, but to a set of conditions concerning tool needs and raw-material availability." In this regard, Bamforth's (1991) admonition that lithic reduction and tool production strategies are subject to local, multicausal conditions is particularly relevant, as is his caution against grafting global conceptions to local conditions.

Unfortunately, the deterministic and constraining role of raw material availability and provisioning has tended to receive the most attention to the detriment of understanding broader issues involving tool use and discard. For example, Brantingham and others (2000) document a case of formal Levallois-like core preparation at a late Pleistocene settlement in Mongolia situated in an area of abundant yet poor quality materials. According to the conventional view of raw material quality and tool production strategies, the technology at this site should have been dominated by informal reduction strategies. In contrast, the presence of such formal core and core-blank technologies lead Brantingham and others (2000:269) to conclude that reduction technology at the site was determined by "…biogeographic, adaptational, or behavioural processes exclusive from the effects of raw material quality."

These sentiments echo those mentioned by Jeske (1996) who noted that the dominant role of settlement pattern studies in the analysis of lithic technology has often obscured broader views of prehistoric behavior. This is the perspective adopted here to explain the nature of the Merchant site. Technological organization at the Merchant site is thought to have been structured by a more complex interplay of ecological, geographic, and social factors. First of all, conventional models derived from conceptions of hunter-gatherer residential and logistical mobility may not fully encompass the nature and dimension of either the residential nature of settlement at the Merchant pueblo, or the logistical component of long-range game hunting. It is proposed that both the sedentary component and logistical hunting component were of greater magnitude than tend to be considered or incorporated into models of tool design and raw material use. Merchant was a relatively sedentary pueblo with houses and ceremonial structures that required some degree of labor investment and dense midden deposits. The substantial quantities of distant materials reflect the fact that hunters returned to the site multiple times over the course of several decades.

Second, the numbers of formal tools and projectile points reflect the processing requirements of the tools rather than raw material constraints and mobility. As Tomka (2001) notes, there are numerous cases of sedentary groups that continued to exploit bison and other large and medium mammals that maintained bifacial implements for weapons and for processing meat and hides.

Third, the hunters who resided at the Merchant village and who journeyed across the southern Plains and central Texas were embedded in multiple, overlapping social networks. The presence of distant materials certainly reflects the procurement of the fine-grained materials and their return to the site to manufacture new sets of tools, many of which may have been taken from the site on the next logistical hunting foray. However, it is also likely that the social and ritual aspects of the raw materials played equally influential roles in structuring material procurement and use. Speth (2018) describes several intriguing alternatives to conventional views of material procurement by Paleoindian hunters, including socially mediated exchange among groups, sacred landscape references, and even cosmological factors.

There is profound evidence at the Merchant site that projectile points, tools, and perhaps the distant materials used to make the points and tools had some significance beyond their basic functional utility. Zone E and other deposits of Pit Structure 1 contained not only thousands of animal bones, but also over 1,000 projectile points and formal tools were placed in the deposit. A substantial proportion of the points were complete specimens without visible flaws, indicating that they had value beyond their utilitarian function (Speth et al. 2013). Although the collections have disappeared and we will never be certain of the materials comprising the artifacts from Zone E, an inspection of Leslie's photographs of points and end scrapers finds that many or most of the artifacts are made of the same translucent silicified materials identified in the 2019 collections. In summary, local and historically contingent conditions may have mediated the factors conditioning technological behavior in terms of raw material procurement, transport, and use.

Groundstone

A total of 104 complete or fragmentary groundstone tools was recovered during the 2019 excavations. Excluding the small polishing stones, only six groundstone tools, representing less than six percent of the collection, were complete. Nevertheless, a variety of grinding, abrading, pounding, and polishing tools were identified (Table 17.16).

A limited range of materials was used for groundstone tools. Slightly over 71 percent of the collection was made of sandstone obtained from bedrock deposits exposed in the escarpment below the pueblo. Quartzite was used for slightly over 18 percent of the tools and was also obtained within a short distance. Limestone is represented among the larger metates and metate fragments. Several of the basalt, quartzite, and the single occurrence of chert were small, unmodified nodules used as polishing stones.

Table 17.16. Groundstone artifact types and raw materials

Artifact Type	**n**	**%**	**Material Type**	**n**	**%**
Metate, whole	3	2.9	Sandstone	74	71.2
Metate, fragment	49	47.1	Quartzite	19	18.3
Mano, whole	3	2.9	Basalt	5	4.8
Mano, fragment	17	16.4	Limestone	5	4.8
Mano/Metate Indeterminate	1	1.00	Chert	1	1.0
Mano/Metate, fragment	2	1.9			
Polishing stone	16	15.4			
Pestle	3	2.9			
Indeterminate small fragment	7	6.7			
Total	**104**	**100.0**	**Total**	**104**	**100.0**

Typical of groundstone assemblages in southern New Mexico, a substantial proportion of the tools had been modified, recycled, or otherwise used for other purposes than grinding. Thirty of the items (28.8 percent) had evidence of secondary use, including battering and flake removals, some of which were probably for resharpening. Groundstone fragments were also used as shims in postholes and recycled as heating or cooking stones in hearths and plant baking pits.

Leading from this observation on incidence of recycling, the overall impression of the metate and mano grinding tool collection is that it was not designed or used for intensive and constant maize processing. While it is certain that the metates and manos were used for some degree of corn processing as indicated by the presence of charred maize remains, the grinding tools at the Merchant site served multiple functions. The collection of metates and metate fragments include predominantly slab (n=34, 69.4 percent) and basin (n=10, 20.4 percent) forms, with only two examples (4.1 percent) of more formal trough metate forms noted. Among the collection of whole and measurable manos, the one-hand type is the only one present (Figure 17.16).

Figure 17.16. One-hand manos collected during the 2019 excavations.

These observations are corroborated by previous reviews of groundstone collections from the Merchant site described by Leslie (2016a) and Miller et al. (2016:237-241). A much larger and complete sample of metates and manos was collected by the LCAS during the 1959-1965 excavations (Figure 17.17 to 17.18) and a nested metate and mano were found on the lower floor of Pit Structure 1 during the 2015 excavations (Figure 17.19).

Figure 17.17. Examples of one-hand manos collected during the 1959–1965 LCAS excavations at the Merchant site (from Miller et al. 2016). Specimen C22 is from a different site.

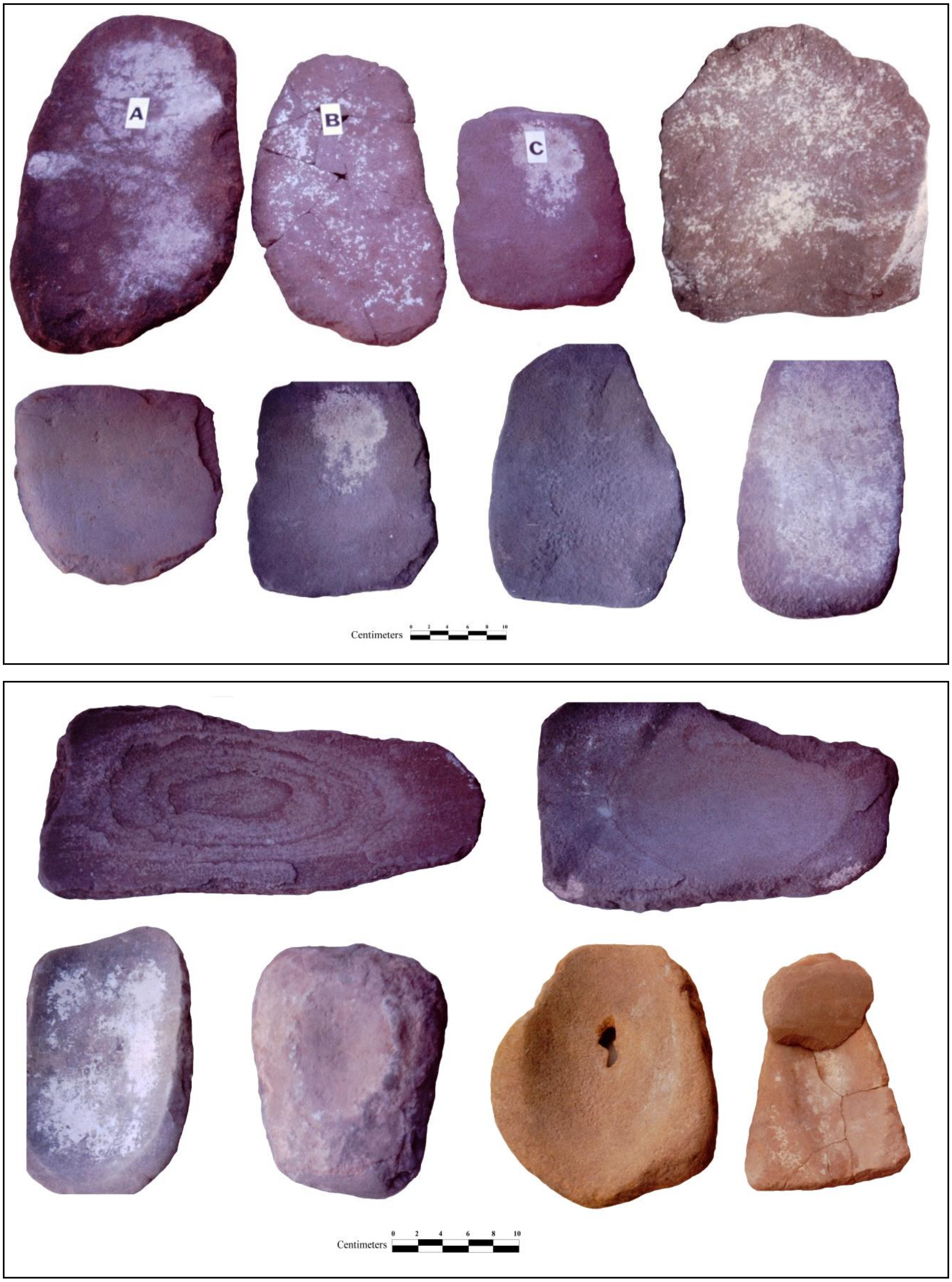

Figure 17.18. Examples slab metates (upper panel) and basin metates (lower panel) collected during the 1959–1965 LCAS excavations at the Merchant site (from Miller et al. 2016).

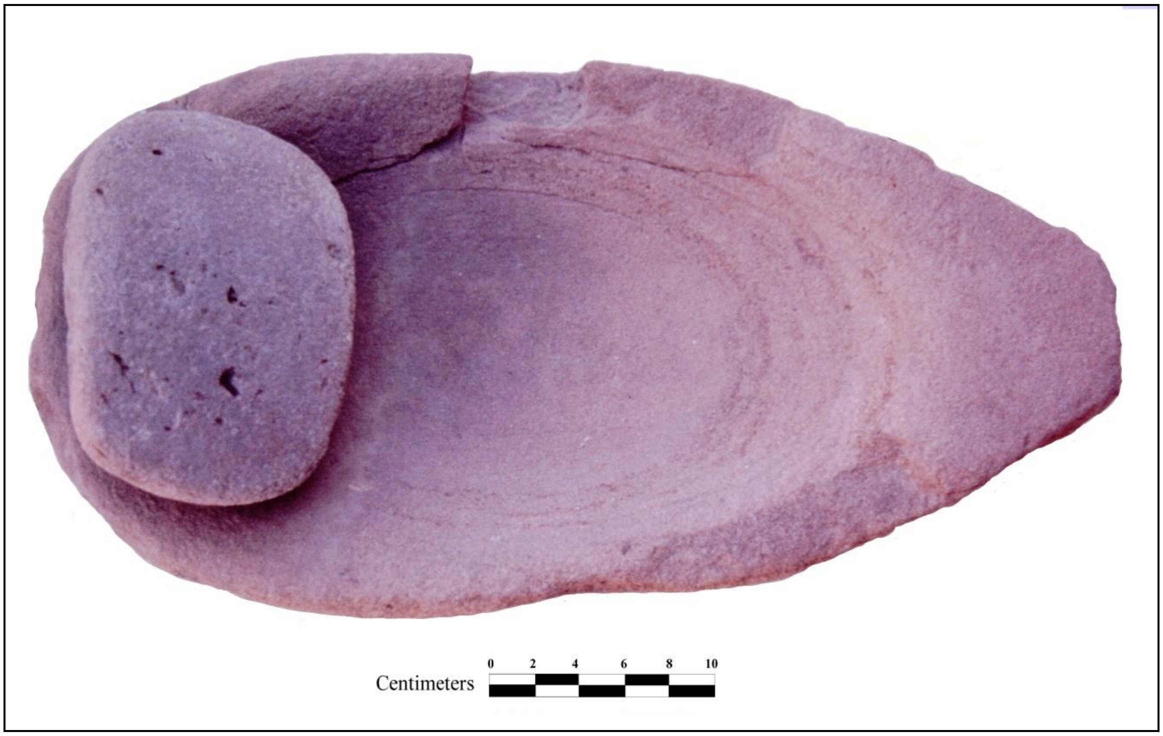

Figure 7.19. Basin metate and nested mano found inverted on the lower floor of Pit Structure 1 during the 2015 excavations (from Miller et al. 2016).

The absence of trough metates and two-hand manos is of interest. Building on the work of Calamia (1991) and Lancaster (1983), several ethnoarchaeological and archaeological studies have identified correlations between the dimensions, surface grinding areas, and morphology of manos and differing processing requirements of maize as opposed to non-domesticated plants and seeds (Hard et al. 1996; Mauldin 1993). Maize processing requires larger manos with greater surface grinding areas, and thus settlements with agriculturally-based subsistence economies should have groundstone assemblages comprised of longer two-hand manos with broader and longer surface areas. In order to explore the relative degree of agricultural processing at the Merchant pueblo, the data on mano length and grinding surface area are compared against mano assemblages from various time intervals and geographic regions across the Southwest, including Sacramento and Madera Quemada pueblos (Miller and Graves 2009, 2012) and Henderson Pueblo (Speth, McKay, and Arntzen 2004) in the Jornada region to the west. The metrics of the Merchant manos are listed in Table 17.17. These data are compared to the larger Southwest data in Figure 17.20.

Table 17.17. Summary statistics for complete manos

	Length (cm)				Grinding Area (cm^2)			
n	**Min**	**Max**	**Mean**	**Sdev**	**Min**	**Max**	**Mean**	**Sdev**
5	6.27	14.41	10.26	3.05	24.88	88.29	47.28	26.11

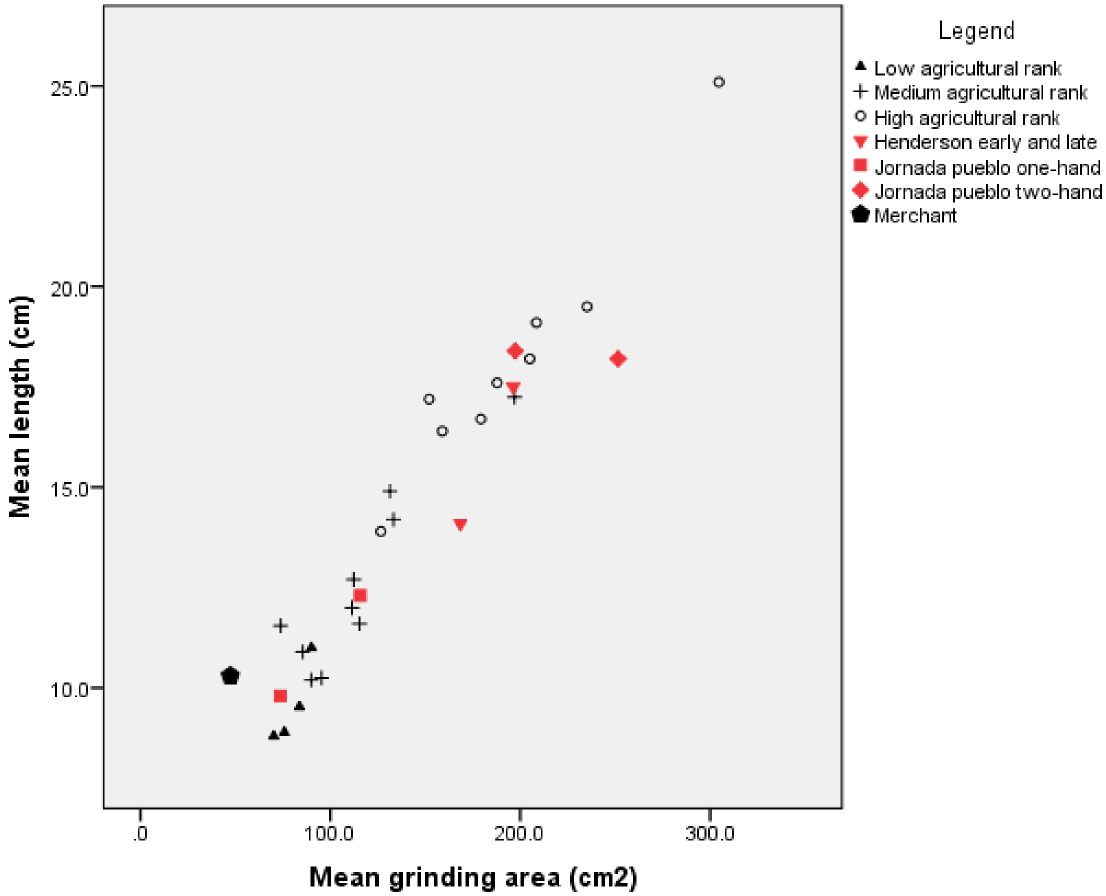

Figure 17.20. Plot of mano dimensions from Merchant pueblo compared to Jornada pueblos (Sacramento, Henderson, and Madera Quemada) and other assemblages assigned to high, medium, and low agricultural rankings based data from Hard et al. (1996).

An often overlooked aspect of mano design and use in southern and southeastern New Mexico is that both one-hand and two-hand manos are present at most pueblo settlements, and this pattern is displayed in the bimodal size dimensions of manos from Jornada pueblos. This pattern is also reflected in the presence of both trough and slab/basin metate forms. However, in the case of the Merchant site, the component of trough metates and two-hand manos is absent. Moreover, the size and grinding surfaces of the one-hand manos plot among the group of Southwestern settlements ranking in the lower end of agricultural production and dependence as determined by Hard and others (1996). The wear patterns observed on both metate and mano surfaces include circular striations and polished facets, indicating functional uses beyond the linear striations formed by the back-and-forth movements of manos on metates during corn grinding (Adams 2014).

These observations are typical of groundstone assemblages from early and late Glencoe phase settlements and from El Paso phase pueblos to the west. The relationship between length, grinding area, and agricultural production summarized by Hard et al. (1996) does not consistently occur in the Jornada region, particularly in the highlands and on the plains. As reported by Railey and Ruscavage-Barz (2008:730–733), the sizes and grinding surfaces of manos at Glencoe phase settlements along the Rio Hondo fall within the range of "none to moderate" and "low" dependence on agriculture, despite the fact that all of the sites had high maize ubiquity values.

The reasons for this are unclear, but various explanations have been proposed such as curation and off-site transport of larger two-hand manos, scavenging and recycling of large manos, or multifunctional uses of small manos. In the case of the Merchant pueblo, it is unlikely that two-hand manos were transported to and from the site, mainly because the corroborating evidence in the form of trough metates is also absent. In the case of the Merchant site, it is also possible that large trough metates and two-hand manos were taken from the site by looters and collectors. However, as shown in Figures 17.17 and 17.18, the LCAS recovered an impressive assortment of whole metates and manos from rooms, middens, and extramural spaces. If trough metates had been used at the site, then surely the LCAS excavators would have found a few examples.

Rather, it is likely that there is much more of a non-linear relationship between mano measurements and agricultural dependence. The sample of mano measurements listed in Hard et al. (1996) is based on several large pueblo settlements where intensive maize processing took place, often with intensive processing areas or facilities. These facilities include large trough metates and formally constructed mealing bins, the use of which required two-hand manos. The measurements of two-hand manos are mostly from such settlements. Agricultural groups of lesser population sizes, such as those typical of the Jornada region and southeastern New Mexico, did not require such intensive processing and therefore continued to use one-hand manos supplemented by small numbers of two-hand manos. These settlements often had less-permanent occupations. Thus, while high or moderate corn ubiquity measurements are noted at such sites, there was less need for intensive processing facilities.

Yet, even when compared to the Jornada examples, Merchant is somewhat of an anomaly. Raw material scarcity was surely not an issue that conditioned mano size, metate form, and groundstone use intensity because extensive outcrops of sandstone and limestone were available directly below the settlement. Accordingly, the most likely explanation is that maize processing was not as intensive as assumed given the presence of agricultural gridded fields near the site.

Other Ground Stone Tools

Other types of grinding and polishing tools 16 small polishing stones, three small palettes, and three pestle fragments. The palettes are small, flat stones with ground surfaces (Figure 17.21) and would be classified as hand stones (Adams 2014). They were recovered from the floors of Rooms 6 and 13. No ground pigment or other evidence of use was noted on these items.

Figure 17.21. Examples of palette fragments recovered from rooms.

The polishing stones are quartzite, basalt, or chert nodules with one or more polished sides (Figure 17.22). Nine polishing stones were found in six of the eleven excavated rooms, including Rooms 7, 13, 25, 26, 28, and 49. The other specimens were found in middens. Twenty-three polishing stones were collected from refuse and backdirt deposits during the 2015 excavations, 20 of which were from Pit Structure 1. Considered together, the polishing stones are among the most common ground stone tools found in rooms at the Merchant site.

Figure 17.22. Examples polishing stones recovered from rooms at the Merchant site. Item at the lower left may be a handstone similar to the examples shown below.

These artifacts are usually interpreted as having been used as ceramic polishers to smooth and polish the surfaces of vessels. It is likely that many of the smaller polishing stones were used to smooth and create the streaky polish on the interiors and the polished obliterated corrugations of the exteriors of Ochoa ware vessels (see Figures 16.6 and 16.26).

However, a larger class of polishing stones are present that were probably used for different tasks. Leslie (2016a) did not include polishing stones in his tables of groundstone artifacts, but one of his photographs displays 19 items described as hammerstones (Miller et al. 2016:246). While most of the artifacts in the image have battered surfaces at the distal ends along the long axis, the central areas of several items have worn and polished surfaces and some of those surfaces are convex rather than flat (Figure 17.23). Another aspect of these items is that they range in size from 8 to 10 cm, which is larger than the sizes of most of the small polishing stones. The sample of polishing stones from the 2019 excavations range in size from 2.75 to 7.6 cm with a mean of 4.85 cm. Geib and Callahan (1988) describe ceramic polishing stones from Walpi pueblo, Arizona as measuring from 3.6 to 6.5 cm, with an average of 4.5 cm that is close to the average size of the Merchant items. The examples displayed in Figure 17.23 and the largest examples from the 2019 excavations may have been used as hide-processing stones, although the only way to confirm this is through microscopic use wear analysis (Adams 2014:101–102).

Figure 17.23. Small handstones from the LCAS excavations. Note the abraded surfaces. Four of the items also have at least one battered edge.

Chapter 18

The Merchant Site and the Ochoa Phase

Myles R. Miller

The Merchant site is a fourteenth and early fifteenth century pueblo settlement located near Grama Ridge, a prominent escarpment near the boundary where the basin-and-range region merges with the southern Plains. The Merchant site is representative of the Ochoa phase, a poorly understood time period of southeastern New Mexico dating from A.D. 1300 to 1450. The Ochoa phase, and the El Paso and Late Glencoe phases of the Jornada Mogollon region to the west, are contemporaneous with the Pueblo IV period of the greater Southwest, the Antelope Creek phase of the southern Plains, and the Toyah phase of central Texas. As such, Merchant and other Ochoa phase settlements were part of the widespread patterns of population aggregation, migrations, and movements, changing subsistence and exchange economies, and accompanying developments in social and ritual organization that occurred throughout the Southwest, northern Mexico, and southern Plains during the fourteenth and early fifteenth centuries.

The Merchant site has been the subject of professional and avocational excavations for over six decades. The site was excavated by the LCAS from 1959 to 1965 (Leslie 1965a; 2016a) and was tested and mapped in 1984 (Speth 1984). The site was surveyed during the oil and gas boom of the 1990s (Gregory 2001; Seymour 2001) and was the subject of two master's thesis studies (Alvarado 2008, 2009; Gregory 2006). In 2015, a series of remedial mitigation studies were completed under the sponsorship of the Carlsbad Field Office of the BLM with funding provided by the Permian Basin Programmatic Agreement. The results of those investigations were described in the 2016 report (Miller et al. 2016).

The present volume describes the results of the third major excavation program completed in 2019. The preceding seventeen chapters reviewed the history of investigations, the excavation of a newly discovered room block and nine individual rooms, and past and present excavations of features such as civic-ceremonial pit structures, middens, and gridded agricultural fields. Chronological and subsistence studies, the indigenous Ochoa Indented Corrugated ceramics, and the flaked and ground stone assemblages were reviewed in the series of technical chapters.

The summary chapter of the 2016 report of investigations presented several musings, speculations, and a few forthright interpretations (Miller 2016) that were based on somewhat limited data gained from remedial work in previously excavated features and a review of Robert Leslie's documentation and photographs. The information gained from the more focused and intensive 2019 field and laboratory work has forced a certain amount of reflection and reconsideration of those previous musings and speculations and some of the forthright interpretations now seem to be a bit less forthright and unequivocal.

On the other hand, an entirely new series of musings and speculations are offered. The Merchant site presents a data base that is so varied and, in some ways so unique, that the information provided here and that can still be extracted from the curated collections will be the source of interpretations and theories for decades to come. Moreover, the surveys conducted as part of the BPA 10 project provided additional insights into the extent and distribution of Ochoa phase settlements across the Mescalero Plain, or what should more precisely be described as a near absence of Ochoa phase settlement across the Mescalero Plain.

Migration

The architecture and material culture of the Merchant site has a distinctive Southwestern appearance. The presence of subsurface civic-ceremonial structures, contiguous room *jacal* architecture, gridded agricultural fields, and corrugated ceramics are found at villages across the prehispanic northern and southern Southwest. The discovery, or actually the rediscovery, of this apparent blend of Southwestern traits at a settlement located 150 km beyond what is conventionally thought of as the eastern boundary of the Southwest was so striking that the immediate and obvious interpretation was that some Southwestern community or social group had migrated to the Mescalero Plain.

A consideration of the more focused and detailed results of the 2019 excavations, including architecture, ceramics, subsistence, flaked stone technologies, and other data categories, did not confirm nor clarify the issue of prehistoric migration. In fact, it might be fair to admit that we are back at the place we were in 2014 when the Merchant site was still a poorly-understood yet somewhat mythical entity in the archaeology of southeastern New Mexico. Upon reviewing the information compiled from the two seasons of excavations and surveys, the migration scenario is not quite as conclusive as it once seemed. Migration is a tidy and simple way to explain the foundational event leading to the settling of Grama Ridge sometime in the early 1300s; the reality was probably a more complex interplay of purposive social actions and economic decisions.

Contiguous room *jacal* architecture is not unique or particular to the Southwest, and the presence of this architectural form at the Merchant site should not be attributed to a Southwest origin. In an analogous situation, the presence of coursed adobe architecture in the Jornada region was often cited as evidence of influence from, or even domination by, the Casas Grandes culture region (Schaafsma 1979; Schaafsma and Riley 1999; Wimberly 1979). This interpretation is no longer considered appropriate because coursed adobe and adobe brick methods are a global method of building houses in arid and semi-arid lands where proper stone for masonry construction is lacking. It is a common method of room construction throughout the arid lowland deserts of North America and cannot be considered a diagnostic trait of migration or diffusion (Cameron 1996; Miller 2018). Similarly, the presence of contiguous room *jacal* architecture at the Merchant site cannot be considered a diagnostic indicator of migration but should more appropriately be viewed as a rational response to both the social dynamics of the settlement and the constraints imposed by the wood-poor local environment. Contiguous room architecture, even with stone foundations (cimientos) similar to the Merchant site, is found across southern New Mexico from the Mimbres region to the Jornada region and Roswell Oasis (Clark and Speth 2022) and northwards in the Texas Panhandle and Oklahoma (Brooks 2004; Duffield 1964; Hughes 1991, 2002; Lintz 1986).

In a similar perspective, the presence of gridded fields does not necessarily mean that agriculturalists from the Southwest traveled to the Mescalero Plain and began building gridded fields. In a similar manner to coursed adobe architecture, dozens of variants of gridded, terraced, mulched, irrigated, and other dryland agricultural technologies were developed in multiple regions across North America. It cannot be conclusively demonstrated that the fields at the Merchant site were a technology brought to the area with immigrants or a technology adapted or emulated by local populations, perhaps who had social and economic ties with agriculturalists to the west and northwest.

Corrugated ceramics are also a Southwestern innovation (Pierce 1999). However, there is no clear conclusion of how or why a corrugated ceramic design style or technological choice appeared on the southern Plains at A.D. 1300. As indicated in the preceding sentence, it is not even certain how the corrugated Ochoa pots may have served functional roles in cooking and handling, or served a social role in intra-community gender dynamics, or were multifaceted vessels that served in both roles. It was hoped that a detailed analysis of Ochoa coiling and corrugation methods would provide a link, or at least some hint, as to the origins of the tradition and thus the origins of the inhabitants of the site, but the issue of whether Ochoa ware was migration, invention, or emulation remains unresolved. Other scenarios might explain the development of the Ochoa tradition, including even intermarriage, a possibility further discussed below.

There are still several clear and concise hints of Southwestern influence or origins at the Merchant site. Subterranean civic-ceremonial structures, or kivas, are a distinctive architectural and social aspect of many past and present Southwestern communities. In fact, the discovery of the eastern room block led to a reconsideration of Pit Structure 2 as perhaps a second kiva associated with the social group residing in the eastern rooms (Figure 18.1).

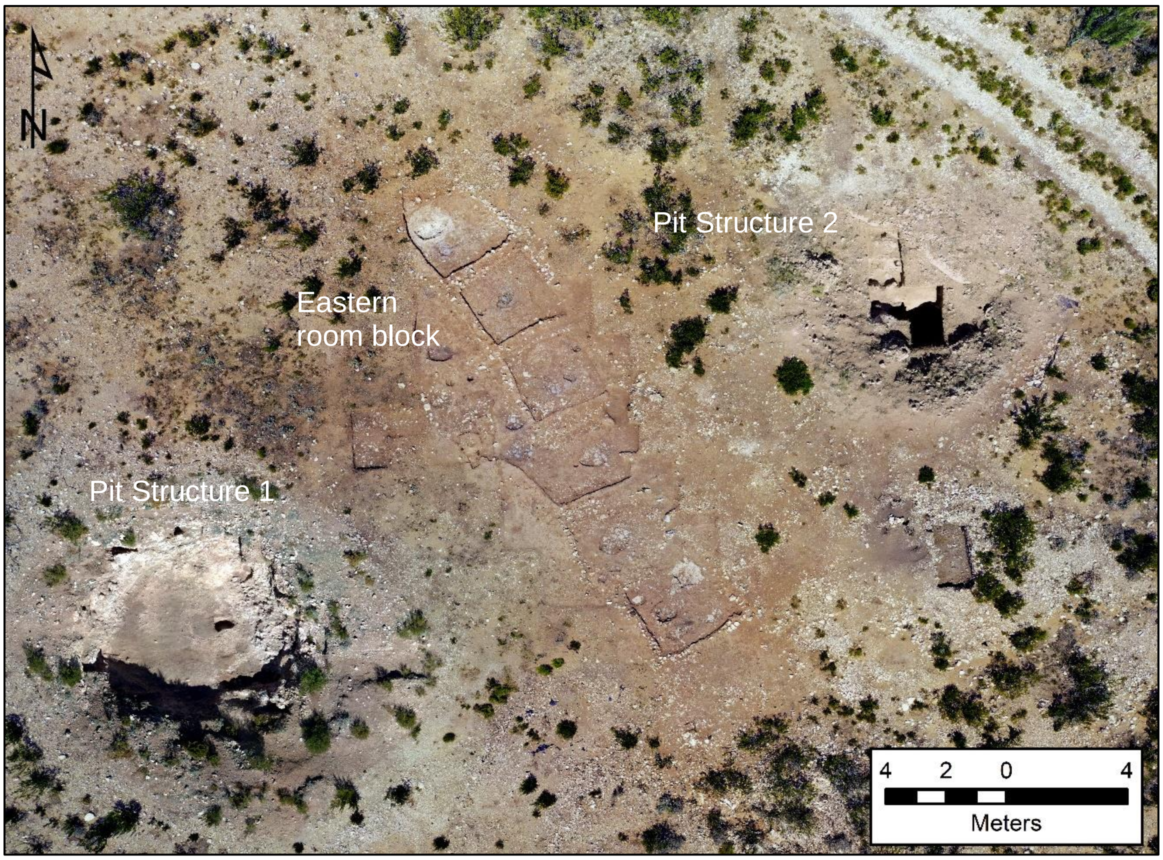

Figure 18.1. Composite aerial image of the two pit structure excavations completed in 2015 and the excavations in the eastern room block completed in 2019. Midden B and its 2019 excavation unit are visible to the south of Pit Structure 2. Image created by Mark Willis.

Of additional interest is the subtle yet provocative evidence that inhabitants of the Merchant site were mapping sacred spaces onto the landscapes surrounding the pueblo in a similar manner to that documented among Puebloan and Mogollon communities (Anschuetz 2005; Duwe 2016; 2020; Fowles 2009; Ortiz 1969; see Miller 2021c for examples from the Jornada region). It is tempting to view the presence of cupule boulders and cairns positioned at azimuth orientations from the pueblo similar to those of the rooms in the eastern and southern room blocks as a similar attempt to define a center place (Figure 18.2), but confirmation of this will require more research and excavation. It is possible that the cairns to the north of the pueblo are burial features or another form of agricultural feature.

Migration remains one of several possible explanations for the settlement of the Merchant site and evolution of the Ochoa phase. However, the present conclusions regarding migration are less certain than those expressed in the 2016 report describing the remedial excavations. It is also possible that migration may have been only one component of broader social and economic developments across the Mescalero Plain.

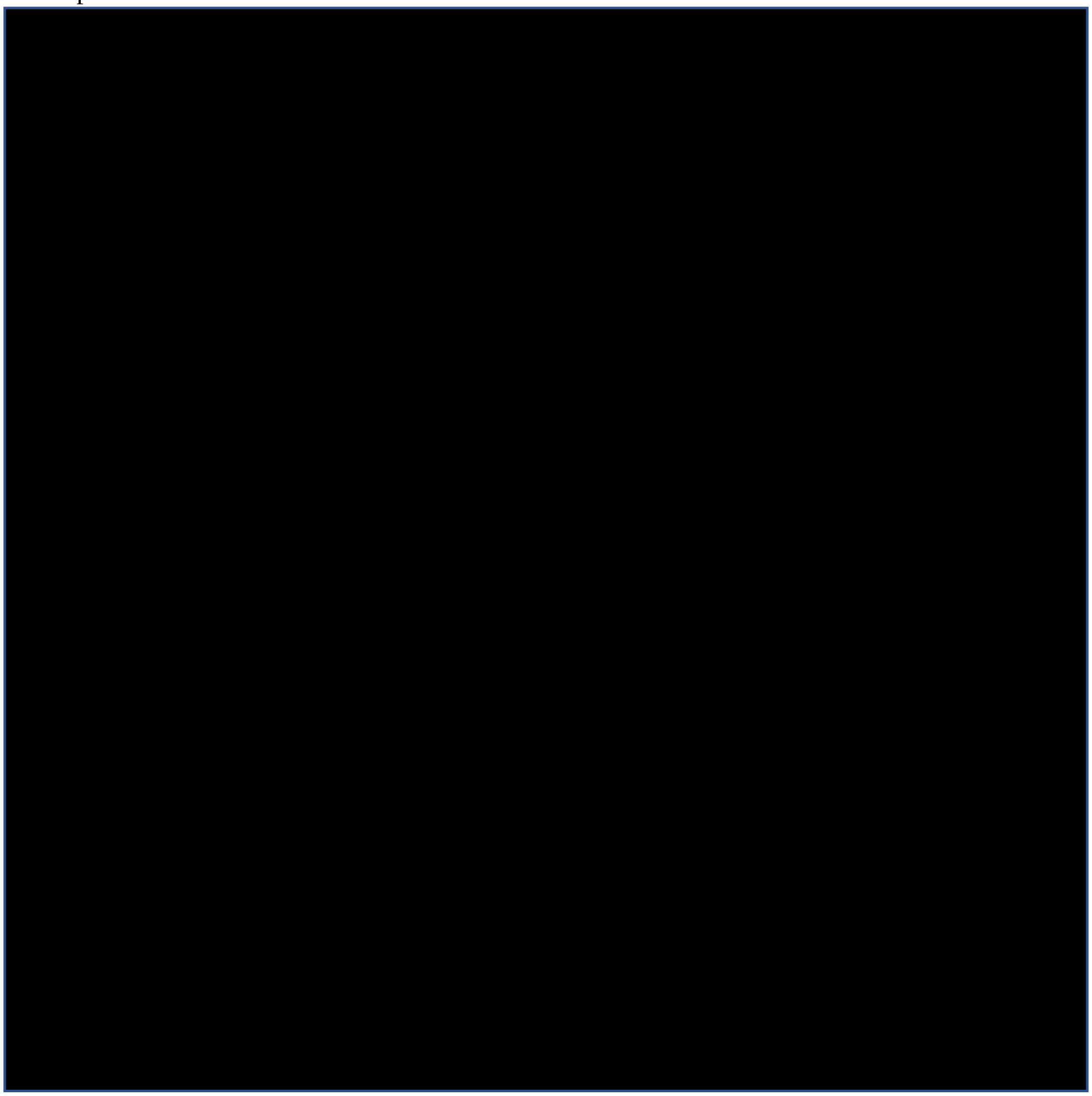

Figure 18.2. Speculation on the cosmographic landscape surrounding the Merchant pueblo. Inset at upper right illustrates the average azimuth orientation of Rooms 7, 13, 24, 25, 26, 27, and 28.

The Corn and Bison Subsistence Economy

A 37.5 percent maize ubiquity value was calculated among the 16 macrobotanical samples analyzed from the 2015 excavations. Maize pollen was also found in three samples collected from floor features in Pit Structure 1. These findings, combined with the evidence of agricultural fields to the north of the pueblo, led to a somewhat tacit conclusion that corn agriculture was a mainstay of the settlement and a primary contributor to the diet of the Merchant inhabitants. Evidence of maize is certainly present among the flotation, pollen, and residue samples submitted in 2015 and 2019. Charred maize fragments were identified in macrobotanical samples from Pit Structure 1 and maize pollen has been found in samples from gridded fields, floor hearths, and pollen washes from artifacts. Maize remains were also found in residues extracted from Ochoa sherds collected from rooms and middens during the 2019 fieldwork. Surprisingly, no maize remains were identified in any of the 45 samples submitted from rooms, middens, and extramural features excavated in 2019, while charred mesquite seeds were observed in 9 percent of the samples. Returning to the 2015 study, it is noteworthy that mesquite seeds have a 68.8 percent ubiquity compared to the 37.5 percent value for maize.

There is a tendency to overemphasize the most archaeologically visible subsistence practice within regions or macroregions such as the Southwest and Plains: maize agriculture is the primary subsistence economy of the former and bison hunting the primary one of the latter. Often overlooked are the mesquite seeds, baked agave, mass communal rabbit catches, prickly pear pads and cactus fruits, and dozens of other plant and animal foods that did not just serve as "buffering" options but rather were primary constituents of Southwestern and Plains subsistence economies. It is easy to fall into the same pattern when viewing the Merchant site data. Agricultural fields are present north of the site and corn remains were identified in multiple contexts and thousands of bison bones were recovered from midden and kiva closure deposits. So, the assumption is that Merchant subsistence centered on maize and bison.

The groundstone evidence from the Merchant site presents a different view, as does the evidence from the flotation studies (Chapter 12) and the bedrock mortar studies reported by Castañeda and Willis (2021). As shown in Chapter 17, the mean mano lengths and grinding surfaces fall within the cluster of measurements associated with low agricultural dependence. Perhaps a more fitting way to describe the grinding tool assemblage of the Merchant site is processing requirements were not as intensive and therefore the larger, two-hand manos and trough metates were not necessary. Instead, tool forms that were equally adaptable to grinding corn, mesquite, seeds, and other plant foods were preferred. The Merchant grinding assemblage of one-hand manos and slab or basin metates is similar to those found at many horticultural and agricultural settlements across southern New Mexico.

Nevertheless, the absence of two-hand manos and trough metates is surprising, particularly considering the presence of gridded agricultural fields near the village. It is possible that our conceptions of agricultural intensity or dependence do not fully encompass the variety of ways that agriculture was incorporated into the larger subsistence and political economies of villages on the southern Plains. Rocek (2007) notes that heavy dependence of agriculture does not necessarily correlate with fully sedentary settlement. Conversely, in the present case, the evidence from the Merchant site suggests that sedentary settlement does not necessarily correlate with increased agricultural dependence. Moreover, the concept of sedentism as applied to the Merchant village should be reconsidered. The occupational history of the village included periods of nearly complete occupancy combined with episodes of partial depopulation during long-distance hunts that took place over what were presumably long periods of time. Although projecting ethnohistoric models to the past is problematic, it is noted that among historic Plains groups the majority of villagers, male and female, took place in long bison distance hunts and in-field processing. It is likely that the Merchant site may have been partially depopulated for periods of time, or perhaps inhabited only by age and sex cohorts who tended the fields and kept the houses in order. In this scenario, the settlement organization of the Merchant village had a decidedly logistical component and is similar to Eder's (1984) observations that during periods of subsistence change, certain societies actually become more mobile while they are also adopting semi-sedentary lifeways.

The inhabitants of the Merchant site developed a subsistence base that was remarkably diversified and fully exploited the ecological niches of the Mescalero Plain. As revealed in Dering's detailed review of maize, mesquite, and acorns in Chapter 12, mesquite has an impressively wide range of uses and preparation methods. One of the more critical observations is that mesquite pod production often increases during a drought year or two that follow a year of average rainfall, although several consecutive years of drought can drastically reduce mesquite pod yields or cause them to completely fail. Accordingly, mesquite crops could have provided an effective buffer to maize crop failures during drought years. On the other hand, maize could have provided a buffer during seasons of poor mesquite bean production.

Clusters of dozens of bedrock mortars are present around the Merchant site (Castañeda and Willis 2021). The results of residue analysis on bedrock mortars was inconclusive, as it usually is. A suggestion for future research is to focus on residue extraction and analysis of pestle tools, both curated and newly recovered items, to search for evidence of acorns, mesquite, or other plants. Yet, it is somewhat confident that the clusters of dozens of bedrock mortars were used to process acorns from Shinnery oak communities. Processed acorn meal has favorable nutritional qualities in terms of fat and carbohydrates, although perhaps not the sufficient fat content to supplement the lean bison meat. As Speth (2020) notes, mass meat quantities do not furnish the necessary fat content for proper nutrition, and other plants and animals are required to supply sufficient fat and/or carbohydrates or any non-protein component to the diet.

An intriguing alternative view is that a substantial number of bison were not hunted and transported back to the pueblo for local consumption as part of the subsistence economy, but rather part of a larger economic strategy of exchanging bison meat and hides with pueblo communities to the west and perhaps even the La Junta region to the southwest (Clark and Speth 2022; Creel 1991; Speth 2017; Speth and Staro 2012). This would signal that the Ochoa villagers had made a significant departure from using bison as a means of subsistence to incorporating bison hunting into a larger economic pursuit, and that as early as the fourteenth century the Merchant villagers had become enmeshed in much wider political and social economies similar to those seen throughout the Plains and Southwest during Protohistoric times.

Movement

The fourteenth and early fifteenth centuries of the prehistoric Southwest and Plains were a period of movement—movement of people, movement of goods and valuables, and movement of ideas and ideologies. Large-scale movements of people from the northern to the southern Southwest have been identified in the archaeological record of southern Arizona, northern New Mexico, and central New Mexico (Clark 2001; Clark and Laumbach 2011; Lekson et al. 2002; Lyons 2003). New technologies, adaptations, and archaeological expressions of material culture are recognized across the southern Plains and central Texas (Boyd 1997; Kelley 1947; Johnson 1994; Kenmotsu and Boyd 2012; Lintz 1986). At a more local frame of reference, it is possible that Jornada groups moved to the Roswell oasis (Kelley 1984), although the skeletal data from Bloom Mound and Henderson pueblo indicate that local indigenous groups may have been drawn into the Jornada sphere (Clark and Speth 2022). Food, hides, ceramics, and other materials were exchanged across broad areas (Creel 1991; Creel et al. 2002; Rocek and Rautman 2007; Speth 2008; Spielmann 1983, 1991). These patterns of movement and interaction are reflected in the archaeological record through the presence of food remains, valued goods, ceramics, and iconographic symbols representing new beliefs or more visible expressions of old beliefs.

The inhabitants of the Merchant site were part of this movement of people, materials, and ideas. While the Merchant site and other Ochoa phase settlements could reflect movement of a Southwest group or Plains group into southeastern New Mexico, we have no data that can unambiguously resolve that question. It is equally plausible that the Merchant village was settled by one or more indigenous groups and the settlement expanded through intermarriage and movements of additional people into the village, as indicated by the accretional growth of the eastern room block.

Although the "movement of people" question remains unresolved, it is certain the Merchant site inhabitants did participate in the widespread movement of goods. Ceramics from production areas in northern Chihuahua, southcentral New Mexico, central New Mexico, and the Roswell oasis were traded to the Merchant site inhabitants (Table 18.1). Both the quantity and the variety of ceramic types recovered during the 2019 excavations in the eastern and southern room blocks and Midden B were substantially lower than those collected during previous excavations, another likely testament to the unique nature of the central plaza area and closure deposits in Pit Structure 1.

Three excavation projects recovered 669 non-local (or non-Ochoa ware) sherds, representing slightly less than 5 percent of the total ceramics. An impressive variety of wares and types are present that were produced in locations ranging from southwestern New Mexico, northwest Chihuahua, and south-central New Mexico. Chupadero Black-on-white is the most common type, accounting for 28 percent of the non-local sherds. Ten of the eleven Chupadero Black-on-white sherds submitted for NAA were assigned to the Capitan Mountains/Robinson Pueblo group (Appendix C.2). Overall, south-central and central New Mexico appears to be the primary sources or pathways for imported ceramics. Chupadero Black-on-white, Rio Grande glazewares, Three Rivers redwares, and Middle Pecos wares account for 58 percent of the imported ceramics. However, another 29 percent of the ceramics originated in southwestern and southern New Mexico and northern Chihuahua and may have been obtained through contacts with the Jornada region to the west or the La Junta del los Rios villages to the south.

Other evidence of movement of goods include the presence of *Olivella* shell from the Pacific Coast or Gulf Coast (Leslie 2016a) and obsidian from northern New Mexico. Seven obsidian artifacts from the 2015 excavations were submitted for XRF analysis (Miller et al. 2016) and three obsidian flakes were submitted from the 2019 fieldwork (Appendix C.4). Of eight measurable specimens, five are identified as Cerro Toledo (Obsidian Ridge) and three as coming from the Valles (Cerro del Medio) source. The proportion of Valles obsidian (37.5 percent) in the Merchant sample is slightly higher than the 23.9 percent obsidian identified in the sample of 140 obsidian source identifications from southeast New Mexico (data on file, Carlsbad Field Office). The Valles source does not erode into the Rio Grande Valley, and it is unlikely that the material came from the Jornada region.

The quantities of ceramics, shell, and obsidian found at the Merchant village may be less significant than the distances those materials were transported. Again, referencing the theme of movement, many of the ceramics vessels and obsidian materials originated at distances of 500 to 600 km from the Merchant village, and even greater when considering marine shell. The Merchant villagers were entangled in, or becoming increasingly entangled in, large-scale exchange networks. The bison meat and hide economy of which the Merchant villagers were clearly a prominent participant becomes much more intriguing when viewed from this broader perspective.

Table 18.1. Ceramic wares and types from the Merchant site

	LCAS 1959-1965		2015		2019		Total	
Ceramic Type	**Count**	**%**	**Count**	**%**	**Count**	**%**	**Count**	**%**
Ochoa ware								
Ochoa Indented Corrugated	9,967	94.6	1,672	78.1	869	95.6	12,508	92.1
Ochoa Indented Corrugated smudged	83	0.8	301	14.1	25	2.8	409	3.0
Subtotal	10,050	95.4	1,973	92.2	894	98.3	12,917	95.1
Imported wares								
Jornada/Roswell Brown	29	0.3	24	1.1	1	0.1	54	0.4
Roswell Corrugated	11	0.1	----	----	----	----	11	0.1
Chupadero Black-on-white	169	1.6	9	0.4	9	1.0	187	1.4
El Paso Polychrome	87	0.8	2	0.1	----	----	89	0.6
El Paso brownware undifferentiated	----	----	16	0.8	----	----	16	0.1
Rio Grande Glaze A Red	51	0.5	----	----	----	----	51	0.4
Rio Grande Glaze A Yellow	27	0.3	----	----	----	----	27	0.2
Gila Polychrome	33	0.3	----	----	----	----	33	0.2
Ramos Polychrome	19	0.2	1	0.1	1	0.1	21	0.2
Ramos Black	----	----	26	1.2	----	----	26	0.2
Lincoln Black-on-red	32	0.3	4	0.2	3	0.3	39	0.3
Three Rivers Red-on-terracotta	16	0.2	4	0.2	----	----	20	0.2
Playas Red Incised	10	0.1	----	----	----	----	10	0.1
Incised polished black	2	<0.1	----	----	----	----	2	<0.1
Undifferentiated whiteware	----	----	----	----	1	0.1	1	<0.1
Undifferentiated brownware	----	----	81	3.8	----	----	81	0.6
Unid patterned incised brownware	----	----	1	0.1	----	----	1	<0.1
Subtotal	486	4.6	168	7.8	15	1.7	669	4.9
Total	**10,536**	**100.0**	**2,140**	**100.0**	**909**	**100.0**	**13,586**	**100.0**

As with the imported ceramics, the numbers of shell and obsidian items are not overly impressive. However, one material class that is present in substantial quantities is the variety of non-local raw materials used for flaked stone tools. Based on UVF responses, it is estimated that 39 percent of the debitage, cores, and tools at the Merchant site were made of Edwards Plateau chert obtained in west-central and perhaps central Texas. Another 20 percent of the artifacts may have been obtained from sources in the Texas Panhandle, including outcrops of white Alibates dolomite, Tecovas jasper, and opalite. The significance and implications of these raw material quantities are reviewed below.

The movement of these materials across the Mescalero Plain means that people too were moving across the landscape, and there is no doubt that the economic and social lives of the Merchant villagers involved movements of people and social groups. One of the more important conclusions from the detailed excavation of the eastern room block is that the growth of the Merchant pueblo was accretional. The absence of axial foundation walls and the presence of abutting wall foundations and changing wall orientations established that the rooms of the eastern block were added in increments. This type of room block expansion has two implications. The first is that people came to the settlement in small groups or social segments; the second is that it is evident that new arrivals were integrated into the larger community.

This is a critical observation. Herr and Clark (2007) present several case studies where immigrant groups were not fully integrated into communities and often occupied outlying positions in the local social hierarchy, both socially and physically. Failure to successfully participate in the social and economic life of a community often leads to conflict and dissolution of the social order. This does not seem to have taken place in the Merchant site community, and additional evidence such as the production and distribution of Ochoa pottery indicates that, for the most part, newcomers were successfully integrated into the community, particularly if those newcomers were women that moved from one village to the Merchant pueblo. However, that does not mean that everything was settled.

Pueblo on the Plains

The connections between movement of people, movement of goods, the accretional growth of the room block, the diverse subsistence economy, and even the possible evidence of creating sacred landscapes and center places are all germane to the final summary discussion. The fundamental question is: How did people survive on the Mescalero Plains during the fourteenth and fifteenth centuries? The Merchant site informs us that it required complex decisions and choices. Those decisions and choices transcended basic subsistence needs, and the conventional models derived from cultural ecology and behavioral ecology do not sufficiently account for those larger social, economic, and political dimensions. It is true that the inhabitants of the Merchant site and other Ochoa phase villages were dealing with environmental risk and uncertainty while settling the Mescalero Plain. But there was another dimension in that the groups involved in long-distance hunting journeys and the people who remained behind in the village settlement were dealing with *social* risk and uncertainty.

Returning to Movement and Migration

One problem with the concept of migration is how it is framed or conceptualized. A criticism of the migration concept as previously applied to the Merchant site (Miller 2016) is that it appears to convey the idea of a large-scale movement of people. That may have been true, but there are other forms and scales of migration. Migration can involve many scales, from individuals to households to larger social segments and entire communities. Mills (2011:354–356) defines three general models of migration: colonization of empty landscapes, internal frontier migration, and diasporas. Colonization of empty spaces characterizes the small-scale movements of people across large areas. It best describes the early movements of hunter-gatherers and foragers into the Southwest or the migration of Athapaskan groups into empty areas in the Southwest during the Protohistoric period. Internal frontier migration is the movement of groups into unoccupied spaces between densely settled regions, occupying different ecological niches and developing different subsistence practices in those locations. Diasporas are movements of large numbers of people into regions that are already settled. Usually consisting of small groups, the migrants end up in new communities together with others sharing common social and cultural origins, but also situated among people with much different cultural commonalities. Mills suggests that this form of migration best describes the large-scale movements of people across the Southwest during the turbulent late 1200s and continuing through the 1300s and early 1400s, the same period of time as the Ochoa phase at the far southeastern frontier of the Southwest.

The Merchant site case study seems to present a combination of internal frontier migration and diasporas. The subsistence economy of the Merchant villagers involved new ways of both exploiting traditional foods as well as applying new farming methods. However, whether southeastern New Mexico and west-central Texas were empty zones is open to debate. More realistically, it seems that the diaspora model best explains the origins of the Ochoa phase. Mills (2011:356) lists several of the salient traits of diasporas identified among global ethnographic and sociological studies of modern diasporas: (1) movements of large or massive populations; (2) movement into distant communities; (3) maintenance of interaction among migrants; (4) creation of zones of hybridity and heterogeneity; (5) transformations in local historical trajectories; (6) differentials of power and access; and (7) the creation of ideologies of return.

One critique of this model is that it supposedly involves large numbers of people. Recalling that migrations occur at widely different scales, both demographically and geographically, it is suggested here that "large numbers of people" is more of a relative and scalar term that must be considered in the context of local, historical developments. In other words, whatever constituted a "large" number of people in the Mogollon Rim region of the 1300s was a different scale and magnitude from whatever a "large" number of people might have been on the Mescalero Plain in the 1300s.

Setting aside the issue of demographic scales, several aspects of Mills' trait list seem to be manifested in the architecture and material culture of the Merchant site. As summarized in Chapter 16, the design and production of Ochoa ceramics, as well as the restricted distribution of vessels beyond the village, may reflect social identity and interaction among females, especially if they were a major part of the migrant communities. The Merchant site and other Ochoa phase villages clearly represent a fascinating case of hybridity and heterogeneity, merging Southwestern and Plains material culture, ceramics, subsistence economies, and architecture into something new and unprecedented on the Mescalero Plain. These developments profoundly altered the historical trajectory of settlement, adaptation, and social arrangements across southeastern New Mexico and west-central Texas. The final trait, the creation of ideologies of return and center place, may be expressed in the kivas within the pueblo and the landscape features of cupule boulders and cairns surrounding the settlement. Placemaking is another component of the formation of social identity and plays an important role in migration. Migrants often transport their cosmology and associated landscape topology that link landscape features of their new surroundings to geographic features and associated cosmologies of their homelands (Eiselt 2012).

In light of these observations, it is suggested that the concept of migration should not be discounted – as in tossing out the baby with the bathwater (Anthony 1990) – but rather should be considered through a more nuanced appraisal and application that considers other factors besides agricultural fields and kivas. But several questions remain: what was the cause of this diaspora? From where did it originate? Given the present state of knowledge, the origins of the Ochoa phase people may be irresolvable unless and until DNA analysis on burial populations or some other means of directly identifying and tracking the human populations of southeast New Mexico can be attempted. As suggested in the 2016 report summary, perhaps these questions should not be the primary focus of inquiry. There is something much more complex and much more intriguing for understanding prehistoric adaptation and social evolution on the southern Plains.

The Social Dynamics of the Merchant Community

The Merchant site was an intensively occupied pueblo settlement comprised of multiple households and had a complex history of occupation. Returning to the issue of demographic scales and distances, it is noted that migration had many forms, including smaller movements of people or social groups back and forth across the landscape (Sullivan and Bayham 2007). This is particularly relevant if women were the primary group moving in and out of Ochoa phase communities. Intermarriage is a distinct possibility to consider (Habicht-Mauche 2000). As Varien (1999:213) notes, in situations where a community is too small to provide sufficient and appropriate marriage partners, men and women will move across community and social boundaries. This form of mobility and movement would have also facilitated increasing access to resources and thus created new networks of political interaction across regions.

The fundamental issue is that new social arrangements were negotiated. Migration and movement of people into new regions severs or complicates lineage and kin structures. Southwestern communities were organized among complex systems of clans, lineages, gender and age groups, moieties, and religious societies and sodalities. The organization of prehistoric Plains societies is conjectural, but likely was structured according to lineages with exogamous marriage practices. It is entirely possible that Ochoa was a blending of men and women from different geographies and societies, perhaps male migrants to the Plains and bride exchange with pueblo communities to the west.

Furthermore, ethnicity and ethnic signaling were probably much more fluid than we understand, especially in the frontier, borderlands, and edge regions of the Ochoa phase villages and those of the Roswell Oasis. A fascinating chapter by Fowles and Eiselt (2019:168) is of relevance here. Reviewing the ethnographic and ethnohistoric records as well as historical photographs of Tiwa and Jicarilla Apache, they find evidence for ethnic shifting among the groups that complicate the conventional understanding of ethnicity and origins, and suggest that the fluid identities, ethnic markings, and social and political agencies might best be viewed as a "composite cultural adaptation in which movements across the village/nomad or Pueblo/Apache divide were strategically facilitated." They (2019:190) further note that these east-west movements and exchanges between the Rio Grande valley and southern Plains run counter to conventional creation narratives invoking emergence, becoming, and center place, and instead appear to be a "pragmatic set of historical responses to shifting political and environmental exigencies."

Perhaps intermarriage and similar trends of ethnic shifting explain the nature of Ochoa ceramics and distributional patterns. The almost complete absence of movement of vessels beyond the Merchant village presents such a drastic and striking contrast to the extensive long-distance movement of stone materials, and clearly the two distributional patterns reflect different social dynamics arranged along lines of gender and perhaps by status. The presence of nested identities where individuals identify or position themselves with increasingly broad and inclusive hierarchies of social groups (Wiessner 1983; Wobst 1977) is another possibility and one that is reflected in the distributions of pottery, projectile points, and stone materials.

Bison: Cooperation, Competition, and Conflict

Another dimension of the Merchant economic and social world centered on the long-range bison hunting and exchange of bison meat and hides. Speth and Newlander (2012) and Clark and Speth (2022) present comprehensive studies of projectile point data, UVF raw material sourcing, and the implications for bison hunting. Noting that ethnohistoric accounts described intense competition among communities for bison on the southern Plains, they propose that similar territorial conflicts and competition existed in the fourteenth and fifteenth centuries.

The UVF data is again referenced. Figure 18.3 presents several comparisons of UVF data from the Merchant site and settlements in the Roswell Oasis (Clark and Speth 2022; Speth and Newlander 2012). The chart at the upper right compares the UVF responses among projectile point types at the Merchant site. The first impression is that orange-yellow responses to long-wave UV light (Edwards Plateau chert) are exceptionally common, ranging from 40 to 75 percent with an average of 54% across all points. Fresno points have approximately twice the number of orange-yellow responses as Washita points, which may indicate the manufacture of Fresno points (possibly as preforms) at the site as opposed to bringing finished Washita points back to the site (Speth and Newlander 2012). Under short-wave UV light, the green and white-gray responses (Panhandle sources) range from 8 to 29 percent, average of 17 percent green and 7 percent white-grey. Harrell and Washita points tend to have lower proportions of Edwards Plateau chert and higher proportions of Panhandle sources. As noted above, it is unclear if this is related to on-site manufacture of Fresno points or preforms as opposed to bringing finished points back from the hunt. The reaction rates among point completeness categories presented in the upper right graphic seems to indicate this may be the case, and Panhandle sources seem to be more common among bases and tips than complete specimens. This brings up some intriguing speculation, because it seems that the organization of point manufacture and raw material provisioning differed for long-distance hunts conducted in the Panhandle as opposed to west-central and perhaps central Texas.

The next three charts present comparisons of the Merchant and Roswell Oasis data, and it is among these charts that significant differences become apparent. The most striking pattern is that Edwards Plateau chert is present in much greater proportions among the projectile points at Merchant than observed at the two pueblos in the Roswell Oasis, while the proportion of Panhandle sources are roughly equal. This overall pattern is also evident among the comparisons of UVF response rates for Fresno and Washita points. Unfortunately, it was not possible at the Merchant site to achieve the temporal resolution provided by ceramics at the Roswell sites (Speth and LeDuc 2007; Clark and Speth 2022), and thus it is unknown if the Merchant UVF data compares temporally with the Early Henderson, Late Henderson, or Bloom Mound response rates, or a combination of two or three of those intervals. Based on the radiocarbon analysis presented in Chapter 11, it is suggested that Merchant best matches the Late Henderson and Bloom Mound periods.

If the proposed temporal relationships hold true, then the Merchant UVF sourcing data offers a significant complement to the Roswell studies and seem to corroborate Speth's interpretations of increasingly competitive and conflicting bison hunting practices and territories. Figure 18.4 displays the geographic distributions of the primary raw material sources identified in the UVF studies. The locations of the Roswell Oasis sites and Ochoa phase Merchant and Salt Cedar villages are plotted in relation to those sources. The establishment of Ochoa villages in a strategic location between the Roswell Oasis and west-central Texas may have curtailed access of the Roswell Oasis pueblos to the central Texas herds, as well as the sources of Edwards Plateau chert. Whether this resulted in increased social conflict or cooperation is an interesting issue. As Speth and Newlander (2012:178) suggest, it is possible that the residents of the Bloom Mound pueblo "increasingly took the role of "middlemen" in the burgeoning Plains-Pueblo trade," which in turn would suggest that Ochoa bison hunters played an increasingly important role in the supply chain providing bison meat and hides to the west.

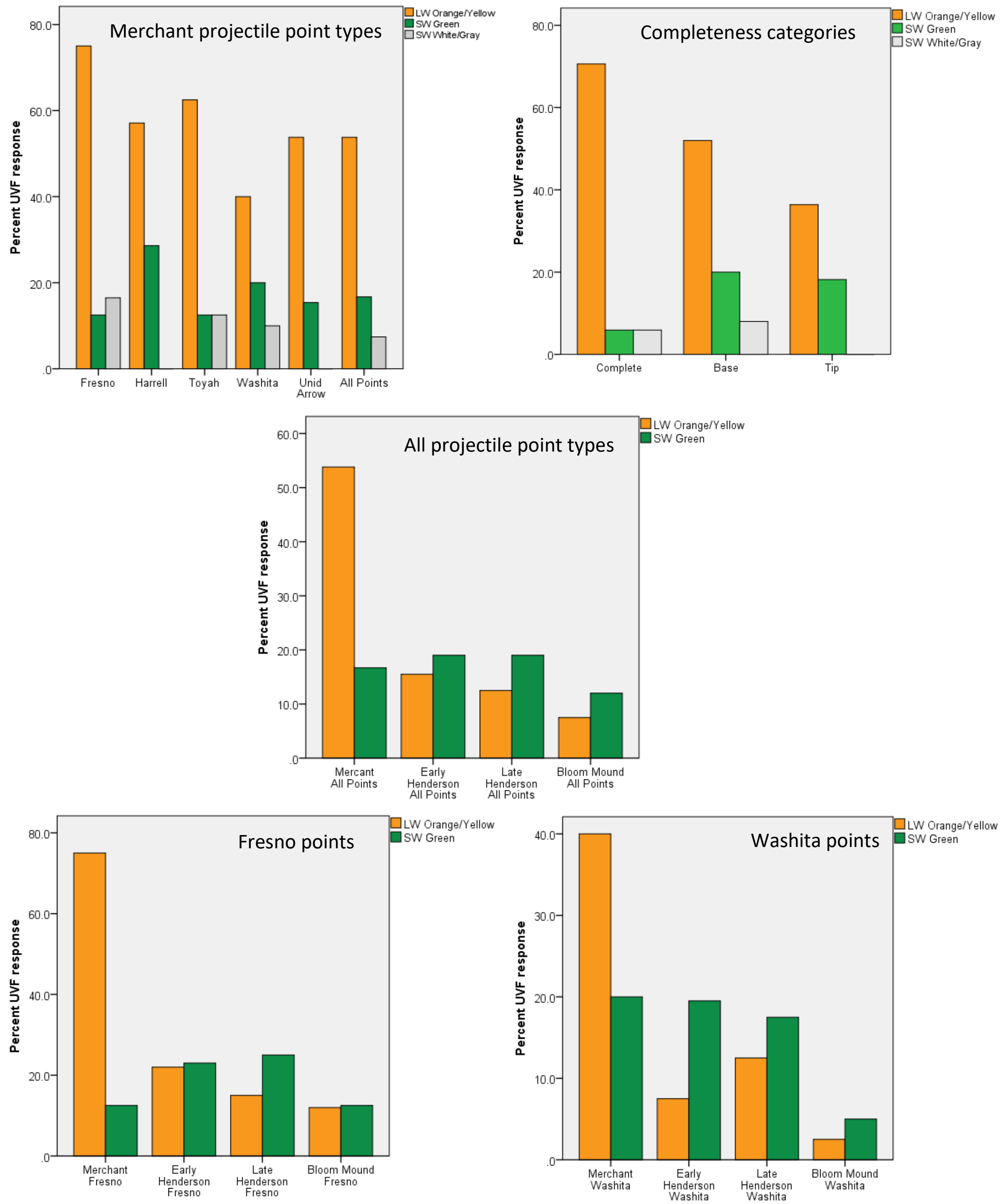

Figure 18.3. Comparisons of UVF response rates at the Merchant site, Henderson pueblo, and Bloom Mound pueblo of the Roswell Oasis (Henderson and Bloom Mound data from Speth and Newlander 2012; Clark and Speth 2022): (upper left, UVF response rates among projectile point types at Merchant; (upper right) UVF responses among Late Formative arrow point completeness categories at the Merchant site; (center row) comparison of UVF responses among all points at Merchant the Roswell Oasis sites; (lower row) UVF responses for Fresno and Washita points from Merchant and the Roswell Oasis sites.

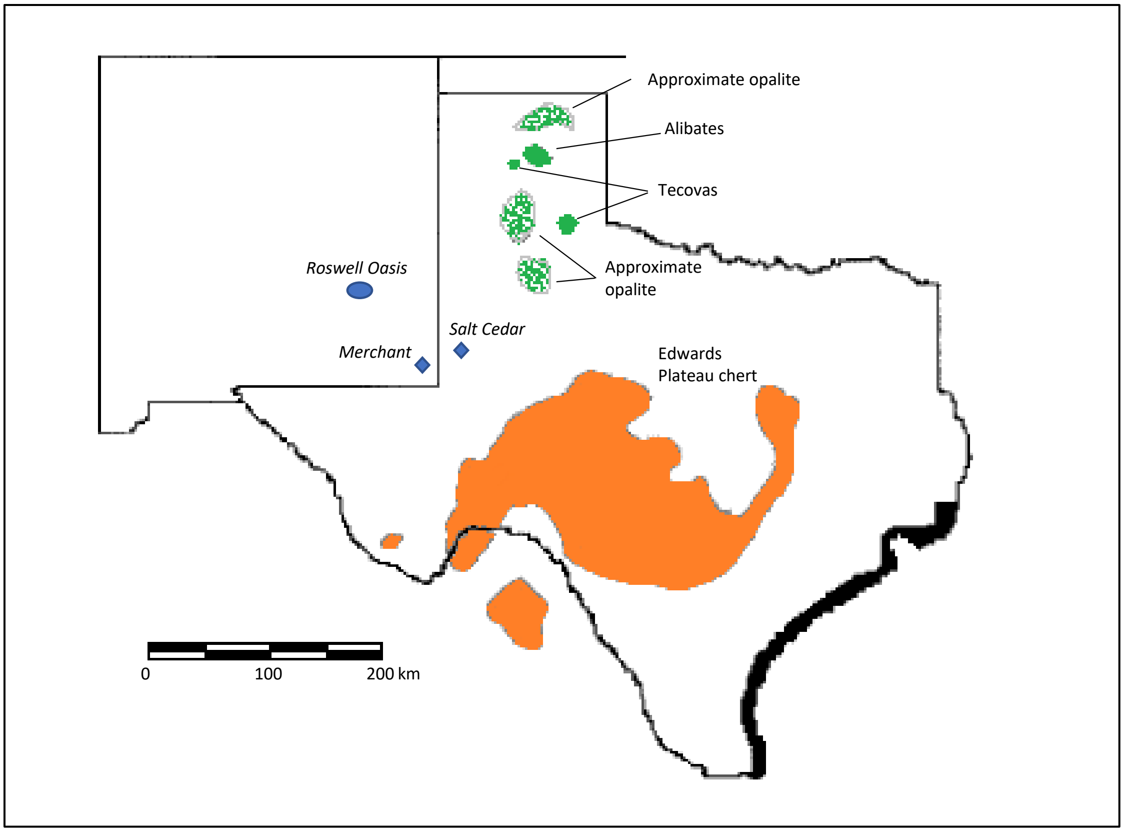

Figure 18.4. Locations of stone materials identified through UVF responses.

Ultimately, the increasing competition seems to have led to social conflict as seen in the evidence of violence at Bloom Mound (Kelley 1984; Clark and Speth 2022), Salt Cedar (Collins 1968), and other locations in southeastern New Mexico (Wiseman 1997). There is no evidence of violence at the Merchant community, although there is surprisingly no evidence of burials at all that might provide insights into violent acts.[1.] However, there is also no archaeological evidence of structural burning, extensive de facto artifact assemblages left on room floors, or other indications that the village was razed or destroyed. Instead, the nature of the floor assemblages documented by Leslie in the 1960s and confirmed through the recent excavations all reflect a planned and prepared departure from the settlement. It appears that the inhabitants of the Merchant site departed the pueblo under much more favorable conditions than the violent ends seen at several villages during the early 1400s, a possibility that is further explored at the end of this discussion.

From this perspective, the nature of Pit Structure 1 becomes even more intriguing. The 2019 excavations further cemented the special nature of this structure, establishing that it was a kiva strategically positioned in the center of a large, ∩-shaped group of room blocks. The status of Pit

[1] The complete absence of burials at a 60+ room pueblo is one of the more perplexing aspects of the Merchant site. Leslie (2016a) does not mention encountering a single burial or human bone, despite the massive strip-looting and excavations that took place over several years. It is likely that the soils were too shallow and the underlying caliche too hard to dig burial pits, suggesting that perhaps middens would be a preferred location, but extensive excavations in middens have found no burials or human remains. It is possible that an off-site location was used, but intensive surveys of 1,257 acres surrounding the village encountered only a single burial.

Structure 2 has also been reconsidered and it was probably a second kiva rather than a trash-filled caliche pipe or unfinished structure.

The Zone E mass deposit of animal bone in Pit Structure 1 is one of the most fascinating and significant components of the site and was related to what was probably one the most fascinating and significant social events in the biography of the Merchant site. All the available evidence points to the fact that the deposit was not a simple layer of trash, but rather was a structured or ritual deposit (Richards and Thomas 1984; Thomas 1991; Walker 1995, 1996, 2002) created through an act of ritual retirement and closure. This deposit was overlain by one or more layers of material or midden debris, a method of ritual closure also seen at Jornada and Mogollon pueblos (Miller and Graves 2009; Montgomery 1993). As shown in Table 18.2, from one-third to nearly one-half of the projectile points, Ochoa ceramics, decorated ceramics, and formal tools were recovered from this single provenience during the LCAS excavations. Even greater proportions were recovered in 2015, but those percentages are biased by the focus of the 2015 excavations on the spoil piles around the structure. The miscellaneous artifact category includes worked marine shell, bone rasps, pendants, pigments, and minerals, and of interest is the fact that over 42 percent of these items were from the deposits in the structure.

A comparison of the artifact assemblages collected from rooms and middens during the 2019 fieldwork leads to the conclusion that the deposits in Pit Structure 1 were even more remarkable than previously thought. The 2019 excavations in rooms recovered a single fragment of marine shell and a single fragmentary bone awl from room contexts. The negligible quantities of imported ceramics, formal bifacial tools, and artifacts of carved shell, bone, and stone found in rooms is a major contrast to the quantities left in the fill of Pit Structure 1. The mass of bison bone of Zone E is significant, but so are the quantities of artifacts that were also placed in the deposits.

Table 18.2. Proportions of material culture classes recovered from major proveniences

Artifact Class	Pit Structure 1	Pit Structure 2	Rooms and Middens
Projectile points LCAS	45.5	3.4	53.1
Projectile points 2015	75.5	6.1	18.4
Ochoa ware LCAS	47.9	17.8	34.3
Ochoa ware 2015	77.1	3.3	19.6
Decorated ceramics LCAS	35.4	14.3	50.3
Decorated ceramics 2015	85.1	0.6	14.3
Formal Tools LCAS	38.8	5.2	55.9
Miscellaneous artifacts LCAS	42.5	0.6	56.9

The retirement of kivas and civic-ceremonial structures in the southern Southwest was directly linked to changes in resident social organization or departures from villages (Adams 2016; Creel and Anyon 2003; Miller and Graves 2009; Varien 1999), and it is assumed that similar social processes prevailed at the Merchant site. The closure event seen in Pit Structure 1 was the end result of a profound change in the social order at the Merchant site. Some of the questions posed in the 2016 report summary are still relevant: what kind of ritual retirement and by whom was it performed? By the residents of the Merchant site merging with another group? By a new resident group who performed some fashion of costly signaling by closing the civic architecture of the previous or displaced residents with a mass of bone from a feasting event? Or was the ritual retirement part of a planned departure from the site? If so, what events forced such a departure?

A central question is how the mass of animal bone, almost certainly related to a feast of large game, was related to the retirement of the civic-ceremonial structure. Feasting is a form of commensal politics with a host of entangled social, ritual, labor, and economic components (Adams 2004; Dietler and Hayden 2001), all of which were present in the prehispanic Southwest (Wills et al. 2004). Perhaps we are seeing something similar at the frontiers of the Southwest and the Plains. At the Henderson site, Speth (2004b, 2004c) describes large roasting pit complexes that had been emptied of fill, had closure offerings of articulated turkeys placed below, and were then covered in deposits of trash, burned rock, and most of the bison bone from the site. As with other large pueblo villages of the Southwest, the open plaza of the Henderson site and its roasting pit complexes served as socially-integrative spaces, and the closure and retirement of that space with a structured deposit of mass bison bone is very reminiscent of Zone E at the Merchant site.

Was the retirement of Pit Structure 1 part of a village-wide departure event? In addition to the mass of bone, the masses of high visibility material culture including decorated ceramics, bifacial tools, and ritual artifacts left in the retired kiva suggest a more profound event took place, and one that marked not only the closure of a feature connected to a specific clan, lineage, or sodality, but rather one that involved the entire village.

As noted above, the Merchant pueblo villagers left the pueblo under more favorable conditions than seen in the violent demise of several villages across southeastern New Mexico and west-central Texas during the early 1400s. While there is no evidence of social violence at the Merchant site in the form of burned room blocks, burned rooms with people inside, or physical traces of violent acts on skeletal remains (of which there are none in the first place), that does not mean that violence was not a factor. It is possible that the closure of Pit Structure 1 and orderly departure from the village might have been a result of the threat or risk of violence (Solomento 2006). Solomento and others (2017:71) propose that one of several forms of culturally constructed landscapes involved "risk landscapes" that were "fundamentally a cultural landscape of the imagination, incorporating memories of past events and experiences, but also including an assessment of the future." They proposed that the anticipation of social conflict was part of the risk landscape of the Salinas (Chupadero) region of the Late Formative period. It is entirely plausible that the Merchant villagers had either witnessed or got word of violence occurring at villages in the region and had made a communal decision to move to what was hoped would be a safer place to reside. Whether or not these events were part of the larger displacements and movements of people away from southern New Mexico as indicated by the precipitous decline in the radiocarbon record of the 15^{th} century is a topic for future study.

Throughout the chapters and summary discussions of this report, it has been assumed that the Merchant villagers made rational economic responses to the social and environmental conditions of the moment and location – but it is likely that their conception of a rational response was quite different from our western economic models. In many traditional societies, trade and exchange are not separated from larger social relations, but instead are understood as a form of sharing and establishing and maintain connections between relatives, both real and fictive. There are hints of these forms of relations in the Ochoa ceramics, architecture, and other material culture of the Merchant site. Perhaps something happened to shift the perspective of the Merchant villagers that the shared economic and social conditions of regional exchange were no longer accessible or viable – a situation where the social dimensions of exchange relationships were being eclipsed by larger economic conditions, such as if the inhabitants of Bloom Mound were pursuing a more direct economic path in the regional bison economy. The collapse of inter-community social relationships in an environment of increasingly competitive and territorial bison hunting could easily have led to the warfare and violent ends seen at Bloom Mound, Salt Cedar, and other villages in southern and southeastern New Mexico.

What the Merchant Site Means

In one manner or another, the discussions and debates presented in this summary chapter have been going on for over 50 years. Leslie (2016a) was somewhat circumspect in his views on the origins of the Merchant site, although he did propose that Ochoa smudged corrugated ceramics had a Southwestern origin and this was cited as evidence for the proposed eastern extension of the Jornada region (Corley 1965; Leslie 1979). Collins (1968) interpreted the features and material culture from the Ochoa phase Salt Cedar site as migrants from Southwestern agricultural communities, while Wiseman (2000) viewed the Merchant site as Plains groups that adopted Southwestern horticultural practices and ceramic technology.

It is encouraging to consider that such debates have endured for over five decades. It is also somewhat disheartening. In one sense, this continuity reflects a healthy theoretical and methodological evolution combined with an increasingly robust data base of excavation and survey data. On the other hand, it is discouraging that we know so much more about the Merchant site, but still understand so little.

One reason we do know much about the Merchant site is that the two seasons of excavations funded by the Permian Basin Programmatic Agreement and supported by the BLM Carlsbad Field Office have demonstrated that much can still be learned from sites that appear to have been mostly destroyed by rampant looting. At the other side of the state, Creel (2006) has reported similar findings at the Old Town site in the southern Mimbres Valley, a project that was also supported by the BLM.

Both the Merchant archaeological site and the curated collections from two seasons of fieldwork at the site have considerable data potential. It is apparent that additional rooms and room blocks, extensive buried midden deposits, and broad extramural activity areas remain intact. Several of the questions explored in this report may be addressed with new information from these contexts. Additionally, the LCAS backdirt deposits contain thousands of artifacts and animal bones that can augment some of the collections. The excavated and looted spoil piles surrounding Pit Structure 1 are some of the most unique deposits in southern New Mexico. Additional analyses of ceramics and flaked stone artifacts can fill in some of the gaps identified in the present studies. Future analyses of the projectile point assemblages could include studies of production skill and standardization, thinning indices to differentiate preforms from points, and more focused inspections of breakage patterns and types. The debitage and tools could be more examined for additional correlations between material types and flake types, sizes, and attributes. As discussed in Chapter 3, faunal assemblages from curated or newly excavated collections can be submitted for DNA and isotopic analysis to determine the sex and age ratios and bison remains, thus providing critical evidence of seasonality and the organization of long-distance hunts.

While there continues to be many unanswered questions and much speculation surrounding the Merchant site and the nature of its inhabitants, there is one overarching conclusion that can be drawn from the three seasons of fieldwork: The Merchant site is a fascinating test case for the study of migration, social interaction, and how new social identities are formed. The manner in which the Plains hunters and pueblo agriculturalists interacted—whether symbiotically through exchange, by merging and creating new expressions of ethnicity and identity, or through conflict and warfare—is an important and fascinating topic of investigation for Southwestern and Plains prehistory and broader anthropological theory. The Merchant site and other Ochoa phase settlements of southeastern New Mexico have much to offer for such pursuits.

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Appendix A: Chronometric Reports

A.1 OSL Dating Report

A.2 Radiocarbon Laboratory Forms

A.3 Ceramic Luminescence Dates

Appendix A.1 OSL Date Report University of Sheffield

Quartz Optical Dating Report
Merchant site, New Mexico, USA

The University Of Sheffield.

Abstract: Optically stimulated luminescence (OSL) dating at the single grain level was applied to coarse quartz grains extracted from four samples taken from the Merchant site, New Mexico, USA. Samples responded reasonably well to OSL measurement at the single grain level. Some samples had zero-dosed grains and some had saturated grains, all had non normal De replicate distributions. The samples are therefore assumed to have been pedoturbated and/or partially bleached prior to burial. Whilst attempts to mitigate this have been made the resultant reported ages may still be impacted by this and should be used in this context. Ages range from 0.29 ± 0.05 to 1.50 ± 0.15 ka for these samples.

1. Introduction

This report comprises the results from four samples from the Merchant site, New Mexico USA submitted by Dr Charles Frederick for single grain OSL dating. Sample codes are listed in Table 1. The samples were assumed not to have been exposed to sunlight during sampling or transportation. All luminescence work was carried out at the Sheffield Luminescence Laboratory (SLL). Upon arrival at SLL, the samples were allocated Sheffield lab numbers (Table 1), which are used throughout this report. This report provides a brief summary of the procedures employed and results obtained for the samples.

In order to derive an optically stimulated luminescence (OSL) age both the palaeodose (De - the amount of absorbed dose since the sample was buried) and the dose rate (the estimated radiation flux for the sedimentary bodies) have to be determined. Bateman (2019) gives a detailed explanation of both these parameters. To calculate an age, the palaeodose (expressed in Grays) is divided by the annual dose rate (Grays/yr). An inherent assumption in these age calculations is that the sediment was fully reset or 'bleached' by exposure to sunlight during the last transport event or whilst *in situ* prior to burial and that no post-depositional sediment pedoturbation has occurred.

As part of this investigation, efforts have been taken to establish if these sediments have been bleached prior to burial or disturbed by, for example, pedoturbation. As the OSL signal measured at the single aliquot level is an average of ~2000 grains, the true distribution of De values may be masked. This is of particular significance in heterogeneously dosed samples (e.g. sediment that has been poorly reset/bleached), where grains with a high De signal will dominate the signal at the expense of grains containing a true burial De. The De of grains recently exhumed and bleached due to pedoturbation (referred to as zero-dosed grains) are also masked at the single aliquot level. In order to investigate whether these issues apply, the samples underwent OSL dating at the single grain level.

Table 1. *Sample descriptive data.*

Locality	Lab No.	Field Reference	Latitude (° N)	Longitude (° W)	Altitude (m)	Sampling Depth (m below present-day surface)
Trench-19	Shfd20020	OSL1 (50cm)	[redacted]		1092	0.50
	Shfd20021	OSL2 (75cm)			1092	0.75
	Shfd20022	OSL3 (100cm)			1092	1.00
	Shfd20023	OSL4 (125cm)			1092	1.25

2. Dose Rate Analysis

Naturally occurring potassium (K), thorium (Th), uranium (U) and Rubidium (Rb) are the main contributors of dose to sedimentary quartz. The concentrations of these elements were determined by inductively coupled plasma mass spectrometry (ICP) at SGS laboratories Ontario Canada (Table 2). Elemental concentrations were converted to annual dose rates using data from Guerin et al. (2011). Calculations took into account attenuation factors relating to sediment grain sizes used, density and palaeomoisture (Table 2). Present-day moistures were applied as the average palaeomoisture level with an uncertainty of ± 3%. The contribution to dose rates from cosmic sources was calculated using the expression published in Prescott and Hutton (1994; Table 2).

The dose rates calculated are based on analyses of the sediment sampled at the present day. This assumption is only valid if no movement and/or reprecipitation of the four key elements has taken place since sediment burial and the adjacent sediments to those sampled had similar dose rates. Further analysis would have to be undertaken to establish whether the latter is true and if radioactive disequilibrium is present in the dose rate.

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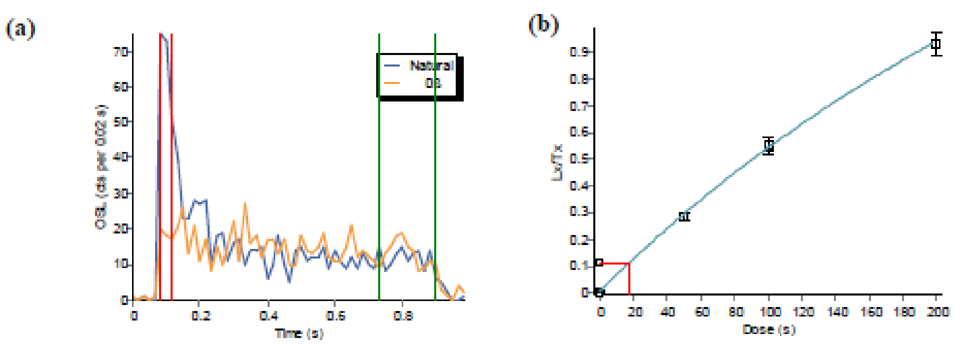

Figure 1 Examples of single grain OSL data for sample Shfd20021: (a) OSL decay of a naturally acquired signal in blue compared to OSL with added beta irradiation (orange); (b) SAR growth curve The red lines in (a) indicate the integration limits for signal measurement, and the green lines background measurement once the signal has been zeroed. In (b) the luminescence response (Lx) to a series of known doses is normalised by test dose response (Tx) and plotted against dose. The red line represents interpolation of the natural dose (D_e).

Table 2. *Summary of dosimetry related data.*

Lab Code	U (PPM)	Th (PPM)	K (%)	Rb (PPM)	D_{cosmic}* (μGy/a^{-1})	Moisture (%)	Beta Dose rate† (μGy/a^{-1})	Gamma Dose rate (μGy/a^{-1})
Shfd20020	0.70	1.8	0.5	21.7	240 ± 12	0.7	493 ± 36	287 ± 13
Shfd20021	0.80	2.1	0.6	23.5	232 ± 12	0.7	585 ± 43	337 ± 15
Shfd20022	0.83	2.1	0.6	23.9	224 ± 11	0.9	587 ± 43	339 ± 15
Shfd20023	0.93	2.2	0.6	24.8	217± 11	1.1	600 ± 43	354 ± 16

* Cosmic dose is calculated as a linear decay curve at depths below 50 cm.

3. Palaeodose Determination

Samples were prepared under subdued red lighting following the procedure to extract and clean quartz outlined in Bateman and Catt (1996). Material for dating was taken from prepared quartz isolated to a size range of 180-250 µm. The samples underwent measurement using a Risø DA-15 luminescence reader with radiation doses administered using a calibrated ^{90}strontium beta source. Grains were mounted in 300 µm pits with 100 pits per 9.6 mm stainless steel aliquot. A focussed 532 nm Nd:YVO4 laser provided the stimulation and luminescence detection was through a Hoya U-340 filter. Samples were analysed using the single aliquot regenerative (SAR) approach (Murray & Wintle, 2000; Murray & Wintle, 2003), in which an interpolative growth curve is constructed using data derived from repeated measurements of a single aliquot which has been given various laboratory irradiations (Figure 1b). Five regeneration points were used to characterise growth curves, with the first regeneration point being identical to the last in order to check if sensitivity changes caused by repeated measurement of the same grains are correctly monitored and corrected for by the SAR protocol (known as the "recycling ratio"). The most appropriate preheat temperature for measurement was selected using a dose recovery preheat plateau test conducted on sample Shfd20023 (Figure 2). Results of this resulted in the selection of a preheat temperature of 180°C for 10 seconds. This was applied to each sample prior to OSL measurement to remove any unstable signal generated by laboratory irradiation. With all single grain OSL analyses, many grains exhibit insufficient OSL signal to be utilised and/or are too poorly behaved for the D_e to be accurately measured. D_e values from individual grains were thus only accepted if they exhibited an OSL signal measurable above background, good growth with dose, recycling values within ± 20 % of unity. Of all the grains measured (up to 2000 for each sample) ~2% of the grains per sample passed the above acceptance criteria.

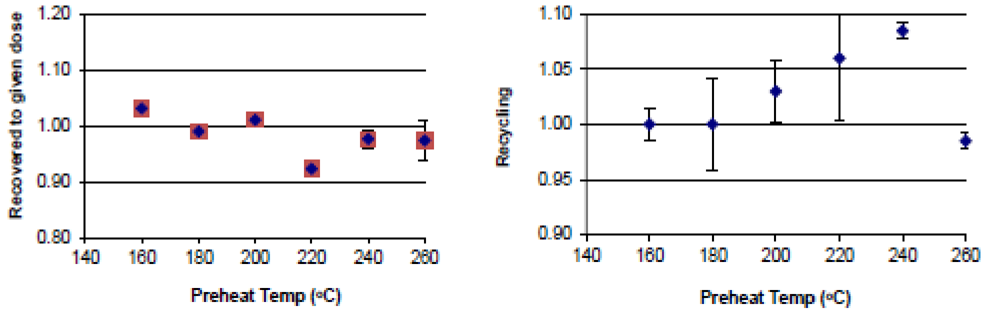

Figure 2 Results of dose recovery test on Shfd20023 used to determine appropriate preheat for SAR protocol

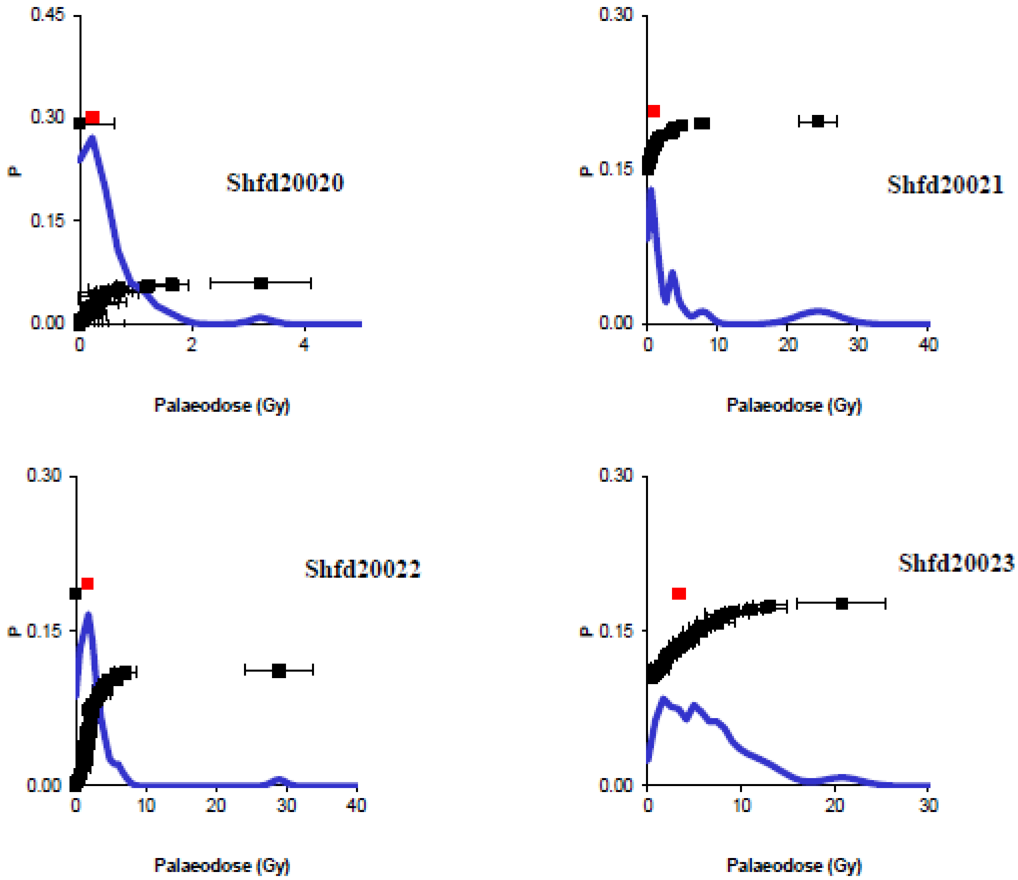

Figure 3. D_e distribution plots for the nine samples from the Merchant site. Blue line is combined probability density for all grains. Black points are results from individual grains. Note dose is given as seconds in front of artificial radiation source and scaled as appropriate for data.

4. Sample behaviour

All samples possessed generally good luminescence characteristics with a moderately bright but rapidly decaying OSL with stimulation indicative of an OSL signal dominated by a fast component (e.g. Fig. 1a). The OSL signal also grew with laboratory dose (Fig. 1b). Some samples (Shfd20022 and Shds20023) had a few saturated grains, i.e. grains which had never seen sunlight prior to burial. These were excluded from age analysis here but would have been incorporated into ages had the measurements not been at the single grain level. Some samples (Shfd20020, Shfd20021 and Shfd20022) also had zero-dosed grains indicative of grains which had recently been at the surface and pedoturbated back down profile. The number of zero-dosed grains decreases markedly from samples Shfd20020 to samples Shfd20021 and Shfd20022).

5. Sedimentary bleaching behaviour

The effects of incomplete bleaching of the sediment during the last period of transport or exposure *in situ* can be profound. Typically, poorly bleached sediments retain a significant level of residual signal from previous phases of sedimentary cycling, leading to inherent inaccuracies in the calculation of a palaeodose value. By plotting the replicate D_e data for the sample as a probability density function (Figure 3) some assessment of whether older or younger material has been included in the sample measurements can be made. In principle a well-bleached sample that has not been subjected to post-depositional pedoturbation should have replicate D_e data which is normally distributed and highly reproducible (see Bateman *et al.*, 2003, Figure 3; Bateman *et al.*, 2007a). Where post-depositional pedoturbation or incomplete bleaching prior to sample burial has occurred skewing of this distribution may occur and/or replicate reproducibility may be lower (Bateman *et al.*, 2007a; Bateman *et al.*, 2007b). In the case of poorly bleached material skewing should be evident with a high De tail (e.g. Olley *et al.*, 2004). High D_e tails may also be indicative of saturated samples and interpolation of the D_e values from the upper, low gradient part of the growth curve (Murray & Funder, 2003).

As Figure 3 and Table 3 demonstrates (see also Appendix 1), OD values are higher than would be expected for well-bleached undisturbed samples, and D_e distributions are broad and non-normally distributed. Additionally, samples Shfd20020, Shfd20021 and Shfd20022 had appreciable numbers of zero-dosed grains indicating some recent incorporation of sediment into these samples (pedoturbation). It is noted these samples all come the upper part of the sampled profiles. Finally it is noted that some of the samples had a few saturated grains (Shfd20022 and Shfd20023). These samples were from the lowest points in sampled profiles and are interpreted as indicating either zero bleaching at deposition or incorporation of geologically old material by sub-surface pedoturbation. As a result of the above, De values for age calculation purposes have been extracted using the Finite mixture model (Galbraith and Green 1990). This model tries to separate out different components so that younger pedoturbated or older partially bleached grains can be isolated from the grains of the true burial age. Table 3 shows all extracted De values for all samples. It is suggested to use the age calculated from the lowest De component identified once zero-dosed grains were excluded as this will hopefully also exclude any partially bleached material. For samples Shfd20020, Shfd20021 and Shfd20023 this low De component is also the dominant component.

Table 3. *Summary of OSL results for Trench 19 from the Merchant Site. For samples with multiple De components extracted using FMM, the individual ages derived from each component are shown. Ages in bold are suggested best estimates based on the nature of the De distribution, number of zero-dose grains and stratigraphy provided.*

Lab Code	Field Ref.	Sampling Depth (m)	FMM component	Proportion (%)	De (Gy)	Dose rate (µGy/a-1)	Age (ka)
Shfd20020	OSL1 (50cm)	0.50	1	80	0.30 ± 0.05	1036 ± 40	**0.29 ± 0.05**
			2	20	1.50 ± 0.20		1.45 ± 0.20
Shfd20021	OSL2 (75cm)	0.75	1	41	0.59 ± 0.11		**0.50 ± 0.10**
			2	24	1.42 ± 0.28	1171 ± 47	1.21 ± 0.24
			3	30	4.13 ± 0.41		3.53 ± 0.38
Shfd20022	OSL3 (100cm)	1.00	1	67	1.76 ± 0.15	1168 ± 47	**1.51 ± 0.15**
			2	31	4.02 ± 0.42		3.44 ± 0.39
Shfd20023	OSL4 (125cm)	1.25	1	31	1.78 ± 0.31		**1.50 ± 0.77**
			2	38	4.24 ± 0.60	1189 ± 48	3.57 ± 0.52
			3	31	9.31 ± 0.97		7.83 ± 0.87

5. Age Calculation and Conclusions

Ages are quoted in years from the present day (2020) and are presented with one sigma confidence intervals which incorporate systematic uncertainties with the dosimetry data, uncertainties with the palaeomoisture content and errors associated with the De determination. Table 3 shows the final OSL age estimates from the single grain data for all FMM components with the ages in bold indicating the preferred final age based on data. Grain specific data for each sample is included in Appendix 1. Given the observed dose distribution, with some saturated and zero-dosed grains and non normal De replicate distributions these samples are assumed to have been pedoturbated and/or partially bleached prior to burial. Whilst attempts to mitigate this have been made the resultant reported ages may still be impacted by this and should be used in this context. Ages from within the same profile appear to increase with depth and based on stratigraphical information provided there is good concordance of ages within identified zones. Ages range from 0.29 ± 0.05 to 1.50 ± 0.15 ka for these samples.

Prof Mark D. Bateman

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Appendix

Single grain data and plots for the Merchant site, New Mexico USA

Sample specific data including:-

- list of De values derived from individual aliquots
- calculated means based on a range of statistical models
- histogram plot of distribution of De within a sample
- probability density plot (curve) with ranked De data (black points) and probability mean (uppermost red point).

Field Code:	**Trench 19-1 OSL 1**	**Merchant Site**
Lab Code:	**Shfd20020**	**New Mexico**
Aliquot Size:	**single grain**	

Aliquot	Palaeodose (Gy)	error	Aliquot	Palaeodose (Gy)	error
1	-0.410	0.509	39	0.004	0.169
2	1.181	0.136			
3	-0.067	0.130			
4	0.113	0.289			
5	0.007	0.117			
6	0.465	0.577			
7	-0.939	0.618			
8	0.688	0.523			
9	0.306	0.375			
10	1.202	0.547			
11	1.636	0.314			
12	0.321	0.519			
13	0.702	0.169			
14	0.235	0.114			
15	0.197	0.055			
16	-0.494	0.335			
17	-0.047	0.392			
18	0.163	0.248			
19	-0.381	0.173			
20	-0.643	0.417			
21	0.163	0.216			
22	0.269	0.190			
23	-0.023	0.787			
24	0.097	0.229			
25	0.460	0.180			
26	0.631	0.316			
27	0.007	0.081			
28	0.275	0.146			
29	0.063	0.083			
30	0.346	0.091			
31	0.345	0.160			
32	-0.408	0.266			
33	0.344	0.139			
34	0.464	0.211			
35	0.170	0.137			
36	0.130	0.363			
37	0.354	0.360			
38	3.223	0.886			

0 saturated grains

Field Code:	Trench 19-1 OSL 1	Site:	Merchant Site
Lab Code:	Shfd20020		New Mexico
Aliquot Size:	single grain		

	De (Gy)	error
Minimum	0.00	0.79
Maximum	3.22	0.89
N	39	

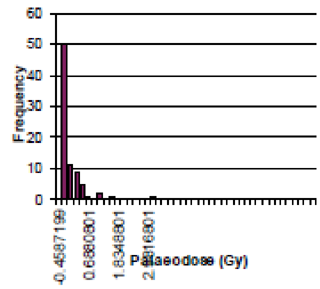
Unweighted	All Data	Minus Outliers
Mean (Gy)	0.37	0.24
SD	0.60	0.21
SE	0.10	0.03
N	39	30

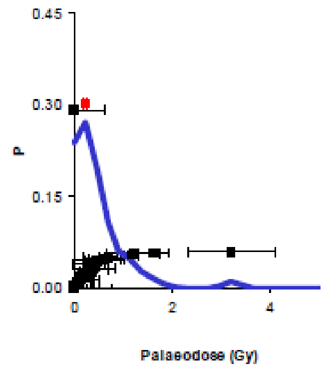
Weighted	All Data	Minus Outliers
Mean (Gy)	0.23	0.19
SD	0.29	0.17
SE	0.05	0.03
N	39	30

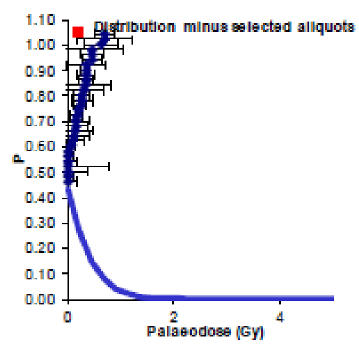
Probability	All Data	Minus Outliers
Mean (Gy)	0.23	0.21
SD	0.28	0.20
SE	0.04	0.04
N	39	30

De Distributic	All Data	Minus Outliers
Skewness	8.27	0.01
Kurtosis	13.71	-0.26
Median	0.20	0.22
Sorting	0.92	0.57

Common Age Model	All Data	Minus Outliers
Mean (Gy)	0.80	0.17
SD	0.08	0.07
OD (all data)	n/a	n/a
N	39	30
N		







Finite Mixture Modelling

Component	Mean De (Gy)	Error	Proportion
1	0.3	0.05	80
2	1.5	0.2	20

Field Code:	Trench 19-1 OSL 2	Merchant Site
Lab Code:	Shfd20021	New Mexico
Aliquot Size:	single grain	

Aliquot	Palaeodose (Gy)	error
1	0.092	0.607
2	1.342	0.330
3	4.954	0.622
4	0.229	0.126
5	2.021	0.479
6	3.756	0.283
7	-0.353	0.759
8	1.479	0.798
9	3.534	0.621
10	0.697	0.091
11	24.320	2.709
12	1.410	0.325
13	0.326	0.147
14	0.400	0.192
15	3.288	0.158
16	0.419	0.527
17	7.792	1.081
18	0.093	0.150
19	0.333	0.424
20	0.664	0.177
21	3.650	0.495
22	0.719	0.374
23	1.175	0.453
24	0.724	0.762

1	saturated grains
3	zero-dose grains
1600	grains measured

Field Code:	Trench 19-1 OSL 2	Site:	Merchant Site
Lab Code:	Shfd20021		New Mexico
Aliquot Size:	single grain		

	De (Gy)	error
Minimum	0.00	0.76
Maximum	24.32	2.71
N	24	

Unweighted	All Data	Minus Outliers
Mean (Gy)	2.64	1.42
SD	5.00	1.46
SE	1.02	0.30
N	24	22

Weighted	All Data	Minus Outliers
Mean (Gy)	0.95	0.93
SD	1.20	1.08
SE	0.24	0.23
N	24	22

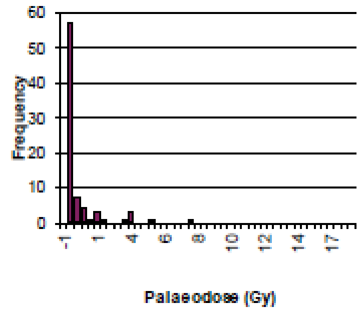
Probability	All Data	Minus Outliers
Mean (Gy)	0.93	0.90
SD	1.23	1.00
SE	0.25	0.21
N	24	22

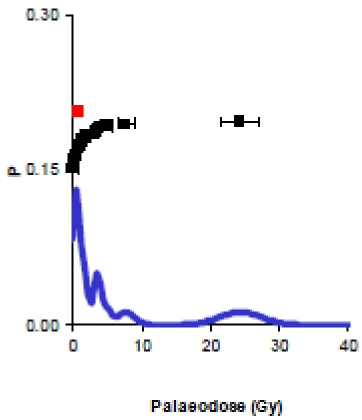
De Distributic	All Data	Minus Outliers
Skewness	6.67	-0.01
Kurtosis	16.69	0.15
Median	0.95	0.72
Sorting	0.74	0.51

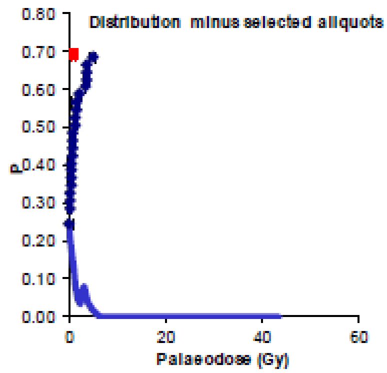
Central Age Model	All Data	Minus Outliers
Mean (Gy)	1.52	1.24
SD	0.40	0.28
OD (all data)	112%	85%
N	24	22

Finite Mixture Modelling

Component	Mean De (Gy)	Error	Proportion
1	0.59	0.11	41
2	1.42	0.28	24
3	4.13	0.41	30





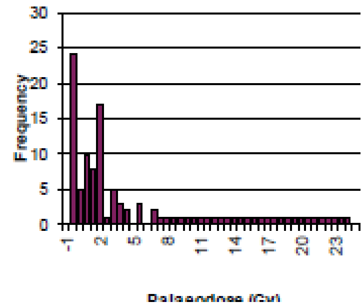


Field Code:	Trench 19-1 OSL 3	Merchant Site
Lab Code:	Shfd20022	New Mexico
Aliquot Size:	single grain	

Aliquot	Palaeodose (Gy)	error	Aliquot	Palaeodose (Gy)	error
1	0.596	0.222	39	2.381	0.741
2	1.292	0.367	40	0.793	0.209
3	5.839	0.945	41	1.820	0.605
4	3.999	0.339	42	3.583	0.497
5	0.996	0.491	43	1.002	0.477
6	7.050	1.531	44	3.037	0.500
7	1.783	0.649	45	0.528	0.766
8	3.551	1.301	46	3.790	1.406
9	0.001	0.324	47	0.076	0.688
10	1.157	1.303	48	1.858	0.801
11	-0.479	0.663	49	4.046	0.956
12	2.333	1.412	50	2.011	0.494
13	1.306	0.122	51	2.237	0.233
14	1.165	1.137	52	5.834	0.942
15	-0.385	0.599	53	0.450	0.211
16	1.292	0.494	54	2.840	0.159
17	2.021	0.531	55	0.737	0.575
18	2.325	0.207	56	1.411	0.534
19	-0.450	1.100	57	3.141	0.558
20	4.471	0.435	58	1.411	0.904
21	2.413	0.509	59	2.194	0.483
22	1.868	0.887	60	0.976	0.550
23	2.376	1.019	61	5.885	0.997
24	1.915	1.052			
25	2.116	0.720			
26	2.191	0.918			
27	1.781	0.839			
28	1.859	1.220			
29	0.821	1.264			
30	28.950	4.838			
31	-0.004	0.575			
32	-0.467	0.832			
33	3.426	0.451			
34	0.613	0.781			
35	1.206	0.447			
36	4.535	1.527			
37	2.009	0.110			
38	1.778	0.189			

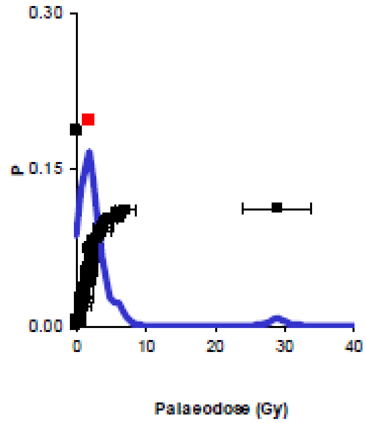
3	saturated grains
7	zero-dose grains
1800	grains measured

Field Code:	Trench 19-1 OSL 3	Site:	Merchant Site
Lab Code:	Shfd20022		New Mexico
Aliquot Size:	single grain		



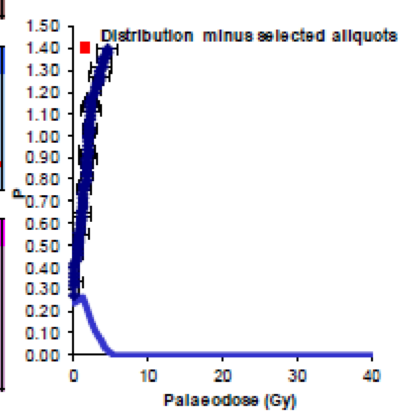
	De (Gy)	error
Minimum	0.00	0.58
Maximum	28.95	4.84
N	61	

Unweighted	All Data	Minus Outliers
Mean (Gy)	2.51	1.78
SD	3.79	1.21
SE	0.49	0.15
N	61	56



Weighted	All Data	Minus Outliers
Mean (Gy)	1.77	1.74
SD	1.04	0.93
SE	0.13	0.12
N	61	56

Probability	All Data	Minus Outliers
Mean (Gy)	1.74	1.66
SD	1.22	0.97
SE	0.16	0.13
N	61	56



De Distributic	All Data	Minus Outliers
Skewness	8.34	0.00
Kurtosis	40.43	-0.34
Median	1.86	1.80
Sorting	0.66	0.49

Central Age Model	All Data	Minus Outliers
Mean (Gy)	2.31	2.05
SD	0.24	0.17
OD (all data)	64.19%	0.41
N	61	56

Finite Mixture Modelling

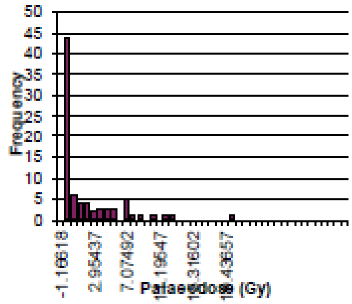
Component	Mean De (Gy)	Error	Proportion
1	1.76	0.16	67
2	4.02	0.42	31

Field Code:	**Trench 19-1 OSL 4**	**Merchant Site**
Lab Code:	**Shfd20023**	**New Mexico**
Aliquot Size:	**single grain**	

Aliquot	Palaeodose (Gy)	error
1	2.924	0.716
2	1.282	0.338
3	4.999	1.242
4	6.141	1.160
5	2.952	0.225
6	4.082	1.449
7	5.561	0.638
8	9.267	0.936
9	1.832	0.496
10	7.528	1.159
11	8.423	2.308
12	7.844	1.584
13	5.650	1.209
14	7.875	0.482
15	7.253	2.015
16	20.759	4.682
17	13.077	1.792
18	12.669	2.138
19	0.833	0.511
20	1.925	0.494
21	4.925	0.488
22	3.873	1.097
23	1.185	1.015
24	4.116	0.696
25	1.272	0.824
26	7.191	0.851
27	2.551	0.660
28	3.506	1.266
29	3.324	0.283
30	2.090	0.390
31	0.483	0.684
32	0.482	0.495
33	1.842	0.281
34	1.031	0.264
35	2.214	0.864
36	4.826	0.630
37	11.045	1.270

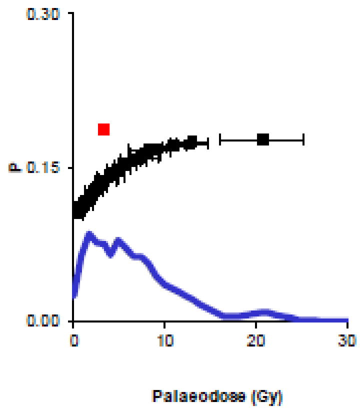
3	saturated grains
0	zero-dose grains
900	grains measured

Field Code:	Trench 19-1 OSL 4	Site:	Merchant Site
Lab Code:	Shfd20023		New Mexico
Aliquot Size:	single grain		



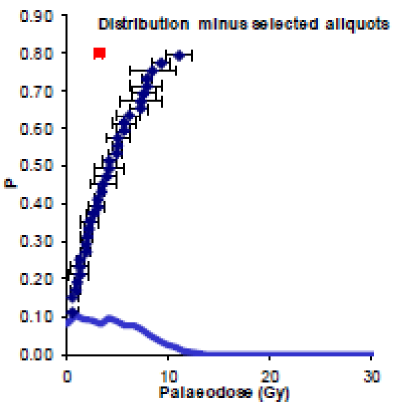
	De (Gy)	error
Minimum	0.48	0.49
Maximum	20.76	4.68
N	37	

Unweighted		
	All Data	Minus Outliers
Mean (Gy)	5.10	4.19
SD	4.27	2.82
SE	0.70	0.46
N	37	34



Weighted		
	All Data	Minus Outliers
Mean (Gy)	2.84	2.79
SD	2.09	1.96
SE	0.34	0.34
N	37	34

Probability		
	All Data	Minus Outliers
Mean (Gy)	3.35	3.22
SD	2.51	2.24
SE	0.41	0.38
N	37	34



De Distributio	All Data	Minus Outliers
Skewness	1.55	0.09
Kurtosis	3.82	-0.52
Median	4.08	3.69
Sorting	0.69	0.54

Central Age Model		
	All Data	Minus Outliers
Mean (Gy)	4.14	3.72
SD	52.80%	0.44
OD (all data)	1	1
N	37	34

Finite Mixture Modelling			
Component	Mean De (Gy)	Error	Proportion
1	1.78	0.31	31
2	4.24	0.6	38
3	9.31	0.97	31

Appendix A.2 Radiocarbon Laboratory Forms Beta Analytic, Inc.

Dendrochronological calibrations for prehistoric dates are provided in Table 11.1 of the report.

Calibrations for three modern dates are included in Appendix A.2.

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Beta Analytic TESTING LABORATORY

ISO/IEC 17025:2005-Accredited Testing Laboratory

REPORT OF RADIOCARBON DATING ANALYSES

Lillian M. Ponce — Report Date: September 17, 2020

Versar, Inc. — Material Received: September 08, 2020

Laboratory Number	Sample Code Number	Conventional Radiocarbon Age (BP) or Percent Modern Carbon (pMC) & Stable Isotopes Calendar Calibrated Results: 95.4 % Probability High Probability Density Range Method (HPD)	
Beta - 567946	**LA 43414 - Feature 6.2 - Charcoal**	**101.25 +/- 0.38 pMC**	IRMS δ13C: -25.2 o/oo

(95.4%) **1954 - 1955 cal AD** **(-5 - -6 cal BP)**

Submitter Material: Charcoal
Pretreatment: (charred material) acid/alkali/acid
Analyzed Material: Charred material
Analysis Service: AMS-Standard delivery
Conventional Radiocarbon Age: -100 +/- 30 BP
Fraction Modern Carbon: 1.0125 +/- 0.0038
D14C: 12.53 +/- 3.78 o/oo
Δ14C: 3.99 +/- 3.78 o/oo (1950:2020)
Raw pMC: (without d13C correction): 101.22 +/- 0.38 pMC
Calibration: BetaCal3.21: HPD method: INTCAL13 + NHZ2

Results are ISO/IEC-17025:2005 accredited. No sub-contracting or student labor was used in the analyses. All work was done at Beta in 4 in-house NEC accelerator mass spectrometers and 4 Thermo IRMSs. The "Conventional Radiocarbon Age" was calculated using the Libby half-life (5568 years), is corrected for total isotopic fraction and was used for calendar calibration where applicable. The Age is rounded to the nearest 10 years and is reported as radiocarbon years before present (BP), "present" = AD 1950. Results greater than the modern reference are reported as percent modern carbon (pMC). The modern reference standard was 95% the 14C signature of NIST SRM-4990C (oxalic acid). Quoted errors are 1 sigma counting statistics. Calculated sigmas less than 30 BP on the Conventional Radiocarbon Age are conservatively rounded up to 30. d13C values are on the material itself (not the AMS d13C). d13C and d15N values are relative to VPDB-1. References for calendar calibrations are cited at the bottom of calibration graph pages.

BetaCal 3.21

Calibration of Radiocarbon Age to Calendar Years

(High Probability Density Range Method (HPD): INTCAL13 + NHZ2)

(Variables: d13C = -25.2 o/oo)

Laboratory number **Beta-567946**

Percent modern carbon **101.25 +/- 0.38 pMC**

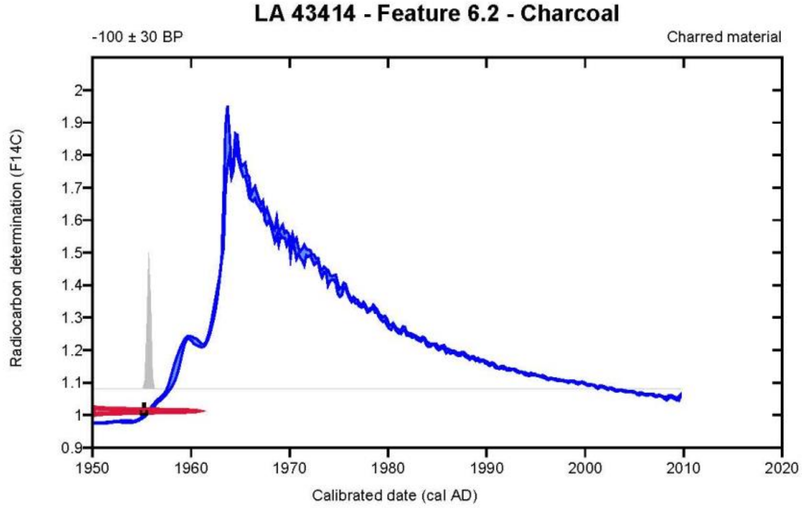
95.4% probability

(95.4%) 1954 - 1955 cal AD (-5 - -6 cal BP)

68.2% probability

(68.2%) 1955 cal AD (-6 cal BP)

LA 43414 - Feature 6.2 - Charcoal



Database used

INTCAL13 + NHZ2

References

References to Probability Method

Bronk Ramsey, C. (2009). Bayesian analysis of radiocarbon dates. Radiocarbon, 51(1), 337-360.

References to Database INTCAL13 + NHZ2

Hua, et.al.,2013, Radiocarbon, 55(4). Reimer, et.al., 2013, Radiocarbon55(4).

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REPORT OF RADIOCARBON DATING ANALYSES

Lillian M. Ponce — Report Date: September 17, 2020

Versar, Inc. — Material Received: September 08, 2020

Laboratory Number	Sample Code Number	Conventional Radiocarbon Age (BP) or Percent Modern Carbon (pMC) & Stable Isotopes Calendar Calibrated Results: 95.4 % Probability High Probability Density Range Method (HPD)	
Beta - 567947	**LA 43414 - Feature 6.2 - Mesquite twig**	**121.13 +/- 0.45 pMC**	IRMS δ13C: -24.2 o/oo

(60.9%)	**1983 - 1985 cal AD**	**(-34 - -36 cal BP)**
(28.3%)	**1959 - 1961 cal AD**	**(-10 - -12 cal BP)**
(6.2%)	**1958 cal AD**	**(-9 cal BP)**

Submitter Material: Woody Material
Pretreatment: (wood) acid/alkali/acid
Analyzed Material: Wood
Analysis Service: AMS-Standard delivery
Conventional Radiocarbon Age: -1540 +/- 30 BP
Fraction Modern Carbon: 1.2113 +/- 0.0045
D14C: 211.32 +/- 4.52 o/oo
Δ14C: 201.11 +/- 4.52 o/oo (1950:2020)
Raw pMC: (without d13C correction): 121.34 +/- 0.45 pMC
Calibration: BetaCal3.21: HPD method: INTCAL13 + NHZ2

Results are ISO/IEC-17025:2005 accredited. No sub-contracting or student labor was used in the analyses. All work was done at Beta in 4 in-house NEC accelerator mass spectrometers and 4 Thermo IRMSs. The "Conventional Radiocarbon Age" was calculated using the Libby half-life (5568 years), is corrected for total isotopic fraction and was used for calendar calibration where applicable. The Age is rounded to the nearest 10 years and is reported as radiocarbon years before present (BP), "present" = AD 1950. Results greater than the modern reference are reported as percent modern carbon (pMC). The modern reference standard was 95% the 14C signature of NIST SRM-4990C (oxalic acid). Quoted errors are 1 sigma counting statistics. Calculated sigmas less than 30 BP on the Conventional Radiocarbon Age are conservatively rounded up to 30. d13C values are on the material itself (not the AMS d13C). d13C and d15N values are relative to VPDB-1. References for calendar calibrations are cited at the bottom of calibration graph pages.

BetaCal 3.21

Calibration of Radiocarbon Age to Calendar Years

(High Probability Density Range Method (HPD): INTCAL13 + NHZ2)

(Variables: d13C = -24.2 o/oo)

Laboratory number **Beta-567947**

Percent modern carbon **121.13 +/- 0.45 pMC**

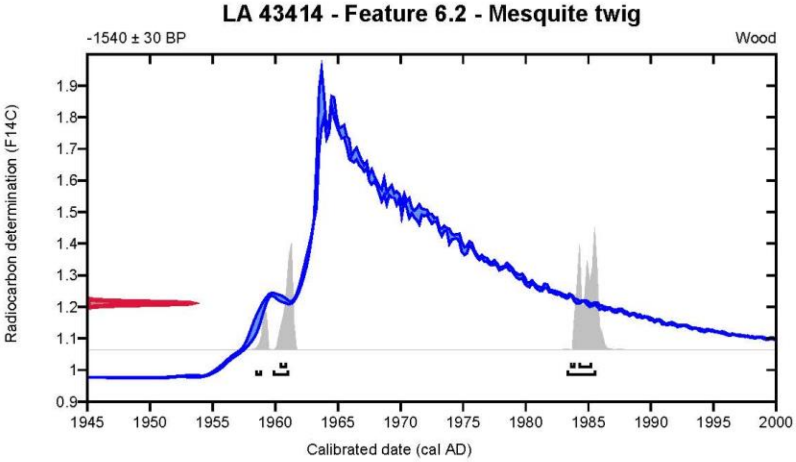
95.4% probability

(60.9%)	1983 - 1985 cal AD	(-34 - -36 cal BP)
(28.3%)	1959 - 1961 cal AD	(-10 - -12 cal BP)
(6.2%)	1958 cal AD	(-9 cal BP)

68.2% probability

(36%)	1984 - 1985 cal AD	(-35 - -36 cal BP)
(19.3%)	1960 cal AD	(-11 cal BP)
(12.9%)	1983 cal AD	(-34 cal BP)

LA 43414 - Feature 6.2 - Mesquite twig



Database used

INTCAL13 + NHZ2

References

References to Probability Method

Bronk Ramsey, C. (2009). Bayesian analysis of radiocarbon dates. Radiocarbon, 51(1), 337-360.

References to Database INTCAL13 + NHZ2

Hua, et.al.,2013, Radiocarbon, 55(4). Reimer, et.al., 2013, Radiocarbon55(4).

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REPORT OF RADIOCARBON DATING ANALYSES

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Laboratory Number	Sample Code Number	Conventional Radiocarbon Age (BP) or Percent Modern Carbon (pMC) & Stable Isotopes Calendar Calibrated Results: 95.4 % Probability High Probability Density Range Method (HPD)	
Beta - 567948	**LA 43414 - Feature 6.3A**	**240 +/- 30 BP**	IRMS δ13C: -26.4 o/oo

(52.6%)	**1632 - 1682 cal AD**	**(318 - 268 cal BP)**
(30.0%)	**1762 - 1803 cal AD**	**(188 - 147 cal BP)**
(6.0%)	**1936 - Post AD 1950**	**(14 - Post BP 0)**
(5.6%)	**1526 - 1556 cal AD**	**(424 - 394 cal BP)**
(1.3%)	**1738 - 1750 cal AD**	**(212 - 200 cal BP)**

Submitter Material: Charcoal
Pretreatment: (charred material) acid/alkali/acid
Analyzed Material: Charred material
Analysis Service: AMS-Standard delivery
Percent Modern Carbon: 97.06 +/- 0.36 pMC
Fraction Modern Carbon: 0.9706 +/- 0.0036
D14C: -29.44 +/- 3.62 o/oo
Δ14C: -37.62 +/- 3.62 o/oo (1950:2020)
Measured Radiocarbon Age: (without d13C correction): 260 +/- 30 BP
Calibration: BetaCal3.21: HPD method: INTCAL13

Results are ISO/IEC-17025:2005 accredited. No sub-contracting or student labor was used in the analyses. All work was done at Beta in 4 in-house NEC accelerator mass spectrometers and 4 Thermo IRMSs. The "Conventional Radiocarbon Age" was calculated using the Libby half-life (5568 years), is corrected for total isotopic fraction and was used for calendar calibration where applicable. The Age is rounded to the nearest 10 years and is reported as radiocarbon years before present (BP), "present" = AD 1950. Results greater than the modern reference are reported as percent modern carbon (pMC). The modern reference standard was 95% the 14C signature of NIST SRM-4990C (oxalic acid). Quoted errors are 1 sigma counting statistics. Calculated sigmas less than 30 BP on the Conventional Radiocarbon Age are conservatively rounded up to 30. d13C values are on the material itself (not the AMS d13C). d13C and d15N values are relative to VPDB-1. References for calendar calibrations are cited at the bottom of calibration graph pages.

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REPORT OF RADIOCARBON DATING ANALYSES

Lillian M. Ponce | Report Date: September 17, 2020

Versar, Inc. | Material Received: September 08, 2020

Laboratory Number	Sample Code Number	Conventional Radiocarbon Age (BP) or Percent Modern Carbon (pMC) & Stable Isotopes Calendar Calibrated Results: 95.4 % Probability High Probability Density Range Method (HPD)	
Beta - 567949	**LA 43414 - Feature 13.2**	**550 +/- 30 BP**	IRMS δ13C: -25.8 o/oo

(55.0%)	**1386 - 1434 cal AD**	**(564 - 516 cal BP)**
(40.4%)	**1311 - 1359 cal AD**	**(639 - 591 cal BP)**

Submitter Material: Charcoal
Pretreatment: (charred material) acid/alkali/acid
Analyzed Material: Charred material
Analysis Service: AMS-Standard delivery
Percent Modern Carbon: 93.38 +/- 0.35 pMC
Fraction Modern Carbon: 0.9338 +/- 0.0035
D14C: -66.18 +/- 3.49 o/oo
Δ14C: -74.05 +/- 3.49 o/oo (1950:2020)
Measured Radiocarbon Age: (without d13C correction): 560 +/- 30 BP
Calibration: BetaCal3.21: HPD method: INTCAL13

Results are ISO/IEC-17025:2005 accredited. No sub-contracting or student labor was used in the analyses. All work was done at Beta in 4 in-house NEC accelerator mass spectrometers and 4 Thermo IRMSs. The "Conventional Radiocarbon Age" was calculated using the Libby half-life (5568 years), is corrected for total isotopic fraction and was used for calendar calibration where applicable. The Age is rounded to the nearest 10 years and is reported as radiocarbon years before present (BP), "present" = AD 1950. Results greater than the modern reference are reported as percent modern carbon (pMC). The modern reference standard was 95% the 14C signature of NIST SRM-4990C (oxalic acid). Quoted errors are 1 sigma counting statistics. Calculated sigmas less than 30 BP on the Conventional Radiocarbon Age are conservatively rounded up to 30. d13C values are on the material itself (not the AMS d13C). d13C and d15N values are relative to VPDB-1. References for calendar calibrations are cited at the bottom of calibration graph pages.

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REPORT OF RADIOCARBON DATING ANALYSES

Lillian M. Ponce	Report Date: September 17, 2020
Versar, Inc.	Material Received: September 08, 2020

Laboratory Number	Sample Code Number	Conventional Radiocarbon Age (BP) or Percent Modern Carbon (pMC) & Stable Isotopes Calendar Calibrated Results: 95.4 % Probability High Probability Density Range Method (HPD)	
Beta - 567950	**LA 43414 - Feature 404.1**	**600 +/- 30 BP**	IRMS δ13C: -24.6 o/oo

(95.4%) **1296 - 1409 cal AD** **(654 - 541 cal BP)**

Submitter Material:	Charcoal
Pretreatment:	(charred material) acid/alkali/acid
Analyzed Material:	Charred material
Analysis Service:	AMS-Standard delivery
Percent Modern Carbon:	92.80 +/- 0.35 pMC
Fraction Modern Carbon:	0.9280 +/- 0.0035
D14C:	-71.97 +/- 3.47 o/oo
Δ14C:	-79.80 +/- 3.47 o/oo (1950:2020)
Measured Radiocarbon Age:	(without d13C correction): 590 +/- 30 BP
Calibration:	BetaCal3.21: HPD method: INTCAL13

Results are ISO/IEC-17025:2005 accredited. No sub-contracting or student labor was used in the analyses. All work was done at Beta in 4 in-house NEC accelerator mass spectrometers and 4 Thermo IRMSs. The "Conventional Radiocarbon Age" was calculated using the Libby half-life (5568 years), is corrected for total isotopic fraction and was used for calendar calibration where applicable. The Age is rounded to the nearest 10 years and is reported as radiocarbon years before present (BP), "present" = AD 1950. Results greater than the modern reference are reported as percent modern carbon (pMC). The modern reference standard was 95% the 14C signature of NIST SRM-4990C (oxalic acid). Quoted errors are 1 sigma counting statistics. Calculated sigmas less than 30 BP on the Conventional Radiocarbon Age are conservatively rounded up to 30. d13C values are on the material itself (not the AMS d13C). d13C and d15N values are relative to VPDB-1. References for calendar calibrations are cited at the bottom of calibration graph pages.

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REPORT OF RADIOCARBON DATING ANALYSES

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Laboratory Number	Sample Code Number	Conventional Radiocarbon Age (BP) or Percent Modern Carbon (pMC) & Stable Isotopes Calendar Calibrated Results: 95.4 % Probability High Probability Density Range Method (HPD)	
Beta - 567951	**LA 43414 - Feature 404**	**650 +/- 30 BP**	IRMS δ13C: -12.7 o/oo

(51.9%)	**1343 - 1394 cal AD**	**(607 - 556 cal BP)**
(43.5%)	**1280 - 1326 cal AD**	**(670 - 624 cal BP)**

Submitter Material: Grass stem/culm.
Pretreatment: (charred material) acid/alkali/acid
Analyzed Material: Charred material
Analysis Service: AMS-Standard delivery
Percent Modern Carbon: 92.23 +/- 0.34 pMC
Fraction Modern Carbon: 0.9223 +/- 0.0034
D14C: -77.73 +/- 3.44 o/oo
Δ14C: -85.51 +/- 3.44 o/oo (1950:2020)
Measured Radiocarbon Age: (without d13C correction): 450 +/- 30 BP
Calibration: BetaCal3.21: HPD method: INTCAL13

Results are ISO/IEC-17025:2005 accredited. No sub-contracting or student labor was used in the analyses. All work was done at Beta in 4 in-house NEC accelerator mass spectrometers and 4 Thermo IRMSs. The "Conventional Radiocarbon Age" was calculated using the Libby half-life (5568 years), is corrected for total isotopic fraction and was used for calendar calibration where applicable. The Age is rounded to the nearest 10 years and is reported as radiocarbon years before present (BP), "present" = AD 1950. Results greater than the modern reference are reported as percent modern carbon (pMC). The modern reference standard was 95% the 14C signature of NIST SRM-4990C (oxalic acid). Quoted errors are 1 sigma counting statistics. Calculated sigmas less than 30 BP on the Conventional Radiocarbon Age are conservatively rounded up to 30. d13C values are on the material itself (not the AMS d13C). d13C and d15N values are relative to VPDB-1. References for calendar calibrations are cited at the bottom of calibration graph pages.

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Laboratory Number	Sample Code Number	Conventional Radiocarbon Age (BP) or Percent Modern Carbon (pMC) & Stable Isotopes Calendar Calibrated Results: 95.4 % Probability High Probability Density Range Method (HPD)	
Beta - 567952	LA 43414 - Feature 409	610 +/- 30 BP	IRMS δ13C: -24.2 o/oo

(95.4%) 1295 - 1404 cal AD (655 - 546 cal BP)

Submitter Material: Seeds
Pretreatment: (charred material) acid/alkali/acid
Analyzed Material: Charred material
Analysis Service: AMS-Standard delivery
Percent Modern Carbon: 92.69 +/- 0.35 pMC
Fraction Modern Carbon: 0.9269 +/- 0.0035
D14C: -73.13 +/- 3.46 o/oo
Δ14C: -80.94 +/- 3.46 o/oo (1950:2020)
Measured Radiocarbon Age: (without d13C correction): 600 +/- 30 BP
Calibration: BetaCal3.21: HPD method: INTCAL13

Results are ISO/IEC-17025:2005 accredited. No sub-contracting or student labor was used in the analyses. All work was done at Beta in 4 in-house NEC accelerator mass spectrometers and 4 Thermo IRMSs. The "Conventional Radiocarbon Age" was calculated using the Libby half-life (5568 years), is corrected for total isotopic fraction and was used for calendar calibration where applicable. The Age is rounded to the nearest 10 years and is reported as radiocarbon years before present (BP), "present" = AD 1950. Results greater than the modern reference are reported as percent modern carbon (pMC). The modern reference standard was 95% the 14C signature of NIST SRM-4990C (oxalic acid). Quoted errors are 1 sigma counting statistics. Calculated sigmas less than 30 BP on the Conventional Radiocarbon Age are conservatively rounded up to 30. d13C values are on the material itself (not the AMS d13C). d13C and d15N values are relative to VPDB-1. References for calendar calibrations are cited at the bottom of calibration graph pages.

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ISO/IEC 17025:2005-Accredited Testing Laboratory

REPORT OF RADIOCARBON DATING ANALYSES

Lillian M. Ponce
Versar, Inc.

Report Date: September 17, 2020
Material Received: September 08, 2020

Laboratory Number	Sample Code Number	Conventional Radiocarbon Age (BP) or Percent Modern Carbon (pMC) & Stable Isotopes Calendar Calibrated Results: 95.4 % Probability High Probability Density Range Method (HPD)	
Beta - 567953	**LA 43414 - Feature 404.5 - Grass stem**	**650 +/- 30 BP**	IRMS δ13C: -10.1 o/oo

(51.9%)	**1343 - 1394 cal AD**	**(607 - 556 cal BP)**
(43.5%)	**1280 - 1326 cal AD**	**(670 - 624 cal BP)**

Submitter Material: Grass stem/culm.
Pretreatment: (charred material) acid/alkali/acid
Analyzed Material: Charred material
Analysis Service: AMS-Standard delivery
Percent Modern Carbon: 92.23 +/- 0.34 pMC
Fraction Modern Carbon: 0.9223 +/- 0.0034
D14C: -77.73 +/- 3.44 o/oo
Δ14C: -85.51 +/- 3.44 o/oo (1950:2020)
Measured Radiocarbon Age: (without d13C correction): 410 +/- 30 BP
Calibration: BetaCal3.21: HPD method: INTCAL13

Results are ISO/IEC-17025:2005 accredited. No sub-contracting or student labor was used in the analyses. All work was done at Beta in 4 in-house NEC accelerator mass spectrometers and 4 Thermo IRMSs. The "Conventional Radiocarbon Age" was calculated using the Libby half-life (5568 years), is corrected for total isotopic fraction and was used for calendar calibration where applicable. The Age is rounded to the nearest 10 years and is reported as radiocarbon years before present (BP), "present" = AD 1950. Results greater than the modern reference are reported as percent modern carbon (pMC). The modern reference standard was 95% the 14C signature of NIST SRM-4990C (oxalic acid). Quoted errors are 1 sigma counting statistics. Calculated sigmas less than 30 BP on the Conventional Radiocarbon Age are conservatively rounded up to 30. d13C values are on the material itself (not the AMS d13C). d13C and d15N values are relative to VPDB-1. References for calendar calibrations are cited at the bottom of calibration graph pages.

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Laboratory Number	Sample Code Number	Conventional Radiocarbon Age (BP) or Percent Modern Carbon (pMC) & Stable Isotopes Calendar Calibrated Results: 95.4 % Probability High Probability Density Range Method (HPD)	
Beta - 567954	LA 43414 - Feature 404.5 - Wood	660 +/- 30 BP	IRMS δ13C: -25.3 o/oo

(47.9%)	1347 - 1393 cal AD	(603 - 557 cal BP)
(47.5%)	1276 - 1322 cal AD	(674 - 628 cal BP)

Submitter Material: Charcoal
Pretreatment: (charred material) acid/alkali/acid
Analyzed Material: Charred material
Analysis Service: AMS-Standard delivery
Percent Modern Carbon: 92.11 +/- 0.34 pMC
Fraction Modern Carbon: 0.9211 +/- 0.0034
D14C: -78.88 +/- 3.44 o/oo
Δ14C: -86.64 +/- 3.44 o/oo (1950:2020)
Measured Radiocarbon Age: (without d13C correction): 660 +/- 30 BP
Calibration: BetaCal3.21: HPD method: INTCAL13

Results are ISO/IEC-17025:2005 accredited. No sub-contracting or student labor was used in the analyses. All work was done at Beta in 4 in-house NEC accelerator mass spectrometers and 4 Thermo IRMSs. The "Conventional Radiocarbon Age" was calculated using the Libby half-life (5568 years), is corrected for total isotopic fraction and was used for calendar calibration where applicable. The Age is rounded to the nearest 10 years and is reported as radiocarbon years before present (BP), "present" = AD 1950. Results greater than the modern reference are reported as percent modern carbon (pMC). The modern reference standard was 95% the 14C signature of NIST SRM-4990C (oxalic acid). Quoted errors are 1 sigma counting statistics. Calculated sigmas less than 30 BP on the Conventional Radiocarbon Age are conservatively rounded up to 30. d13C values are on the material itself (not the AMS d13C). d13C and d15N values are relative to VPDB-1. References for calendar calibrations are cited at the bottom of calibration graph pages.

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Laboratory Number	Sample Code Number	Conventional Radiocarbon Age (BP) or Percent Modern Carbon (pMC) & Stable Isotopes Calendar Calibrated Results: 95.4 % Probability High Probability Density Range Method (HPD)	
Beta - 567955	**LA 43414 - Feature 402.2**	**660 +/- 30 BP**	IRMS δ13C: -25.2 o/oo

(47.9%)	**1347 - 1393 cal AD**	**(603 - 557 cal BP)**
(47.5%)	**1276 - 1322 cal AD**	**(674 - 628 cal BP)**

Submitter Material: Charcoal
Pretreatment: (charred material) acid/alkali/acid
Analyzed Material: Charred material
Analysis Service: AMS-Standard delivery
Percent Modern Carbon: 92.11 +/- 0.34 pMC
Fraction Modern Carbon: 0.9211 +/- 0.0034
D14C: -78.88 +/- 3.44 o/oo
Δ14C: -86.64 +/- 3.44 o/oo (1950:2020)
Measured Radiocarbon Age: (without d13C correction): 660 +/- 30 BP
Calibration: BetaCal3.21: HPD method: INTCAL13

Results are ISO/IEC-17025:2005 accredited. No sub-contracting or student labor was used in the analyses. All work was done at Beta in 4 in-house NEC accelerator mass spectrometers and 4 Thermo IRMSs. The "Conventional Radiocarbon Age" was calculated using the Libby half-life (5568 years), is corrected for total isotopic fraction and was used for calendar calibration where applicable. The Age is rounded to the nearest 10 years and is reported as radiocarbon years before present (BP), "present" = AD 1950. Results greater than the modern reference are reported as percent modern carbon (pMC). The modern reference standard was 95% the 14C signature of NIST SRM-4990C (oxalic acid). Quoted errors are 1 sigma counting statistics. Calculated sigmas less than 30 BP on the Conventional Radiocarbon Age are conservatively rounded up to 30. d13C values are on the material itself (not the AMS d13C). d13C and d15N values are relative to VPDB-1. References for calendar calibrations are cited at the bottom of calibration graph pages.

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Laboratory Number	Sample Code Number	Conventional Radiocarbon Age (BP) or Percent Modern Carbon (pMC) & Stable Isotopes Calendar Calibrated Results: 95.4 % Probability High Probability Density Range Method (HPD)	
Beta - 567956	**LA 43414 - Feature 402.4 - Wood**	**890 +/- 30 BP**	IRMS δ13C: -24.4 o/oo

(59.6%)	**1116 - 1218 cal AD**	**(834 - 732 cal BP)**
(35.8%)	**1040 - 1108 cal AD**	**(910 - 842 cal BP)**

Submitter Material: Charcoal
Pretreatment: (charred material) acid/alkali/acid
Analyzed Material: Charred material
Analysis Service: AMS-Standard delivery
Percent Modern Carbon: 89.51 +/- 0.33 pMC
Fraction Modern Carbon: 0.8951 +/- 0.0033
D14C: -104.88 +/- 3.34 o/oo
Δ14C: -112.42 +/- 3.34 o/oo (1950:2020)
Measured Radiocarbon Age: (without d13C correction): 880 +/- 30 BP
Calibration: BetaCal3.21: HPD method: INTCAL13

Results are ISO/IEC-17025:2005 accredited. No sub-contracting or student labor was used in the analyses. All work was done at Beta in 4 in-house NEC accelerator mass spectrometers and 4 Thermo IRMSs. The "Conventional Radiocarbon Age" was calculated using the Libby half-life (5568 years), is corrected for total isotopic fraction and was used for calendar calibration where applicable. The Age is rounded to the nearest 10 years and is reported as radiocarbon years before present (BP), "present" = AD 1950. Results greater than the modern reference are reported as percent modern carbon (pMC). The modern reference standard was 95% the 14C signature of NIST SRM-4990C (oxalic acid). Quoted errors are 1 sigma counting statistics. Calculated sigmas less than 30 BP on the Conventional Radiocarbon Age are conservatively rounded up to 30. d13C values are on the material itself (not the AMS d13C). d13C and d15N values are relative to VPDB-1. References for calendar calibrations are cited at the bottom of calibration graph pages.

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Laboratory Number	Sample Code Number	Conventional Radiocarbon Age (BP) or Percent Modern Carbon (pMC) & Stable Isotopes Calendar Calibrated Results: 95.4 % Probability High Probability Density Range Method (HPD)	
Beta - 567957	**LA 43414 - Feature 402.4 - Seed**	**630 +/- 30 BP**	IRMS δ13C: -24.1 o/oo

(95.4%) **1286 - 1398 cal AD** **(664 - 552 cal BP)**

Submitter Material: Seeds
Pretreatment: (charred material) acid/alkali/acid
Analyzed Material: Charred material
Analysis Service: AMS-Standard delivery
Percent Modern Carbon: 92.46 +/- 0.35 pMC
Fraction Modern Carbon: 0.9246 +/- 0.0035
D14C: -75.43 +/- 3.45 o/oo
Δ14C: -83.23 +/- 3.45 o/oo (1950:2020)
Measured Radiocarbon Age: (without d13C correction): 620 +/- 30 BP
Calibration: BetaCal3.21: HPD method: INTCAL13

Results are ISO/IEC-17025:2005 accredited. No sub-contracting or student labor was used in the analyses. All work was done at Beta in 4 in-house NEC accelerator mass spectrometers and 4 Thermo IRMSs. The "Conventional Radiocarbon Age" was calculated using the Libby half-life (5568 years), is corrected for total isotopic fraction and was used for calendar calibration where applicable. The Age is rounded to the nearest 10 years and is reported as radiocarbon years before present (BP), "present" = AD 1950. Results greater than the modern reference are reported as percent modern carbon (pMC). The modern reference standard was 95% the 14C signature of NIST SRM-4990C (oxalic acid). Quoted errors are 1 sigma counting statistics. Calculated sigmas less than 30 BP on the Conventional Radiocarbon Age are conservatively rounded up to 30. d13C values are on the material itself (not the AMS d13C). d13C and d15N values are relative to VPDB-1. References for calendar calibrations are cited at the bottom of calibration graph pages.

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Laboratory Number	Sample Code Number	Conventional Radiocarbon Age (BP) or Percent Modern Carbon (pMC) & Stable Isotopes Calendar Calibrated Results: 95.4 % Probability High Probability Density Range Method (HPD)	
Beta - 567958	**LA 43414 - Feature 407.1**	**570 +/- 30 BP**	IRMS δ13C: -25.8 o/oo

(57.7%)	**1304 - 1364 cal AD**	**(646 - 586 cal BP)**
(37.7%)	**1384 - 1422 cal AD**	**(566 - 528 cal BP)**

Submitter Material: Charcoal
Pretreatment: (charred material) acid/alkali/acid
Analyzed Material: Charred material
Analysis Service: AMS-Standard delivery
Percent Modern Carbon: 93.15 +/- 0.35 pMC
Fraction Modern Carbon: 0.9315 +/- 0.0035
D14C: -68.50 +/- 3.48 o/oo
Δ14C: -76.35 +/- 3.48 o/oo (1950:2020)
Measured Radiocarbon Age: (without d13C correction): 580 +/- 30 BP
Calibration: BetaCal3.21: HPD method: INTCAL13

Results are ISO/IEC-17025:2005 accredited. No sub-contracting or student labor was used in the analyses. All work was done at Beta in 4 in-house NEC accelerator mass spectrometers and 4 Thermo IRMSs. The "Conventional Radiocarbon Age" was calculated using the Libby half-life (5568 years), is corrected for total isotopic fraction and was used for calendar calibration where applicable. The Age is rounded to the nearest 10 years and is reported as radiocarbon years before present (BP), "present" = AD 1950. Results greater than the modern reference are reported as percent modern carbon (pMC). The modern reference standard was 95% the 14C signature of NIST SRM-4990C (oxalic acid). Quoted errors are 1 sigma counting statistics. Calculated sigmas less than 30 BP on the Conventional Radiocarbon Age are conservatively rounded up to 30. d13C values are on the material itself (not the AMS d13C). d13C and d15N values are relative to VPDB-1. References for calendar calibrations are cited at the bottom of calibration graph pages.

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Laboratory Number	Sample Code Number	Conventional Radiocarbon Age (BP) or Percent Modern Carbon (pMC) & Stable Isotopes Calendar Calibrated Results: 95.4 % Probability High Probability Density Range Method (HPD)	
Beta - 567959	**LA 43414 - Feature 407.3**	**670 +/- 30 BP**	IRMS δ13C: -25.8 o/oo

(53.1%)	**1274 - 1320 cal AD**	**(676 - 630 cal BP)**
(42.3%)	**1350 - 1391 cal AD**	**(600 - 559 cal BP)**

Submitter Material: Seeds
Pretreatment: (charred material) acid/alkali/acid
Analyzed Material: Charred material
Analysis Service: AMS-Standard delivery
Percent Modern Carbon: 92.00 +/- 0.34 pMC
Fraction Modern Carbon: 0.9200 +/- 0.0034
D14C: -80.02 +/- 3.44 o/oo
Δ14C: -87.78 +/- 3.44 o/oo (1950:2020)
Measured Radiocarbon Age: (without d13C correction): 680 +/- 30 BP
Calibration: BetaCal3.21: HPD method: INTCAL13

Results are ISO/IEC-17025:2005 accredited. No sub-contracting or student labor was used in the analyses. All work was done at Beta in 4 in-house NEC accelerator mass spectrometers and 4 Thermo IRMSs. The "Conventional Radiocarbon Age" was calculated using the Libby half-life (5568 years), is corrected for total isotopic fraction and was used for calendar calibration where applicable. The Age is rounded to the nearest 10 years and is reported as radiocarbon years before present (BP), "present" = AD 1950. Results greater than the modern reference are reported as percent modern carbon (pMC). The modern reference standard was 95% the 14C signature of NIST SRM-4990C (oxalic acid). Quoted errors are 1 sigma counting statistics. Calculated sigmas less than 30 BP on the Conventional Radiocarbon Age are conservatively rounded up to 30. d13C values are on the material itself (not the AMS d13C). d13C and d15N values are relative to VPDB-1. References for calendar calibrations are cited at the bottom of calibration graph pages.

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REPORT OF RADIOCARBON DATING ANALYSES

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Laboratory Number	Sample Code Number	Conventional Radiocarbon Age (BP) or Percent Modern Carbon (pMC) & Stable Isotopes Calendar Calibrated Results: 95.4 % Probability High Probability Density Range Method (HPD)	
Beta - 567960	**LA 43414 - Feature 406.1 - Wood**	**560 +/- 30 BP**	IRMS δ13C: -27.0 o/oo

(49.9%)	**1307 - 1362 cal AD**	**(643 - 588 cal BP)**
(45.5%)	**1385 - 1429 cal AD**	**(565 - 521 cal BP)**

Submitter Material: Charcoal
Pretreatment: (charred material) acid/alkali/acid
Analyzed Material: Charred material
Analysis Service: AMS-Standard delivery
Percent Modern Carbon: 93.27 +/- 0.35 pMC
Fraction Modern Carbon: 0.9327 +/- 0.0035
D14C: -67.34 +/- 3.48 o/oo
Δ14C: -75.20 +/- 3.48 o/oo (1950:2020)
Measured Radiocarbon Age: (without d13C correction): 590 +/- 30 BP
Calibration: BetaCal3.21: HPD method: INTCAL13

Results are ISO/IEC-17025:2005 accredited. No sub-contracting or student labor was used in the analyses. All work was done at Beta in 4 in-house NEC accelerator mass spectrometers and 4 Thermo IRMSs. The "Conventional Radiocarbon Age" was calculated using the Libby half-life (5568 years), is corrected for total isotopic fraction and was used for calendar calibration where applicable. The Age is rounded to the nearest 10 years and is reported as radiocarbon years before present (BP), "present" = AD 1950. Results greater than the modern reference are reported as percent modern carbon (pMC). The modern reference standard was 95% the 14C signature of NIST SRM-4990C (oxalic acid). Quoted errors are 1 sigma counting statistics. Calculated sigmas less than 30 BP on the Conventional Radiocarbon Age are conservatively rounded up to 30. d13C values are on the material itself (not the AMS d13C). d13C and d15N values are relative to VPDB-1. References for calendar calibrations are cited at the bottom of calibration graph pages.

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Laboratory Number	Sample Code Number	Conventional Radiocarbon Age (BP) or Percent Modern Carbon (pMC) & Stable Isotopes Calendar Calibrated Results: 95.4 % Probability High Probability Density Range Method (HPD)	
Beta - 567961	**LA 43414 - Feature 406.1 - Seed**	**640 +/- 30 BP**	IRMS δ13C: -25.1 o/oo

(54.5%)	**1340 - 1396 cal AD**	**(610 - 554 cal BP)**
(40.9%)	**1282 - 1329 cal AD**	**(668 - 621 cal BP)**

Submitter Material: Seeds
Pretreatment: (charred material) acid/alkali/acid
Analyzed Material: Charred material
Analysis Service: AMS-Standard delivery
Percent Modern Carbon: 92.34 +/- 0.34 pMC
Fraction Modern Carbon: 0.9234 +/- 0.0034
D14C: -76.58 +/- 3.45 o/oo
Δ14C: -84.37 +/- 3.45 o/oo (1950:2020)
Measured Radiocarbon Age: (without d13C correction): 640 +/- 30 BP
Calibration: BetaCal3.21: HPD method: INTCAL13

Results are ISO/IEC-17025:2005 accredited. No sub-contracting or student labor was used in the analyses. All work was done at Beta in 4 in-house NEC accelerator mass spectrometers and 4 Thermo IRMSs. The "Conventional Radiocarbon Age" was calculated using the Libby half-life (5568 years), is corrected for total isotopic fraction and was used for calendar calibration where applicable. The Age is rounded to the nearest 10 years and is reported as radiocarbon years before present (BP), "present" = AD 1950. Results greater than the modern reference are reported as percent modern carbon (pMC). The modern reference standard was 95% the 14C signature of NIST SRM-4990C (oxalic acid). Quoted errors are 1 sigma counting statistics. Calculated sigmas less than 30 BP on the Conventional Radiocarbon Age are conservatively rounded up to 30. d13C values are on the material itself (not the AMS d13C). d13C and d15N values are relative to VPDB-1. References for calendar calibrations are cited at the bottom of calibration graph pages.

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Laboratory Number	Sample Code Number	Conventional Radiocarbon Age (BP) or Percent Modern Carbon (pMC) & Stable Isotopes Calendar Calibrated Results: 95.4 % Probability High Probability Density Range Method (HPD)	
Beta - 567962	**LA 43414 - Feature 407.2**	**670 +/- 30 BP**	IRMS δ13C: -24.6 o/oo

(53.1%)	**1274 - 1320 cal AD**	**(676 - 630 cal BP)**
(42.3%)	**1350 - 1391 cal AD**	**(600 - 559 cal BP)**

Submitter Material: Charcoal
Pretreatment: (charred material) acid/alkali/acid
Analyzed Material: Charred material
Analysis Service: AMS-Standard delivery
Percent Modern Carbon: 92.00 +/- 0.34 pMC
Fraction Modern Carbon: 0.9200 +/- 0.0034
D14C: -80.02 +/- 3.44 o/oo
Δ14C: -87.78 +/- 3.44 o/oo (1950:2020)
Measured Radiocarbon Age: (without d13C correction): 660 +/- 30 BP
Calibration: BetaCal3.21: HPD method: INTCAL13

Results are ISO/IEC-17025:2005 accredited. No sub-contracting or student labor was used in the analyses. All work was done at Beta in 4 in-house NEC accelerator mass spectrometers and 4 Thermo IRMSs. The "Conventional Radiocarbon Age" was calculated using the Libby half-life (5568 years), is corrected for total isotopic fraction and was used for calendar calibration where applicable. The Age is rounded to the nearest 10 years and is reported as radiocarbon years before present (BP), "present" = AD 1950. Results greater than the modern reference are reported as percent modern carbon (pMC). The modern reference standard was 95% the 14C signature of NIST SRM-4990C (oxalic acid). Quoted errors are 1 sigma counting statistics. Calculated sigmas less than 30 BP on the Conventional Radiocarbon Age are conservatively rounded up to 30. d13C values are on the material itself (not the AMS d13C). d13C and d15N values are relative to VPDB-1. References for calendar calibrations are cited at the bottom of calibration graph pages.

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Laboratory Number	Sample Code Number	Conventional Radiocarbon Age (BP) or Percent Modern Carbon (pMC) & Stable Isotopes Calendar Calibrated Results: 95.4 % Probability High Probability Density Range Method (HPD)	
Beta - 567963	**LA 43414 - Feature 410.1**	**560 +/- 30 BP**	IRMS δ13C: -24.2 o/oo

(49.9%)	**1307 - 1362 cal AD**	**(643 - 588 cal BP)**
(45.5%)	**1385 - 1429 cal AD**	**(565 - 521 cal BP)**

Submitter Material: Charcoal
Pretreatment: (charred material) acid/alkali/acid
Analyzed Material: Charred material
Analysis Service: AMS-Standard delivery
Percent Modern Carbon: 93.27 +/- 0.35 pMC
Fraction Modern Carbon: 0.9327 +/- 0.0035
D14C: -67.34 +/- 3.48 o/oo
Δ14C: -75.20 +/- 3.48 o/oo (1950:2020)
Measured Radiocarbon Age: (without d13C correction): 550 +/- 30 BP
Calibration: BetaCal3.21: HPD method: INTCAL13

Results are ISO/IEC-17025:2005 accredited. No sub-contracting or student labor was used in the analyses. All work was done at Beta in 4 in-house NEC accelerator mass spectrometers and 4 Thermo IRMSs. The "Conventional Radiocarbon Age" was calculated using the Libby half-life (5568 years), is corrected for total isotopic fraction and was used for calendar calibration where applicable. The Age is rounded to the nearest 10 years and is reported as radiocarbon years before present (BP), "present" = AD 1950. Results greater than the modern reference are reported as percent modern carbon (pMC). The modern reference standard was 95% the 14C signature of NIST SRM-4990C (oxalic acid). Quoted errors are 1 sigma counting statistics. Calculated sigmas less than 30 BP on the Conventional Radiocarbon Age are conservatively rounded up to 30. d13C values are on the material itself (not the AMS d13C). d13C and d15N values are relative to VPDB-1. References for calendar calibrations are cited at the bottom of calibration graph pages.

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Laboratory Number	Sample Code Number	Conventional Radiocarbon Age (BP) or Percent Modern Carbon (pMC) & Stable Isotopes Calendar Calibrated Results: 95.4 % Probability High Probability Density Range Method (HPD)	
Beta - 567964	**LA 43414 - Feature 400.1**	**600 +/- 30 BP**	IRMS δ13C: -25.5 o/oo

(95.4%) 1296 - 1409 cal AD (654 - 541 cal BP)

Submitter Material: Charcoal
Pretreatment: (charred material) acid/alkali/acid
Analyzed Material: Charred material
Analysis Service: AMS-Standard delivery
Percent Modern Carbon: 92.80 +/- 0.35 pMC
Fraction Modern Carbon: 0.9280 +/- 0.0035
D14C: -71.97 +/- 3.47 o/oo
Δ14C: -79.80 +/- 3.47 o/oo (1950:2020)
Measured Radiocarbon Age: (without d13C correction): 610 +/- 30 BP
Calibration: BetaCal3.21: HPD method: INTCAL13

Results are ISO/IEC-17025:2005 accredited. No sub-contracting or student labor was used in the analyses. All work was done at Beta in 4 in-house NEC accelerator mass spectrometers and 4 Thermo IRMSs. The "Conventional Radiocarbon Age" was calculated using the Libby half-life (5568 years), is corrected for total isotopic fraction and was used for calendar calibration where applicable. The Age is rounded to the nearest 10 years and is reported as radiocarbon years before present (BP), "present" = AD 1950. Results greater than the modern reference are reported as percent modern carbon (pMC). The modern reference standard was 95% the 14C signature of NIST SRM-4990C (oxalic acid). Quoted errors are 1 sigma counting statistics. Calculated sigmas less than 30 BP on the Conventional Radiocarbon Age are conservatively rounded up to 30. d13C values are on the material itself (not the AMS d13C). d13C and d15N values are relative to VPDB-1. References for calendar calibrations are cited at the bottom of calibration graph pages.

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ISO/IEC 17025:2005-Accredited Testing Laboratory

REPORT OF RADIOCARBON DATING ANALYSES

Lillian M. Ponce
Versar, Inc.

Report Date: September 17, 2020
Material Received: September 08, 2020

Laboratory Number	Sample Code Number	Conventional Radiocarbon Age (BP) or Percent Modern Carbon (pMC) & Stable Isotopes Calendar Calibrated Results: 95.4 % Probability High Probability Density Range Method (HPD)	
Beta - 567965	**LA 43414 - Feature 7.2**	**660 +/- 30 BP**	IRMS δ13C: -24.8 o/oo

(47.9%)	**1347 - 1393 cal AD**	**(603 - 557 cal BP)**
(47.5%)	**1276 - 1322 cal AD**	**(674 - 628 cal BP)**

Submitter Material: Charcoal
Pretreatment: (charred material) acid/alkali/acid
Analyzed Material: Charred material
Analysis Service: AMS-Standard delivery
Percent Modern Carbon: 92.11 +/- 0.34 pMC
Fraction Modern Carbon: 0.9211 +/- 0.0034
D14C: -78.88 +/- 3.44 o/oo
Δ14C: -86.64 +/- 3.44 o/oo (1950:2020)
Measured Radiocarbon Age: (without d13C correction): 660 +/- 30 BP
Calibration: BetaCal3.21: HPD method: INTCAL13

Results are ISO/IEC-17025:2005 accredited. No sub-contracting or student labor was used in the analyses. All work was done at Beta in 4 in-house NEC accelerator mass spectrometers and 4 Thermo IRMSs. The "Conventional Radiocarbon Age" was calculated using the Libby half-life (5568 years), is corrected for total isotopic fraction and was used for calendar calibration where applicable. The Age is rounded to the nearest 10 years and is reported as radiocarbon years before present (BP), "present" = AD 1950. Results greater than the modern reference are reported as percent modern carbon (pMC). The modern reference standard was 95% the 14C signature of NIST SRM-4990C (oxalic acid). Quoted errors are 1 sigma counting statistics. Calculated sigmas less than 30 BP on the Conventional Radiocarbon Age are conservatively rounded up to 30. d13C values are on the material itself (not the AMS d13C). d13C and d15N values are relative to VPDB-1. References for calendar calibrations are cited at the bottom of calibration graph pages.

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REPORT OF RADIOCARBON DATING ANALYSES

Lillian M. Ponce — Report Date: September 17, 2020

Versar, Inc. — Material Received: September 08, 2020

Laboratory Number	Sample Code Number	Conventional Radiocarbon Age (BP) or Percent Modern Carbon (pMC) & Stable Isotopes Calendar Calibrated Results: 95.4 % Probability High Probability Density Range Method (HPD)	
Beta - 567968	**LA 43414 - Feature 412**	**620 +/- 30 BP**	IRMS δ13C: -24.6 o/oo

(95.4%) **1292 - 1400 cal AD** **(658 - 550 cal BP)**

Submitter Material: Charcoal
Pretreatment: (charred material) acid/alkali/acid
Analyzed Material: Charred material
Analysis Service: AMS-Standard delivery
Percent Modern Carbon: 92.57 +/- 0.35 pMC
Fraction Modern Carbon: 0.9257 +/- 0.0035
D14C: -74.28 +/- 3.46 o/oo
Δ14C: -82.08 +/- 3.46 o/oo (1950:2020)
Measured Radiocarbon Age: (without d13C correction): 610 +/- 30 BP
Calibration: BetaCal3.21: HPD method: INTCAL13

Results are ISO/IEC-17025:2005 accredited. No sub-contracting or student labor was used in the analyses. All work was done at Beta in 4 in-house NEC accelerator mass spectrometers and 4 Thermo IRMSs. The "Conventional Radiocarbon Age" was calculated using the Libby half-life (5568 years), is corrected for total isotopic fraction and was used for calendar calibration where applicable. The Age is rounded to the nearest 10 years and is reported as radiocarbon years before present (BP), "present" = AD 1950. Results greater than the modern reference are reported as percent modern carbon (pMC). The modern reference standard was 95% the 14C signature of NIST SRM-4990C (oxalic acid). Quoted errors are 1 sigma counting statistics. Calculated sigmas less than 30 BP on the Conventional Radiocarbon Age are conservatively rounded up to 30. d13C values are on the material itself (not the AMS d13C). d13C and d15N values are relative to VPDB-1. References for calendar calibrations are cited at the bottom of calibration graph pages.

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REPORT OF RADIOCARBON DATING ANALYSES

Lillian M. Ponce
Versar, Inc.

Report Date: March 24, 2020
Material Received: March 18, 2020

Laboratory Number	Sample Code Number	Conventional Radiocarbon Age (BP) or Percent Modern Carbon (pMC) & Stable Isotopes Calendar Calibrated Results: 95.4 % Probability High Probability Density Range Method (HPD)	
Beta - 555817	**LA 43414 - Feature 82**	**106.69 +/- 0.40 pMC**	IRMS δ13C: -13.5 o/oo

(83.9%)	**2003 - 2008 cal AD**	**(-54 - -59 cal BP)**
(8.2%)	**1956 - 1957 cal AD**	**(-7 - -8 cal BP)**
(1.7%)	**2002 cal AD**	**(-53 cal BP)**
(1.6%)	**2009 cal AD**	**(-60 cal BP)**

Submitter Material: Seeds
Pretreatment: (plant material) acid/alkali/acid
Analyzed Material: Plant material
Analysis Service: AMS-Standard delivery
Conventional Radiocarbon Age: -520 +/- 30 BP
Fraction Modern Carbon: 1.0669 +/- 0.0040
D14C: 66.87 +/- 3.98 o/oo
Δ14C: 57.88 +/- 3.98 o/oo (1950:2020)
Raw pMC: (without d13C correction): 109.21 +/- 0.40 pMC
Calibration: BetaCal3.21: HPD method: INTCAL13 + NHZ2

Results are ISO/IEC-17025:2005 accredited. No sub-contracting or student labor was used in the analyses. All work was done at Beta in 4 in-house NEC accelerator mass spectrometers and 4 Thermo IRMSs. The "Conventional Radiocarbon Age" was calculated using the Libby half-life (5568 years), is corrected for total isotopic fraction and was used for calendar calibration where applicable. The Age is rounded to the nearest 10 years and is reported as radiocarbon years before present (BP), "present" = AD 1950. Results greater than the modern reference are reported as percent modern carbon (pMC). The modern reference standard was 95% the 14C signature of NIST SRM-4990C (oxalic acid). Quoted errors are 1 sigma counting statistics. Calculated sigmas less than 30 BP on the Conventional Radiocarbon Age are conservatively rounded up to 30. d13C values are on the material itself (not the AMS d13C). d13C and d15N values are relative to VPDB-1. References for calendar calibrations are cited at the bottom of calibration graph pages.

BetaCal 3.21

Calibration of Radiocarbon Age to Calendar Years

(High Probability Density Range Method (HPD): INTCAL13 + NHZ2)

(Variables: d13C = -13.5 o/oo)

Laboratory number **Beta-555817**

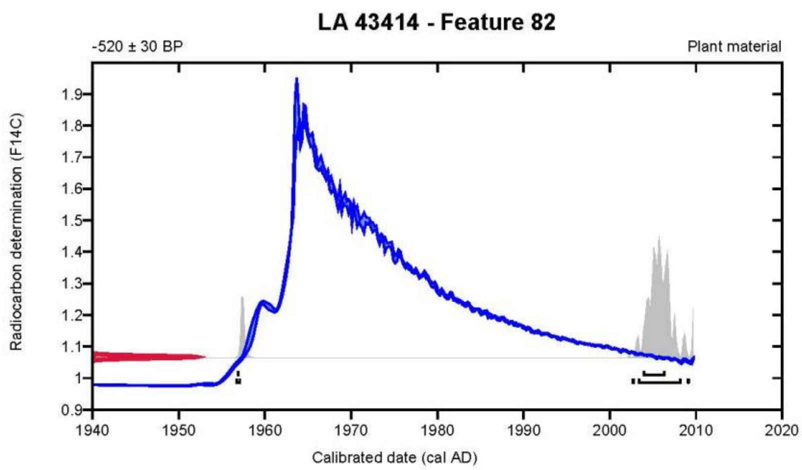
Percent modern carbon **106.69 +/- 0.40 pMC**

95.4% probability

(83.9%)	2003 - 2008 cal AD	(-54 - -59 cal BP)
(8.2%)	1956 - 1957 cal AD	(-7 - -8 cal BP)
(1.7%)	2002 cal AD	(-53 cal BP)
(1.6%)	2009 cal AD	(-60 cal BP)

68.2% probability

(64.1%)	2003 - 2006 cal AD	(-54 - -57 cal BP)
(4%)	1956 cal AD	(-7 cal BP)



Database used

INTCAL13 + NHZ2

References

References to Probability Method

Bronk Ramsey, C. (2009). Bayesian analysis of radiocarbon dates. Radiocarbon, 51(1), 337-360.

References to Database INTCAL13 + NHZ2

Hua, et.al.,2013, Radiocarbon, 55(4). Reimer, et.al., 2013, Radiocarbon55(4).

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REPORT OF RADIOCARBON DATING ANALYSES

Lillian M. Ponce
Versar, Inc.

Report Date: April 03, 2020
Material Received: March 18, 2020

Laboratory Number	Sample Code Number	Conventional Radiocarbon Age (BP) or Percent Modern Carbon (pMC) & Stable Isotopes Calendar Calibrated Results: 95.4 % Probability High Probability Density Range Method (HPD)	
Beta - 555833	**LA 43414 - Feature 482**	**2860 +/- 30 BP**	IRMS δ13C: -24.7 o/oo

(95.4%) **1118 - 929 cal BC** **(3067 - 2878 cal BP)**

Submitter Material: Charcoal
Pretreatment: (charred material) acid/alkali/acid
Analyzed Material: Charred material
Analysis Service: AMS-Standard delivery
Percent Modern Carbon: 70.04 +/- 0.26 pMC
Fraction Modern Carbon: 0.7004 +/- 0.0026
D14C: -299.55 +/- 2.62 o/oo
Δ14C: -305.46 +/- 2.62 o/oo (1950:2020)
Measured Radiocarbon Age: (without d13C correction): 2860 +/- 30 BP
Calibration: BetaCal3.21: HPD method: INTCAL13

Results are ISO/IEC-17025:2005 accredited. No sub-contracting or student labor was used in the analyses. All work was done at Beta in 4 in-house NEC accelerator mass spectrometers and 4 Thermo IRMSs. The "Conventional Radiocarbon Age" was calculated using the Libby half-life (5568 years), is corrected for total isotopic fraction and was used for calendar calibration where applicable. The Age is rounded to the nearest 10 years and is reported as radiocarbon years before present (BP), "present" = AD 1950. Results greater than the modern reference are reported as percent modern carbon (pMC). The modern reference standard was 95% the 14C signature of NIST SRM-4990C (oxalic acid). Quoted errors are 1 sigma counting statistics. Calculated sigmas less than 30 BP on the Conventional Radiocarbon Age are conservatively rounded up to 30. d13C values are on the material itself (not the AMS d13C). d13C and d15N values are relative to VPDB-1. References for calendar calibrations are cited at the bottom of calibration graph pages.

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REPORT OF RADIOCARBON DATING ANALYSES

Lillian M. Ponce	Report Date: October 12, 2020
Versar, Inc.	Material Received: October 02, 2020

Laboratory Number	Sample Code Number	Conventional Radiocarbon Age (BP) or Percent Modern Carbon (pMC) & Stable Isotopes	
Beta - 570074	**LA 43414 - Feature 110 - Level 2**	**700 +/- 30 BP**	IRMS δ13C: -25.3 o/oo

(77.3%)	**1260 - 1310 cal AD**	**(690 - 640 cal BP)**
(18.1%)	**1360 - 1387 cal AD**	**(590 - 563 cal BP)**

Submitter Material: Charcoal
Pretreatment: (charred material) acid/alkali/acid
Analyzed Material: Charred material
Analysis Service: AMS-Standard delivery
Percent Modern Carbon: 91.65 +/- 0.34 pMC
Fraction Modern Carbon: 0.9165 +/- 0.0034
D14C: -83.45 +/- 3.42 o/oo
Δ14C: -91.18 +/- 3.42 o/oo (1950:2020)
Measured Radiocarbon Age: (without d13C correction): 710 +/- 30 BP
Calibration: BetaCal3.21: HPD method: INTCAL13

Results are ISO/IEC-17025:2017 accredited. No sub-contracting or student labor was used in the analyses. All work was done at Beta in 4 in-house NEC accelerator mass spectrometers and 4 Thermo IRMSs. The "Conventional Radiocarbon Age" was calculated using the Libby half-life (5568 years), is corrected for total isotopic fraction and was used for calendar calibration where applicable. The Age is rounded to the nearest 10 years and is reported as radiocarbon years before present (BP), "present" = AD 1950. Results greater than the modern reference are reported as percent modern carbon (pMC). The modern reference standard was 95% the 14C signature of NIST SRM-4990C (oxalic acid). Quoted errors are 1 sigma counting statistics. Calculated sigmas less than 30 BP on the Conventional Radiocarbon Age are conservatively rounded up to 30. d13C values are on the material itself (not the AMS d13C). d13C and d15N values are relative to VPDB-1. References for calendar calibrations are cited at the bottom of calibration graph pages.

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REPORT OF RADIOCARBON DATING ANALYSES

Lillian M. Ponce — Report Date: October 12, 2020

Versar, Inc. — Material Received: October 02, 2020

Laboratory Number	Sample Code Number	Conventional Radiocarbon Age (BP) or Percent Modern Carbon (pMC) & Stable Isotopes	
Beta - 570075	**LA 43414 - Feature 110 - Level 4**	**620 +/- 30 BP**	IRMS δ13C: -23.8 o/oo

(95.4%) 1292 - 1400 cal AD (658 - 550 cal BP)

Submitter Material:	Charcoal
Pretreatment:	(charred material) acid/alkali/acid
Analyzed Material:	Charred material
Analysis Service:	AMS-Standard delivery
Percent Modern Carbon:	92.57 +/- 0.35 pMC
Fraction Modern Carbon:	0.9257 +/- 0.0035
D14C:	-74.28 +/- 3.46 o/oo
Δ14C:	-82.08 +/- 3.46 o/oo (1950:2020)
Measured Radiocarbon Age:	(without d13C correction): 600 +/- 30 BP
Calibration:	BetaCal3.21: HPD method: INTCAL13

Results are ISO/IEC-17025:2017 accredited. No sub-contracting or student labor was used in the analyses. All work was done at Beta in 4 in-house NEC accelerator mass spectrometers and 4 Thermo IRMSs. The "Conventional Radiocarbon Age" was calculated using the Libby half-life (5568 years), is corrected for total isotopic fraction and was used for calendar calibration where applicable. The Age is rounded to the nearest 10 years and is reported as radiocarbon years before present (BP), "present" = AD 1950. Results greater than the modern reference are reported as percent modern carbon (pMC). The modern reference standard was 95% the 14C signature of NIST SRM-4990C (oxalic acid). Quoted errors are 1 sigma counting statistics. Calculated sigmas less than 30 BP on the Conventional Radiocarbon Age are conservatively rounded up to 30. d13C values are on the material itself (not the AMS d13C). d13C and d15N values are relative to VPDB-1. References for calendar calibrations are cited at the bottom of calibration graph pages.

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REPORT OF RADIOCARBON DATING ANALYSES

Lillian M. Ponce	Report Date: October 12, 2020
Versar, Inc.	Material Received: October 02, 2020

Laboratory Number	Sample Code Number	Conventional Radiocarbon Age (BP) or Percent Modern Carbon (pMC) & Stable Isotopes	
Beta - 570076	**LA 43414 - Feature 110 - Level 6**	**610 +/- 30 BP**	IRMS δ13C: -25.2 o/oo

(95.4%) 1295 - 1404 cal AD (655 - 546 cal BP)

Submitter Material: Charcoal
Pretreatment: (charred material) acid/alkali/acid
Analyzed Material: Charred material
Analysis Service: AMS-Standard delivery
Percent Modern Carbon: 92.69 +/- 0.35 pMC
Fraction Modern Carbon: 0.9269 +/- 0.0035
D14C: -73.13 +/- 3.46 o/oo
Δ14C: -80.94 +/- 3.46 o/oo (1950:2020)
Measured Radiocarbon Age: (without d13C correction): 610 +/- 30 BP
Calibration: BetaCal3.21: HPD method: INTCAL13

Results are ISO/IEC-17025:2017 accredited. No sub-contracting or student labor was used in the analyses. All work was done at Beta in 4 in-house NEC accelerator mass spectrometers and 4 Thermo IRMSs. The "Conventional Radiocarbon Age" was calculated using the Libby half-life (5568 years), is corrected for total isotopic fraction and was used for calendar calibration where applicable. The Age is rounded to the nearest 10 years and is reported as radiocarbon years before present (BP), "present" = AD 1950. Results greater than the modern reference are reported as percent modern carbon (pMC). The modern reference standard was 95% the 14C signature of NIST SRM-4990C (oxalic acid). Quoted errors are 1 sigma counting statistics. Calculated sigmas less than 30 BP on the Conventional Radiocarbon Age are conservatively rounded up to 30. d13C values are on the material itself (not the AMS d13C). d13C and d15N values are relative to VPDB-1. References for calendar calibrations are cited at the bottom of calibration graph pages.

Appendix A.3 Ceramic Luminescence Dates

Luminescence Dating Laboratory, University of Washington

LUMINESCENCE DATING OF CERAMICS FROM SOUTHERN NEW MEXICO

James Feathers

Luminescence Dating Laboratory

University of Washington

Seattle, WA 98195-3412

Fifteen ceramic sherds from the Merchant site (43414) in southeastern New Mexico were submitted for luminescence analysis by Myles Miller, Versar, Inc., El Paso. The samples are all representative of Ochoa indented corrugated ware. The Merchant site is a pueblo settlement on the southern Plains of New Mexico, combining artifact elements from both the Southwest and Plains cultures. There are some radiocarbon dates but because the calibration curve is flat for this time range, there are two probability peaks, A.D. 1320–1350 and A.D. 1380–1425, and one reason for the luminescence dating is to see which time range is more probable. The samples are listed in Table A.3.1. Laboratory procedures are given in the appendix.

Table A.3.1. Samples

UW Lab #	CN Number	Feature	Depth of Burial (cm)
UW4042	203	407	42
UW4043	211	407	48
UW4044	221	406	37-57
UW4045	244	406	50
UW4046	262	6	69
UW4047	270	6	55-58
UW4048	310	404.5	3-7
UW4049	311	404.6	5-95
UW4050	382	400	15-28
UW4051	337	407	50-53
UW4052	347	406.1	27-47
UW4053	350	406.6	50-53
UW4054	356	406.6	35-50
UW4055	362	410	50-61
UW4056	394	409	40-60

Dose Rate

The dose rate was measured on each ceramic and on associated sediments, as outlined in the appendix. Dose rates on the sherds were mainly determined using alpha counting and flame photometry. The beta dose rate calculated from these measurements on the ceramics was compared with the beta dose rate measured directly by beta counting. These were in statistical agreement at one sigma for all samples except UW4044 and UW4050 (values in italics in Table 2). For both samples it is thought the K measurement was in error, so the K value was adjusted to agree with the beta counting. Note that beta counting was not done for UW4045 because of insufficient material. Moisture content was estimated as 50 ± 20 % of saturated value for the ceramic sherds and 6 ±3 percent for the sediments. The area is quite dry and it is possible, the moisture estimate is overestimated. The ages are also calculated assuming a moisture content of 30 ± 20 % of saturated value. Table A.3.2 gives the radioactivity data and comparison of the beta dose rate calculated in the two ways mentioned earlier. Table A.3.3 gives total dose rates for each sample.

Table A.3.2. Radionuclide concentrations

Sample	^{238}U (ppm)	^{232}Th (ppm)	K (%)	Beta dose rate	
				ß counting	α counting/flame photometry
UW4042	3.37 ± 0.20	4.43 ± 0.74	1.70 ± 0.36	1.84 ± 0.23	2.01 ± 0.30
Sediment	1.53 ± 0.13	5.82 ± 0.96	0.64 ± 0.03		
UW4043	4.11 ± 0.29	12.11 ± 1.52	1.51 ± 0.07	2.03 ± 0.25	2.17 ± 0.08
Sediment	1.45 ± 0.12	4.07 ± 0.72	0.84 ± 0.03		
UW4044	3.43 ± 0.21	5.64 ± 0.92	1.66 ± 0.07	*1.70 ± 0.21*	*2.02 ± 0.07*
Sediment	1.42 ± 0.12	4.12 ± 0.79	0.75 ± 0.03		
UW4045	3.56 ± 0.23	6.36 ± 1.06	0.21 ± 0.02		
Sediment	1.48 ± 0.12	3.33 ± 0.72	0.78 ± 0.02		
UW4046	2.54 ± 0.16	2.53 ± 0.65	1.47 ± 0.08	1.87 ± 0.24	1.65 ± 0.07
Sediment	1.30 ± 0.11	4.62 ± 0.77	0.75 ± 0.05		
UW4047	2.66 ± 0.20	9.26 ± 1.17	1.23 ± 0.14	1.78 ± 0.22	1.65 ± 0.12
Sediment	1.68 ± 0.12	3.20 ± 0.71	0.85 ± 0.05		
UW4048	2.18 ± 0.15	4.48 ± 0.78	1.80 ± 0.06	1.75 ± 0.22	1.92 ± 0.06
Sediment	1.44 ± 0.10	2.73 ± 0.59	0.84 ± 0.02		
UW4049	4.44 ± 0.26	4.93 ± 0.89	1.30 ± 0.05	1.75 ± 0.23	1.85 ± 0.06
sediment	1.21 ± 0.10	3.07 ± 0.64	0.86 ± 0.02		

UW4050	5.14 ± 0.29	4.95 ± 1.02	0.68 ± 0.02	*1.92 ± 0.24*	*1.44 ± 0.05*
Sediment	1.32 ± 0.10	1.60 ± 0.50	0.71 ± 0.05		
UW4051	2.82 ± 0.20	7.93 ± 1.17	1.38 ± 0.07	1.74 ± 0.24	1.77 ± 0.07
Sediment	1.45 ± 0.13	5.18 ± 0.89	0.79 ± 0.03		
UW4052	4.18 ± 0.25	4.99 ± 0.98	1.31 ± 0.15	1.72 ± 0.22	1.82 ± 0.13
Sediment	1.18 ± 0.11	5.51 ± 0.84	1.53 ± 0.06		
UW4053	2.19 ± 0.13	0.78 ± 0.39	1.69 ± 0.06	1.94 ± 0.24	1.73 ± 0.05
Sediment	1.38 ± 0.14	6.88 ± 1.05	0.71 ± 0.03		
UW4054	2.58 ± 0.20	9.00 ± 1.15	1.60 ± 0.04	1.70 ± 0.21	1.94 ± 0.06
Sediment	1.42 ± 0.14	8.09 ± 1.04	0.74 ± 0.03		
UW4055	4.29 ± 0.28	9.50 ± 1.23	1.69 ± 0.04	2.31 ± 0.32	2.28 ± 0.06
Sediment	1.42 ± 0.12	4.46 ± 0.83	0.83 ± 0.03		
UW4056	3.04 ± 0.22	8.24 ± 1.20	1.45 ± 0.06	1.83 ± 0.22	1.86 ± 0.07
sediment	1.29 ± 0.10	2.76 ± 0.59	0.57 ± 0.03		

Table A.3.3. Dose rates (Gy/ka)*

Sample	**alpha**	**beta**	**gamma**	**cosmic**	**total**
UW4042	0.58 ± 0.10	1.82 ± 0.30	0.63 ± 0.05	0.26 ± 0.05	3.29 ± 0.32
UW4043	2.07 ± 1.05	2.00 ± 0.10	0.62 ± 0.04	0.25 ± 0.05	4.95 ± 1.06
UW4044	0.41 ± 0.02	1.59 ± 0.12	0.56 ± 0.04	0.25 ± 0.05	2.82 ± 0.14
UW4045	0.52 ± 0.04	0.80 ± 0.05	0.52 ± 0.04	0.25 ± 0.05	2.09 ± 0.09
UW4046	0.38 ± 0.05	1.52 ± 0.08	0.56 ± 0.04	0.24 ± 0.05	2.70 ± 0.11
UW4047	0.27 ± 0.02	1.53 ± 0.12	0.58 ± 0.04	0.25 ± 0.05	2.63 ± 0.14
UW4048	0.21 ± 0.02	1.78 ± 0.07	0.32 ± 0.02	0.32 ± 0.06	2.63 ± 0.10
UW4049	0.42 ± 0.04	1.70 ± 0.08	0.53 ± 0.03	0.25 ± 0.05	2.90 ± 0.11
UW4050	0.50 ± 0.04	1.73 ± 0.12	0.43 ± 0.03	0.28 ± 0.06	2.95 ± 0.14
UW4051	0.43 ± 0.05	1.64 ± 0.08	0.62 ± 0.05	0.25 ± 0.05	2.95 ± 0.12

UW4052	0.36 ± 0.04	1.68 ± 0.13	0.77 ± 0.05	0.26 ± 0.05	3.07 ± 0.15
UW4053	0.24 ± 0.03	1.59 ± 0.07	0.65 ± 0.05	0.25 ± 0.05	2.73 ± 0.10
UW4054	0.35 ± 0.02	1.80 ± 0.07	0.75 ± 0.05	0.26 ± 0.05	3.16 ± 0.11
UW4055	0.61 ± 0.07	2.10 ± 0.09	0.64 ± 0.04	0.25 ± 0.05	3.60 ± 0.13
UW4056	0.34 ± 0.03	1.71 ± 0.08	0.47 ± 0.03	0.25 ± 0.05	2.77 ± 0.11

* Dose rates are calculated for OSL, except for UW4043 where the dose rates are for TL. TL, OSL and IRSL dose rates will differ because of differences in b-value. Beta dose rates differ from those given in Table 2 because of moisture content correction.

Equivalent Dose

Equivalent dose was measured for TL, OSL and IRSL as described in the appendix. For UW4042 and UW4046, there was no growth with dose in the TL signal, so no equivalent dose could be determined for those samples. For the others, TL plateaus (Table A.3.4), were relatively narrow, none more than 100°C, and most 60°C or less. Scatter was relatively low, however, and none of the samples showed a sensitivity change with heating. TL anomalous fading was evident in all samples where it was measured and where the data were of sufficient quality. The fading rate, or g-value, was quite variable. For those rates above about 14%, a fading correction was not possible because it would result in an infinite age. Correction on the others, following Huntley and Lamothe (2001), was of variable precision.

OSL/IRSL was measured on 6-8 aliquots per sample (Table A.3.5). No measurable signal was obtained for UW4043. On the other samples, scatter was low, over-dispersion being more than 10% on only five samples. A dose recovery test showed that the measured dose agreed at 1 or 2-sigma with the given dose for all but UW4042, a sample with other problems.

The IRSL signal comes from feldspars; the OSL signal comes from quartz but also from feldspar to some degree. In these samples the IRSL signal was generally weak, and a measurable signal was not obtained for many aliquots, on no aliquots for four samples. The OSL signal is normally much stronger than the IRSL signal because heat (applied when the ceramic was made) increases the sensitivity of quartz but lowers it for feldspar. The OSL signal was from 2 to 100 times more intense than the IRSL signal in these samples.

Table A.3.4. TL data

Sample	Plateau (°C)	$1^{st}/2^{nd}$ glow ratio*	fit	g-value (%/decade)**
UW4043	280-310	1.0	Linear	Poor data
UW4044	250-310	1.0	Linear	8.07 ± 0.09
UW4045	250-310	1.0	Linear	0.95 ± 5.39
UW4047	250-330	1.0	Linear	15.2 ± 0.08
UW4048	250-310	1.0	Linear	Poor data
UW4049	250-310	1.0	Linear	16.4 ± 3.59

UW4050	250-290	1.0	Linear	1.54 ± 20.5
UW4051	250-330	1.0	Linear	15.3 ± 6.21
UW4052	250-320	1.0	Linear	No test
UW4053	270-310	1.0	Linear	7.24 ± 2.81
UW4054	270-330	1.0	Linear	18.48 ± 5.63
UW4055	250-350	1.0	Linear	8.90 ± 4.92
UW4056	260-330	1.0	Linear	0.70 ± 0.28

*Refers to slope ratio between the first and second glow growth curves. A glow refers to luminescence as a function of temperature; a second glow comes after heating to 450°C.

** A g-value is a rate of anomalous fading, measured as percent of signal loss per decade, where a decade is a power of 10.

Table A.3. 5. OSL/IRSL data

	# aliquots*		**OSL Over-dispersion (%)**	**Dose Recovery (OSL)**	
Sample	**OSL**	**IRSL**		**Given Dose (sß)**	**Recovered Dose (sß)**
UW4042	8	2	15.2 ± 5.4	30	52.7 ± 10.0
UW4044	6	3	6.5 ± 2.2	50	50.9 ± 1.8
UW4045	6	5	0	50	54.0 ± 3.8
UW4046	5	3	14.2 ± 10.5	40	38.2 ± 8.6
UW4047	5	3	0	50	52.9 ± 2.3
UW4048	6	0	20.4 ± 6.1	20	22.0 ± 1.2
UW4049	6	5	15.3 ± 5.4	40	38.3 ± 2.3
UW4050	5	4	2.1 ± 3.8	20	20.7 ± 1.1
UW4051	6	0	19.4 ± 7.6	20	24.6 ± 2.4
UW4052	6	0	0	40	41.3 ± 5.0
UW4053	6	0	0	40	40.8 ± 5.3
UW4054	6	4	8.9 ± 2.8	20	21.4 ± 0.6
UW4055	6	1	0	40	38.5 ± 4.9
UW4056	6	2	0	50	49.7 ± 1.7

Equivalent dose and b-values are given in Table A.3.6. The b-value is a measure of the lower efficiency at producing luminescence of alpha radiation as opposed to beta or gamma radiation. Globally the b-value for quartz is less than that for feldspar, usually with a value between 0.4 and 0.6. In these sample the OSL b-value is within that range, while the IRSL b-value is significantly higher. This suggests the OSL signal is dominated by quartz and thus not likely to be subject to anomalous fading, which is common to feldspars, but not quartz.

Table A.3.6. Equivalent dose (Gy) and b-value (Gy µm^2)

Sample	Equivalent Dose (Gy)			b-value (Gy µm^2)		
	TL	IRSL	OSL	TL	IRSL	OSL
UW4042		17.6±4.15	20.0±1.28		1.48±1.09	0.81±0.13
UW4043	2.24±0.62			1.75±0.83		
UW4044	5.21±0.31	3.39±1.68	1.94±0.06	0.98±0.13		0.52±0.02
UW4045	3.00±0.47	5.81±0.99	1.87±0.04	1.36±0.21		0.63±0.03
UW4046		6.20±1.12	2.70±0.26		1.86±0.46	0.74±0.07
UW4047	6.58±1.19	6.70±0.67	1.93±0.04	1.39±0.48	1.06±0.16	0.33±0.01
UW4048	2.28±0.40		3.38±0.29	2.11±0.75	2.73±1.43	0.39±0.03
UW4049	3.19±0.32	3.90±0.74	2.17±0.15	1.75±0.23	1.32±0.08	0.46±0.04
UW4050	2.87±0.19	3.78±0.51	2.22±0.05	2.15±0.37	1.40±0.11	0.48±0.03
UW4051	2.21±0.39		2.18±0.11	0.82±0.20	1.62±0.62	0.54±0.05
UW4052	6.87±1.56		1.92±0.05	1.75±0.53		0.42±0.04
UW4053	3.32±0.33		2.12±0.12	1.54±0.35		0.62±0.06
UW4054	4.26±0.38	4.47±0.76	2.36±0.09	0.80±0.09	1.57±0.59	0.44±0.02
UW4055	4.07±0.84	4.82±1.95	2.09±0.06	1.07±0.22		0.56±0.06
UW4056	2.96±0.50	3.78±1.27	2.24±0.03	1.90±0.42	2.57±1.58	0.41±0.02

* Denotes number of aliquots with measurable signals.
** Over-dispersion after one or two outliers removed.

Ages

Best estimate of age are given in Table A.3.7. Calendar ages using both 50% and 30% of saturation value were calculated.

The TL age considered the best estimate for only two samples: UW4043, where no significant OSL or IRSL signal was detected, and UW4048, where the OSL age is much older than the TL age and also older than other ceramics from the site. It is assumed the OSL signal on this sample was not completely reset, perhaps because of dominance by a slow bleaching component. On four samples, UW4049, UW4050, UW4051 and UW4056, there was statistical agreement between the TL and OSL ages (and with IRSL for UW4056). On UW4050 and UW4056, the agreement was with the TL age after correction for anomalous fading. On UW4049 and UW4051, the agreement was with the uncorrected age, as the correction yielded an infinite age or one that was quite old. On all the other samples, only the OSL signal gave a reasonable result. The TL (or IRSL) age was much older in all cases, probably because of signals that were not completely reset. This might also explain the rather poor plateaus of the TL signals. This suggests the ceramics may not have been fired at very high temperatures, an observation supported by the examination of ceramic pastes and petrographic analysis described in Chapter 16.

The ages (using 30% moisture) are plotted as a radial graph in Figure A.3.1 (UW4042 is omitted.). Radial graphs plot precision on the x-axis, measured as the coefficient of variance or its reciprocal. More precise points are plotted to the right. Age is plotted on the y-axis but normalized by the number of standard errors the value is from some reference. The two references are 0.685 (blue shading) and 0.620 (yellow shading), which are the average of the two expected age ranges (A.D. 1320–1350 and A.D. 1380–1425, respectively). The green area represents overlap. Lines passing from the origin through any point intersect the right axis at the calculated age. Most of the ages are consistent with the 1320–1350 range. Only one age is clearly restricted to the 1380-1425 age range. There are also three ages that fall earlier than these ranges.

Table A.3.7. Ages

Sample	**Age (ka)**	**% Error**	**Basis for Age**	**Calendar Date (50% moisture)**	**Calendar Date (30% moisture)**
UW4042	6.08 ± 0.74	12.1	OSL	B.C. 4050 ± 740	B.C. 3880 ± 720
UW4043	0.45 ± 0.16	35.2	TL	A.D. 1570 ± 160	A.D. 1580 ± 160
UW4044	0.69 ± 0.04	6.4	OSL	A.D. 1330 ± 40	A.D. 1350 ± 40
UW4045	0.89 ± 0.05	5.7	OSL	A.D. 1130 ± 50	A.D. 1150 ± 50
UW4046	1.00 ± 0.11	11.0	OSL	A.D. 1020 ± 110	A.D. 1040 ± 110
UW4047	0.74 ± 0.05	6.5	OSL	A.D. 1290 ± 48	A.D. 1300 ± 47
UW4048	0.64 ± 0.14	21.7	TL	A.D. 1380 ± 140	A.D. 1400 ± 140
	1.29 ± 0.13	9.8	OSL	A.D. 730 ± 130	A.D. 760 ± 120
UW4049	0.76 ± 0.05	7.0	OSL/uncorrected TL	A.D. 1260 ± 50	A.D. 1280 ± 50

UW4050	0.75 ± 0.05	6.0	OSL/ corrected TL	A.D. 1270 ± 40	A.D. 1290 ± 40
UW4051	0.73 ± 0.05	6.8	OSL/uncorrected TL	A.D. 1290 ± 50	A.D. 1300 ± 50
UW4052	0.62 ± 0.04	6.5	OSL	A.D. 1400 ± 40	A.D. 1410 ± 40
UW4053	0.78 ± 0.06	7.6	OSL	A.D. 1250 ± 60	A.D. 1260 ± 60
UW4054	0.75 ± 0.04	6.0	OSL	A.D. 1270 ± 40	A.D. 1290 ± 40
UW4055	0.58 ± 0.03	5.7	OSL	A.D. 1440 ± 30	A.D. 1450 ± 30
UW4056	0.81 ± 0.04	4.9	OSL/IRSL/corrected TL	A.D. 1220 ± 40	A.D. 1240 ± 40

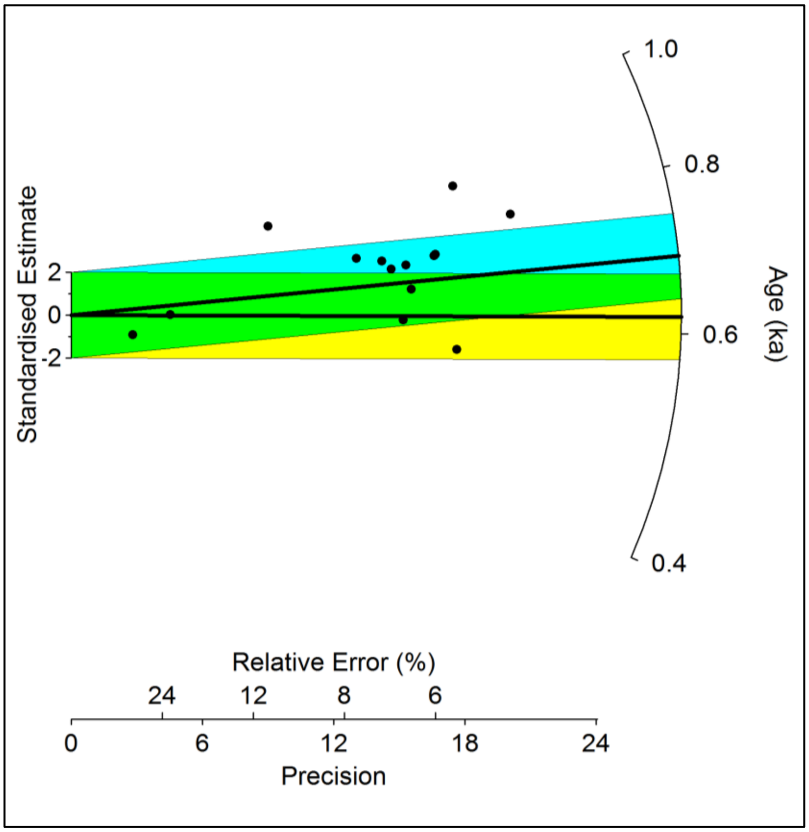

Figure A.3.1. Radial graph of ages.

Appendix: Methods

Sample preparation -- fine grain

The sherd is broken to expose a fresh profile. Material is drilled from the center of the cross-section, more than 2 mm from either surface, using a tungsten carbide drill tip. The material retrieved is ground gently by an agate mortar and pestle, treated with HCl, and then settled in acetone for 2 and 20 minutes to separate the 1-8 µm fraction. This is settled onto a maximum of 72 stainless steel discs.

Procedures for Thermoluminescence Analysis of Pottery

Glow-outs

Thermoluminescence is measured by a Daybreak reader using a 9635Q photomultiplier with a Corning 7-59 blue filter, in N_2 atmosphere at 1°C/s to 450°C. A preheat of 240°C with no hold time precedes each measurement. Artificial irradiation is given with a ^{241}Am alpha source and a ^{90}Sr beta source, the latter calibrated against a ^{137}Cs gamma source. Discs are stored at room temperature for at least one week after irradiation before glow out. Data are processed by Daybreak TLApplic software.

Fading test

Several discs are used to test for anomalous fading, which is an athermal loss of signal through time. The natural luminescence is first measured by heating to 450°C. The discs are then given an equal alpha irradiation and stored at room temperature for varied times: 10 min, 2 hours, 1 day, 1 week and 8 weeks. The irradiations are staggered in time so that all of the second glows are performed on the same day. The second glows are normalized by the natural signal and then compared to determine any loss of signal with time (on a log scale). If the sample shows fading and the signal versus time values can be reasonably fit to a logarithmic function, an attempt is made to correct the age following procedures recommended by Huntley and Lamothe (2001). The fading rate is calculated as the g-value, which is given in percent per decade, where decade represents a power of 10.

Equivalent dose

The equivalent dose is determined by a combination additive dose and regeneration (Aitken 1985). Additive dose involves administering incremental doses to natural material. A growth curve plotting dose against luminescence can be extrapolated to the dose axis to estimate an equivalent dose, but for pottery this estimate is usually inaccurate because of errors in extrapolation due to nonlinearity. Regeneration involves zeroing natural material by heating to 450°C and then rebuilding a growth curve with incremental doses. The problem here is sensitivity change caused by the heating. By constructing both curves, the regeneration curve can be used to define the extrapolated area and can be corrected for sensitivity change by comparing it with the additive dose curve. This works where the shapes of the curves differ only in scale (i.e., the sensitivity change is independent of dose). The curves are combined using the "Australian slide" method in a program developed by David Huntley of Simon Fraser University (Prescott et al. 1993). The equivalent dose is taken as the horizontal distance between the two curves after a scale adjustment for sensitivity change. Where the growth curves are not linear, they are fit to quadratic or saturating exponential functions. Dose increments (usually five) are determined so that the maximum additive dose results in a signal about three times that of the natural and the maximum regeneration dose about five times the natural. Where the slide procedure produces a large negative dose-axis intercept, equivalent dose is also determined just by additive dose. This is used in age calculation is the value is more consistent with other data than the value from the slide procedure.

A plateau region is determined by calculating the equivalent dose at temperature increments between 240° and 450°C and determining over which temperature range the values do not differ significantly. This plateau region is compared with a similar one constructed for the b-value (alpha efficiency), and the overlap defines the integrated range for final analysis.

Alpha effectiveness

Alpha efficiency is determined by comparing additive dose curves using alpha and beta irradiations. The slide program is also used in this regard, taking the scale factor (which is the ratio of the two slopes) as the b-value (Aitken 1985).

Procedures for Optically Stimulated or Infrared Stimulated Luminescence of Fine-grained pottery.

Optically stimulated luminescence (OSL) and infrared stimulated luminescence (IRSL) on fine-grain (1-8µm) pottery samples are carried out on single aliquots following procedures adapted from Banerjee et al. (2001) and Roberts and Wintle (2001). Equivalent dose is determined by the single-aliquot regenerative dose (SAR) method (Murray and Wintle 2000).

The SAR method measures the natural signal and the signal from a series of regeneration doses on a single aliquot. The method uses a small test dose to monitor and correct for sensitivity changes brought about by preheating, irradiation or light stimulation. SAR consists of the following steps: 1) preheat, 2) measurement of natural signal (OSL or IRSL), L(1), 3) test dose, 4) cut heat, 5) measurement of test dose signal, T(1), 6) regeneration dose, 7) preheat, 8) measurement of signal from regeneration, L(2), 9) test dose, 10) cut heat, 11) measurement of test dose signal, T(2), 12) repeat of steps 6 through 11 for various regeneration doses. A growth curve is constructed from the L(i)/T(i) ratios and the equivalent dose is found by interpolation of L(1)/T(1). Usually, a zero regeneration dose and a repeated regeneration dose are employed to ensure the procedure is working properly. For fine-grained ceramics, a preheat of 240°C for 10s, a test dose of 3.1 Gy, and a cut heat of 200°C are currently being used, although these parameters may be modified from sample to sample.

The luminescence, L(i) and T(i), is measured on a Risø TL-DA-15 automated reader by a succession of two stimulations: first 100 s at 60°C of IRSL (880nm diodes), and then 100s at 125°C of OSL (470nm diodes). Detection is through 7.5mm of Hoya U340 (ultra-violet) filters. The two stimulations are used to construct IRSL and OSL growth curves, so that two estimations of equivalent dose are available. Anomalous fading usually involves feldspars and only feldspars are sensitive to IRSL stimulation. The rationale for the IRSL stimulation is to remove most of the feldspar signal, so that the subsequent OSL (post IR blue) signal is free from anomalous fading. However, feldspar is also sensitive to blue light (470nm), and it is possible that IRSL does not remove all the feldspar signal. Some preliminary tests in our laboratory have suggested that the OSL signal does not suffer from fading, but this may be sample specific. The procedure is still undergoing study.

An equivalent dose value is determined for each aliquot. Something like a weighted average is determined by the central age model (Galbraith and Roberts 2012), which also computes an over-dispersion parameter. The latter is a measure of spread and can be thought of as the percentage of values that differ from the central tendency by more than can be accounted for by differential precision.

A dose recovery test is performed by first zeroing the sample by exposure to light and then administering a known dose. The SAR protocol is then applied to see if the known dose can be obtained.

Alpha efficiency will surely differ among IRSL, OSL and TL on fine-grained materials. It does differ between coarse-grained feldspar and quartz (Aitken 1985). Research is currently underway in the laboratory to determine how much b-value varies according to stimulation method. Results from several samples from different geographic locations show that OSL b-value is less variable and centers around 0.5. IRSL b-value is more variable and is higher than that for OSL. TL b-value tends to fall between the OSL and IRSL values, but often higher than both. We currently are measuring the b-value for IRSL and OSL by giving an alpha dose to aliquots whose luminescence have been drained by exposure to light. An equivalent dose is determined by SAR using beta irradiation, and the beta/alpha equivalent dose ratio is taken as the b-value. A high OSL b-value is indicative that feldspars might be contributing to the signal and thus subject to anomalous fading.

Radioactivity

Radioactivity is measured by alpha counting in conjunction with atomic emission for ^{40}K. Samples for alpha counting are crushed in a mill to flour consistency, packed into plexiglass containers with ZnS:Ag screens, and sealed for one month before counting. The pairs technique is used to separate the U and Th decay series. For atomic emission measurements, samples are dissolved in HF and other acids and analyzed by a Jenway flame photometer. K concentrations for each sample are determined by bracketing between standards of known concentration. Conversion to ^{40}K is by natural atomic abundance. Radioactivity is also measured, as a check, by beta counting, using a Risø low level beta GM multicounter system. About 0.5 g of crushed sample is placed on each of four plastic sample holders. All are counted for 24 hours. The average is converted to dose rate following Bøtter-Jensen and Mejdahl (1988) and compared with the beta dose rate calculated from the alpha counting and flame photometer results. Cosmic radiation is determined after Prescott and Hutton (1994). Radioactivity concentrations are translated into dose rates following Guérin et al. (2011).

Moisture Contents

Water absorption values for the sherds are determined by comparing the saturated and dried weights. For the relatively dry climate, moisture in the pottery is taken to be 50 ± 20 percent of total absorption.

Age and error terms

The age and error for OSL, IRSL and TL are calculated by a laboratory constructed spreadsheet, based on Aitken (1985). All error terms are reported at 1-sigma. Values quoted as ka (thousand years before present) use 2020 or 2021 as the present. They are also rounded to the nearest 10 years.

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Appendix B: Subsistence Data

B.1 Plant List Pollen Table

B.2 Pollen Table

Appendix B.1 Plant List

Susan J. Smith

Merchant Site Plant List. Compiled on July 8-10, 2019

Modern cattle grazing was noted in the area of the site and surrounding land

Form+A4:I24	Family	Genus	Species	Common Name	Abundance	Environment/ Habitat	Notes
Shrub/ Small Tree	Fabaceae	Prosopis	glandulosa	Honey Mesquite	D	ridge and basin	
Shrub/ Small Tree	Fagaceae	Quercus	havardii	Shinnery Oak/ Harvard's Oak	C	ridge	most common N end site and beyond; inter-dune swale to N filled with oak
Shrubs/ Subshrub	Asteraceae	Artemisia	filifolia	Sand Sage	S	ridge	disturbed soils along edge powerline road to N
	Asteraceae	cf. Flourensia	cernua	Tarbush	R-S	west ridge slope	W? facing sideslopes off Merchant Ridge on finger ridges of dissected arroyos
	Asteraceae	Gutierrezzia	sp.	Snakeweed	D	ridge and basin	everywhere, particularly abundant along interior drainage and in what might have been a field area
	Asteraceae	Parthenium	incanum	Mariola	D	ridge	
	Chenopodiaceae	Atriplex	canescens	Four Wing Saltbush	R	basin	
	Euphorbiaceae	Croton	sp.	Doveweed	D	ridge	most visible just east of roomblock and structure cluster
	Koeberliniaceae	Koeberlinia	spinosa	Crown-of-Thorns	R	ridge	
	Krameriaceae	Krameria	cf. lanceolata	Trailing Krameria	C	ridge	ridge, esp. N. of site, heavily browsed
	Rhamnaceae	Condalia	ericoides	Javelina Bush	S	ridge west slope	
	Solanaceae	Lycium	sp.	Wolfberry	R	basin	
	Zygophyllaceae	Larrea	tridentata	Creosote Bush	D	S end ridge and basin	gradient S to N; Creosote dominant S end of ridge on S-facing aspect as ridge grades to flats; N end of Merchant Ridge, mesquite and oak become dominant
Cacti	Cactaceae	Opuntia	sp.	Prickly Pear	R	ridge and basin	
Yucca	Agavaceae	Yucca	campestris	Plains Yucca	C	ridge	common N. end of site area
Herbs and Forbs	Asteraceae	Helianthus	annuus	Sunflower	R	ridge	
	Asteraceae	Melampodium	leucanthum	Plains Blackfoot Daisy	C	ridge	
	Asteraceae	Psilostrophe	cf. tagetina	Paperflower	S	ridge	
	Boraginaceae	Tiquilia	sp.	Crinklemat	S	ridge	S end of site
	Brassicaceae	Dimorphocarpa	wislizeni	Spectacle-Pod	C	ridge	
	Brassicaceae	Lepidium	sp.	Pepperweed	R	ridge	
	Brassicaceae	Lesquerella	cf. fendleri	Bladderpod	S	ridge	
	Euphorbiaceae	Euphorbia/Chamaesyce	spp.	Spurge Family	R	ridge	wrong season - should be abundant following monsoons
	Fabaceae	Astragalus	mollissimus	Locoweed	C	ridge	large area of dead clumps, N. end site (winter/spring flower or from last year)
	Fabaceae	Hoffmannseggia	glauca	Waxy Rush Pea/ Hogpotato	C	basin	C in basin; R along ridge
	Fabaceae	Senna	bauhinioides	Twinleaf Sennna	R-S	ridge	
	Linaceae	Linum	cf. aristatum	Bristle Flax/ Yellow Flax	R	ridge	
	Nyctaginaceae	Abronia	fragans	Sand Verbena	R	ridge	
	Onagraceae	Calylophus	sp.	Sundrops	S	ridge	along site boundary road to N
	Verbenaceae	Glandularia	sp.	Mock Vervain	R	ridge	
Grasses	Poaceae	Aristida	sp.	Three-Awn	C	ridge	
	Poaceae	Sporobolus	spp.	Dropseed	D	ridge	increases from common in S to dominant on N end with oak; grasses in general more common to N of site. comparison photo of Fea. 65 checkdam with expansion of snakeweek over grasses; project area grazed
	Poaceae	Bouteloua	spp.	Grama	S	ridge	possibly the dominant grass in the basin at mud playa edge
	Poaceae	Chloris	cf. cucullata	Windmillgrass	C	ridge	N of site
	Poaceae	cf. Dasyochloa	pulchella	Fluffgrass	R	ridge	
	Poaceae	cf. Muhlenbergia	sp.	Muhlygrass	S, C	ridge	
	Poaceae	Setaria	sp.	Bristlegrass	R	ridge	
Unknowns		poss. Peganum		5 petals	R	basin	 
	Fabaceae	poss. 2nd Astragalus		small flowers	R	ridge	disturbed road/powerline edge N. of site
	Unknown - Polemoniaceae?	looks like Phlox - not Nama?			R	ridge	

Abundance codes: R = Rare, S = Sparse, C = Common, D = Dominant

Appendix B.2 Pollen Data

Susan J. Smith

Extended Microscopy Samples and Results

Large Fraction

Samples Analyzed by Intensive Systematic Scanning (ISM)

2019 Sample Numbers	ISM Number of Slides Scanned	Total Number Tracers Observed (Tracer Conc. 20848)	ISM Analysis Level, Concentration gr/gm of one grain (sample weight 10 gm)	LFS Samples	Pecan (Carya)	Maize (Zea)	Large Grass (Large Poaceae)	Evening Primrose (Onagraceae)	Unknown porate grain with four? equatorial pores
2019-1	3	1968	1.0	X					
2019-2	5	2426	0.8	X					
2019-3	3	2829	0.7	X			X		
2019-4	3	2148	0.9	X	X				
2019-5	4	2378	0.8	X	X				
2019-6	4	2214	0.9	X		X			
2019-7	4	2665	0.7	X	X				X
2019-8	4	2460	0.8	X	X				
2019-9	2	2214	0.9	X	X				
2019-10	2	1968	1.0	X					
401				X			X	X	
402				X					
403				X					
404				X					
405				X					
406				X					
407				X					
408				X	X				
409				X					
410				X					
452				X					
453				X					
454				X		X			
457				X	X				
458				X					
459				X			X		
460				X					
461				X	X		X		

Pollen Data Raw Counts. X notes scan-identified taxa.

Samples from rooms and artifacts (black text) and bedrock mortars (red text)

CN/ Field Collection Sample Number		2015-1.3	2015-1.4	2015-1.12	189	381	280	313	314	315	369	457	458	459	460	461
Feature Number		1.3	1.4	1.12	110	6.4	6	404	404	404	410.1	441.2	441.3	441.4	441.5	442.9
Sample Depth cm below Surface												5-14.4	23-28	5-11.3	15-22.7	10-16.3
Tracers Counted		123	69	98	41	109	117	54	13	46	96	29	19	150	79	15
Tracer Concentration		18583	18583	18583	19332	19332	19332	19332	19332	19332	19332	19332	19332	19332	19332	19332
Sample Weight		10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
Pollen Sum		221	235	216	227	108	216	208	201	206	217	204	213	241	234	240
Pollen Concentration gr/gm		3338.9	6329.0	4095.8	10703.3	1915.5	3569.0	7446.4	29890.2	8657.4	4369.8	13599.1	21672.2	3106.0	5726.2	30931.2
Taxon Richness		12	14	19	14	10	11	9	11	17	9	14	10	13	7	15
Degraded		46	52	42	18	14	32	31	39	34	14	52	45	44	32	6
Unknown		2	3	2	1	1	4	2		1	4	5	4	2	1	1
Fir	*Abies*															
Acacia	*Acacia*											1				
Acalypha	*Acalypha*											1		2		
Alder	*Alnus*															
Ragweed	*Ambrosia*		1	1					1	2						
Sagebrush	*Artemisia*	2	1													
Sunflower Family	Asteraceae	57	53	42	51	39	40	52	77	79	32	84	53	75	82	91
Birch	*Betula*															
Mustard Family	Brassicaceae	1	1	3	5			1				2	2	5	1	8
Pecan	*Carya*															
Buckbrush	*Ceanothus*			1												
Hog Potato	cf. *Hoffmannseggia*								1							
Cheno-am	Cheno-am	68	63	64	91	33	111	95	57	53	57	29	89	54	84	45
Doveweed	*Croton*													1		2
Juniper	Cupressaceae	4	6	6						1		5		14		13
Cholla	*Cylindropuntia*															
Spectaclepod	*Dimorphocarpa*			1	1				5	1						
Mormon Tea	*Ephedra*	1	1	4	1	6	2	1		5	1	1	1	1		1
Buckwheat	*Eriogonum*			2		1	1	1		1	1					
Crane's Bill	*Erodium*															
Spurge Family	Euphorbiaceae		3	1		1				1		1	6	3		1
Pea Family	Fabaceae						1									3
Sunflower type	*Helianthus* type															
Kallstromia type	*Kallstromia* type															
Ratany	*Krameria*															
Mint Family	Lamiaceae															
Large Grass	Large Poaceae			1									2			8
Creosote	*Larrea*											1				
Chicory	Liguliflorae	1														
Yucca type	Liliaceae	1								1						
Honeysuckle	*Lonicera*			1												
Mallow Family cf. Globemallow	Malvaceae, *Sphaeralcea*															
Four O'Clock Family	Nyctaginaceae							1								
Evening Primrose	Onagraceae		1	X	1											
Spruce	*Picea*															
Large Pine	*Pinus*			5	3	3	1	1	1	4	3			3	2	9
Small Pine	*Pinus edulis* type	1	1	1	3	2	2		1	2	2	4	5		11	3
Plantain	*Plantago*															
Prickly Pear	*Platyopuntia*								2	1						
Grass Family	*Poaceae*	31	41	28	16	1	17	16	14	15	14	12	3	32	20	42
Mesquite	*Prosopis*				1					1				1		
cf. Cherry	*Prunus*															
Oak	*Quercus*			1	1		3			1	1	3	1	3	1	2
Javelina bush type	Rhamnaceae			1					1							
Rose Family	*Rosaceae*						1					1				2
Greasewood	*Sarcobatus*															
Wolfberry type	Solanaceae															
Tidestromia	*Tidestromia*	4	4	5	30	6	1	6	2	2	78	2	2	1		
Cattail	*Typha*			1												
Elm	*Ulmus*															
Verbena	*Verbena*				1											1
Maize	*Zea*	2	3	1	3	1				1						
Total Aggregates			1	3				1			10					2
Sunflower Family Aggregates																
Cheno-am Aggregates			X(75+)					1(12)								
Tidestromia Aggregates			1(100+)	1(30+)							10(50+)					
Grass Aggregates				2(8)												2(8)
Dimorphocarpa Aggregates																

Samples from agricultural field Feature 82

CN/ Field Collection Sample Number		2019-8	401	402	403	404	405	406	407	408	409	410	2019-5	2019-6	2019-9
Feature Number		82	82	82	82	82	82	82	82	82	82	82	82	82	82
Sample Depth cm below Surface		0-5	6-11	11-16	7-12	12-17	9-14	14-19	11-16	16-21	5-10	10-15	8-10	8-10	5-7
Tracers Counted		16	25	70	64	65	36	51	65	61	78	38	18	12	41
Tracer Concentration		20848	19332	19332	19332	19332	19332	19332	19332	19332	19332	19332	20848	20848	20848
Sample Weight		10	10	10	10	10	10	10	10	10	10	10	10	10	10
Pollen Sum		383	232	247	220	218	211	210	227	200	241	103	331	271	352
Pollen Concentration gr/gm		49904.9	17940.1	6821.4	6645.4	6483.7	11330.7	7960.2	6751.3	6338.4	5973.1	5240.0	38337.2	47081.7	17898.8
Taxon Richness		16	15	13	12	13	15	12	14	17	13	6	15	19	15
Degraded		14	39	28	32	28	29	28	41	41	42	19	21	26	52
Unknown		4	5	2	1	5	3	3	10	3	2	1	2	1	6
Fir	*Abies*												X		
Acacia	*Acacia*														
Acalypha	*Acalypha*														
Alder	*Alnus*														
Ragweed	*Ambrosia*					1									
Sagebrush	*Artemisia*				1			1							2
Sunflower Family	Asteraceae	269	75	135	120	114	96	128	110	88	123	61	220	156	202
Birch	*Betula*														
Mustard Family	Brassicaceae	5	11	2	7	7	3	5	4	7	6	6	5	12	9
Pecan	*Carya*	X	1							X			X	X	X
Buckbrush	*Ceanothus*														
Hog Potato	cf. *Hoffmannseggia*														
Cheno-am	Cheno-am	21	31	27	26	16	25	18	19	12	26	13	20	23	41
Doveweed	*Croton*	3				1	1				2		2	X	1
Juniper	Cupressaceae	9	9	4	2	7	5	1		4	4	1	9	4	3
Cholla	*Cylindropuntia*		1												
Spectaclepod	*Dimorphocarpa*	3		2	1		3	1	2	1	2		4	1	5
Mormon Tea	*Ephedra*	3	1	2						1				2	3
Buckwheat	*Eriogonum*	1					1	1		1	1			X	
Crane's Bill	*Erodium*														
Spurge Family	Euphorbiaceae	2	5	5	2	7	5	3	2	5	8	1	4	4	4
Pea Family	Fabaceae							1	4					X	
Sunflower type	*Helianthus* type														
Kallstromia type	*Kallstromia* type													X	
Ratany	*Krameria*								1						
Mint Family	Lamiaceae		1	1											
Large Grass	Large Poaceae							1	1						
Creosote	*Larrea*														
Chicory	Liguliflorae														
Yucca type	Liliaceae														
Honeysuckle	*Lonicera*														
Mallow Family cf. Globemallow	Malvaceae, *Sphaeralcea*									1				X	
Four O'Clock Family	Nyctaginaceae									2					
Evening Primrose	Onagraceae	X											X	X	
Spruce	*Picea*													1	
Large Pine	*Pinus*	3	7	3	3	4	6		5	1	2		5	9	2
Small Pine	*Pinus edulis* type	9	6	7	4	4	1		1		2		11	4	3
Plantain	*Plantago*														
Prickly Pear	*Platyopuntia*														
Grass Family	*Poaceae*	31	27	16	15	20	20	17	16	22	16		27	26	13
Mesquite	*Prosopis*	1	1				2			1	2				1
cf. Cherry	*Prunus*														
Oak	*Quercus*	5	6	12	3	2	4	2	4	4	3		1	2	3
Javelina bush type	Rhamnaceae														
Rose Family	*Rosaceae*														
Greasewood	*Sarcobatus*						1								
Wolfberry type	Solanaceae									1					
Tidestromia	*Tidestromia*		5	1	2	1	5		6	4		1			
Cattail	*Typha*					1			1	1					
Elm	*Ulmus*														
Verbena	*Verbena*														
Maize	*Zea*													X	
Total Aggregates			1		1		1								2
Sunflower Family Aggregates			1(10)		1(20+)		1(20+)								1(15)
Cheno-am Aggregates															
Tidestromia Aggregates															
Grass Aggregates															
Dimorphocarpa Aggregates													X(8)		1(30+)

Samples from check dams and vicinity

CN/ Field Collection Sample Number		2019-1	2019-10	454	452	453	2019-2	2019-4	2019-3	2019-7
Feature Number					65	65	65			
Sample Depth cm below Surface		0-5	5-8	35	45-50	40-45	7.5	10-15	0-5	8-10
Tracers Counted		38	27	73	178	132	64	82	35	12
Tracer Concentration		20848	20848	19332	19332	19332	20848	20848	20848	20848
Sample Weight		10	10	10	10	10	10	10	10	10
Pollen Sum		140	211	46	107	109	210	107	425	206
Pollen Concentration gr/gm		7680.8	16292.3	1218.2	1162.1	1596.4	6840.8	2720.4	25315.4	35789.1
Taxon Richness		16	11	5	7	9	10	9	17	10
Degraded		27	11	14	16	8	41	32	40	39
Unknown		7	3	1		1	4	3	2	3
Fir	*Abies*									
Acacia	*Acacia*								X	
Acalypha	*Acalypha*									
Alder	*Alnus*									
Ragweed	*Ambrosia*	1					1			
Sagebrush	*Artemisia*								2	
Sunflower Family	Asteraceae	29	128	21	75	76	124	45	246	122
Birch	*Betula*									
Mustard Family	Brassicaceae	2	12			8	6	2	5	8
Pecan	*Carya*	1	X					X	1	
Buckbrush	*Ceanothus*									
Hog Potato	cf. *Hoffmannseggia*									
Cheno-am	Cheno-am	18	11	7	9		11	19	34	7
Doveweed	*Croton*	1	X				1		X	
Juniper	Cupressaceae	8	4	1	1	3	3		25	
Cholla	*Cylindropuntia*									
Spectaclepod	*Dimorphocarpa*		6		1	9	3		3	9
Mormon Tea	*Ephedra*									1
Buckwheat	*Eriogonum*	1								
Crane's Bill	*Erodium*									
Spurge Family	Euphorbiaceae	1			1		1	1		2
Pea Family	Fabaceae									
Sunflower type	*Helianthus* type									
Kallstromia type	*Kallstromia* type									
Ratany	*Krameria*									
Mint Family	Lamiaceae									
Large Grass	Large Poaceae	1								
Creosote	*Larrea*							1		
Chicory	Liguliflorae									
Yucca type	Liliaceae									
Honeysuckle	*Lonicera*									
Mallow Family cf. Globemallow	Malvaceae, *Sphaeralcea*	X						X		1
Four O'Clock Family	Nyctaginaceae					X				
Evening Primrose	Onagraceae								X	1
Spruce	*Picea*									
Large Pine	*Pinus*	6	5					X	7	2
Small Pine	*Pinus edulis* type	3	4						4	
Plantain	*Plantago*								2	
Prickly Pear	*Platyopuntia*							1		
Grass Family	*Poaceae*	20	24	2	3	1	13	3	43	10
Mesquite	*Prosopis*	5				1			X	
cf. Cherry	*Prunus*									
Oak	*Quercus*	8	2		1	1	1		7	
Javelina bush type	Rhamnaceae									
Rose Family	*Rosaceae*								1	
Greasewood	*Sarcobatus*									
Wolfberry type	Solanaceae									
Tidestromia	*Tidestromia*					1				
Cattail	*Typha*									
Elm	*Ulmus*									
Verbena	*Verbena*									
Maize	*Zea*			X						
Total Aggregates		1	1				1		3	1
Sunflower Family Aggregates		1(10)					1(12)		2(20+)	1(100+)
Cheno-am Aggregates										
Tidestromia Aggregates										
Grass Aggregates							X(8)		1(10)	
Dimorphocarpa Aggregates										

Samples from other fields and contexts

CN/ Field Collection Sample Number		2015-108-1	2015-108-2	2015-108-3	2015-108-4	2015-108-5	2014-BHT 2-1	2014-BHT 2-2	2014-BHT 3-1	2014-BHT 3-2	Control
Feature Number		108	108	108	108	108					
Sample Depth cm below Surface											
Tracers Counted		64	53	64	81	69	90	98	404	295	153
Tracer Concentration		18583	18583	18583	18583	18583	18583	18583	18583	18583	18583
Sample Weight		10	10	10	10	10	10	10	10	10	10
Pollen Sum		208	235	211	235	222	104	132	209	204	100
Pollen Concentration gr/gm		6039.5	8239.6	6126.6	5391.4	5978.9	2147.4	2582.1	961.3	1285.1	1214.6
Taxon Richness		13	18	11	13	16	6	6	15	7	7
Degraded		24	31	28	25	28	16	30	21	43	27
Unknown		5		2	3	4	1	2	6	4	3
Fir	*Abies*								1	1	
Acacia	*Acacia*								1		
Acalypha	*Acalypha*										
Alder	*Alnus*								2		
Ragweed	*Ambrosia*										
Sagebrush	*Artemisia*		1								
Sunflower Family	Asteraceae	112	124	120	144	125	62	52	88	86	34
Birch	*Betula*									1	
Mustard Family	Brassicaceae	9	7	7	7	7	3	6	3	7	1
Pecan	*Carya*		1		X	1					
Buckbrush	*Ceanothus*										
Hog Potato	cf. *Hoffmannseggia*										
Cheno-am	Cheno-am	16	29	22	27	19	14	31	29	31	10
Doveweed	*Croton*										
Juniper	Cupressaceae	17	9	12	6	9	1	3	9	4	5
Cholla	*Cylindropuntia*										
Spectaclepod	*Dimorphocarpa*	4	1	2	1	3					
Mormon Tea	*Ephedra*				1	1					
Buckwheat	*Eriogonum*	1	2								1
Crane's Bill	*Erodium*					1					
Spurge Family	Euphorbiaceae	2	4		2	1		3	2	4	5
Pea Family	Fabaceae										
Sunflower type	*Helianthus* type		1								
Kallstromia type	*Kallstromia* type			1		2					
Ratany	*Krameria*										
Mint Family	Lamiaceae										
Large Grass	Large Poaceae	X				X					
Creosote	*Larrea*										
Chicory	Liguliflorae										
Yucca type	Liliaceae						2				1
Honeysuckle	*Lonicera*										
Mallow Family cf. Globemallow	Malvaceae, *Sphaeralcea*										
Four O'Clock Family	Nyctaginaceae										
Evening Primrose	Onagraceae		1		X					X	
Spruce	*Picea*								1		
Large Pine	*Pinus*	1	3	2	2	1			23	4	1
Small Pine	*Pinus edulis* type		2	1	2	1			2	5	
Plantain	*Plantago*										
Prickly Pear	*Platyopuntia*					1					
Grass Family	*Poaceae*	12	9	10	13	12	4	3	12	9	11
Mesquite	*Prosopis*	1	2	3							
cf. Cherry	*Prunus*								1		
Oak	*Quercus*		3		2	2		1	3	2	1
Javelina bush type	Rhamnaceae										
Rose Family	*Rosaceae*			1		3			5	3	
Greasewood	*Sarcobatus*										
Wolfberry type	Solanaceae										
Tidestromia	*Tidestromia*	2	3				1	1			
Cattail	*Typha*										
Elm	*Ulmus*	1	1								
Verbena	*Verbena*										
Maize	*Zea*										
Total Aggregates		1	1			1					
Sunflower Family Aggregates			1(10)			1(25+)					
Cheno-am Aggregates											
Tidestromia Aggregates											
Grass Aggregates		1(12)									
Dimorphocarpa Aggregates											

Appendix C: Geochemical Compositional Analyses

C.1 Ochoa Ware NAA Report

C.2 Chupadero BW NAA Report

C.3 Ochoa Ware Petrographic Report

C.4 Obsidian XRF Report

Appendix C.1 NAA Analysis of Ochoa Ware

Jeffrey R. Ferguson

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Archaeometry Laboratory

Neutron Activation Analysis of Ochoa Ceramics from the Merchant Site (LA43414) in Southern Lea County, New Mexico

ANIDS: MRM781 – MRM860

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Introduction

This report describes the preparation, analysis, and interpretation of 73 Ochoa pottery specimens, four clay samples, and one caliche sample from the Merchant Site (LA43414) in Southeastern New Mexico, and two additional Ochoa pottery specimens from LA121688. The new specimens in this study have been combined with 28 Ochoa Indented specimens from the Merchant Site previously analyzed for Luis Alvarado (Ferguson and Glascock 2007), three Ochoa samples also analyzed for Alvarado from Gaines and Crane counties in Texas, and eleven Ochoa specimens analyzed for Darrell Creel from Andrews, Potter, and Ward counties in Texas. All combined this analysis includes 117 Ochoa ceramic specimens, four clay samples, and one caliche sample. Some descriptive information and group assignments for these specimens are provided in the appended data table.

Ochoa ceramics were likely produced at the Merchant site, and the vast majority of the sample from that site belongs to a single main compositional group. Three additional small groups are identified and mostly represent local production distinct from that of the Merchant site. The caliche sample and one of the clays are clearly distinct from the rest of the specimens. The remaining clays are generally similar to the main cluster, but statistically eliminated as members. Raw clay samples rarely match local ceramics, indication that ceramic paste preparation involved significant modification (mixing, tempering, and/or levigating) of local clays.

Sample Preparation

Pottery specimens were prepared for NAA using procedures standard at MURR. Fragments of about $1cm^2$ were removed from each specimen and abraded using a silicon carbide burr in order to remove slip, paint, and adhering soil, thereby reducing the risk of measuring contamination. The samples were washed in deionized water and allowed to dry in the laboratory. Once dry, the individual sherds were ground to powder in an agate mortar to homogenize the samples. Archival samples were retained from each sherd (when possible) for future research.

Two analytical samples were prepared from each source specimen. Portions of approximately 50 mg of powder were weighed into clean high-density polyethylene vials used for short irradiations at MURR. At the same time, 200 mg samples were weighed into clean high-purity quartz vials used for long irradiations. Individual sample weights were recorded to the nearest 0.01 mg using an analytical balance. Both vials were sealed prior to irradiation. Along with the unknown samples, Standards made from National Institute of Standards and Technology (NIST) certified standard reference materials of SRM-1633a (coal fly ash) and SRM-688 (basalt rock) were similarly prepared, as were quality control samples (e.g., standards treated as unknowns) of SRM-278 (obsidian rock) and Ohio Red Clay (a standard developed for in-house applications).

Irradiation and Gamma-Ray Spectroscopy

Neutron activation analysis of ceramics at MURR, which consists of two irradiations and a total of three gamma counts, constitutes a superset of the procedures used at most other NAA laboratories (Glascock 1992; Neff 1992, 2000). As discussed in detail by Glascock (1992), a short irradiation is carried out through the pneumatic tube irradiation system. Samples in the polyvials are sequentially irradiated, two at a time, for five seconds by a neutron flux of 8×10^{13} n cm^{-2} s^{-1} The 720-second count yields gamma spectra containing peaks for nine short-lived elements aluminum (Al), barium (Ba), calcium (Ca), dysprosium (Dy), potassium (K), manganese (Mn), sodium (Na), titanium (Ti), and vanadium (V). The samples are encapsulated in quartz vials and are subjected to a 24–hour irradiation at a neutron flux of 5×10^{13} n cm^{-2} s^{-1}. This long irradiation is analogous to the single irradiation utilized at most other laboratories. After the long irradiation, samples decay for seven days, and then are counted for 1,800 seconds (the "middle count") on a high-resolution germanium detector coupled to an automatic sample changer. The middle count yields determinations of seven medium half-life elements, namely arsenic (As), lanthanum (La), lutetium (Lu), neodymium (Nd), samarium (Sm), uranium (U), and ytterbium (Yb). After an additional three- or four-week decay, a final count of 8,500 seconds is carried out on each sample. The latter measurement yields the following 17 long half-life elements: cerium (Ce), cobalt (Co), chromium (Cr), cesium (Cs), europium (Eu), iron (Fe), hafnium (Hf), nickel (Ni), rubidium (Rb), antimony (Sb), scandium (Sc), strontium (Sr), tantalum (Ta), terbium (Tb), thorium (Th), zinc (Zn), and zirconium (Zr). The element concentration data from the three measurements are tabulated in parts per million

Interpreting Chemical Data

The analyses at MURR, described above, produced elemental concentration values for 33 elements in most of the analyzed samples. Data for Ni in many samples was below detection limits (as is the norm for most New World ceramics) and was removed from consideration during the statistical analysis.

Use of log concentrations rather than raw data compensates for differences in magnitude between the major elements, such as calcium, and trace elements, such as the rare earth or lanthanide elements (REEs). Transformation to base-10 logarithms also yields a more normal distribution for many trace elements.

The interpretation of compositional data obtained from the analysis of archaeological materials is discussed in detail elsewhere (e.g., Baxter and Buck 2000; Bieber et al. 1976; Bishop and Neff 1989; Glascock 1992; Harbottle 1976; Neff 2000) and will only be summarized here. The main goal of data analysis is to identify distinct homogeneous groups within the analytical database. Based on the provenance postulate of Weigand *et al*. (1977), different chemical groups may be assumed to represent geographically restricted sources. For lithic materials such as obsidian, basalt, and cryptocrystalline silicates (e.g., chert, flint, or jasper), raw material samples are frequently collected from known outcrops or secondary deposits and the compositional data obtained on the samples is used to define the source localities or boundaries. The locations of sources can also be inferred by comparing unknown specimens (i.e., ceramic artifacts) to knowns (i.e., clay samples) or by indirect methods such as the "criterion of abundance" (Bishop *et al*. 1992) or by arguments based on geological and sedimentological characteristics (e.g., Steponaitis *et al*. 1996). The ubiquity of ceramic raw materials usually makes it impossible to sample all potential "sources" intensively enough to create groups of knowns to which unknowns can be compared. Lithic sources tend to be more localized and compositionally homogeneous in the case of obsidian or compositionally heterogeneous as is the case for most cherts.

Compositional groups can be viewed as "centers of mass" in the compositional hyperspace described by the measured elemental data. Groups are characterized by the locations of their centroids and the unique relationships (i.e., correlations) between the elements. Decisions about whether to assign a specimen to a particular compositional group are based on the overall probability that the measured concentrations for the specimen could have been obtained from that group.

Initial hypotheses about source-related subgroups in the compositional data can be derived from non-compositional information (e.g., archaeological context, decorative attributes, etc.) or from application of various pattern-recognition techniques to the multivariate chemical data. Some of the pattern recognition techniques that have been used to investigate archaeological data sets are cluster analysis (CA), principal components analysis (PCA), and discriminant analysis (DA). Each of the techniques has its own advantages and disadvantages which may depend upon the types and quantity of data available for interpretation.

The variables (measured elements) in archaeological and geological data sets are often correlated and frequently large in number. This makes handling and interpreting patterns within the data difficult. Therefore, it is often useful to transform the original variables into a smaller set of uncorrelated variables in order to make data interpretation easier. Of the above-mentioned pattern recognition techniques, PCA is a technique that transforms from the data from the original correlated variables into uncorrelated variables most easily.

PCA creates a new set of reference axes arranged in decreasing order of variance subsumed. The individual PCs are linear combinations of the original variables. The data can be displayed on combinations of the new axes, just as they can be displayed on the original elemental concentration axes. PCA can be used in a pure pattern-recognition mode, i.e., to search for subgroups in an undifferentiated data set, or in a more evaluative mode, i.e., to assess the coherence of hypothetical groups suggested by other criteria. Generally, compositional differences between specimens can be expected to be larger for specimens in different groups than for specimens in the same group, and this implies that groups should be detectable as distinct areas of high point density on plots of the first few components. It is well known that PCA of chemical data is scale dependent (Mardia *et al*. 1979), and analyses tend to be dominated by those elements or isotopes for which the concentrations are relatively large. This is yet another reason for the log transformation of the data.

One frequently exploited strength of PCA, discussed by Baxter (1992), Baxter and Buck (2000z), and Neff (1994, 2002), is that it can be applied as a simultaneous R- and Q-mode technique, with both variables (elements) and objects (individual analyzed samples) displayed on the same set of principal component reference axes. A plot using the first two principal components as axes is usually the best possible two-dimensional representation of the correlation or variance-covariance structure within the data set. Small angles between the vectors from the origin to variable coordinates indicate strong positive correlation; angles at 90 degrees indicate no correlation; and angles close to 180 degrees indicate strong negative correlation. Likewise, a plot of sample coordinates on these same axes will be the best two-dimensional representation of Euclidean relations among the samples in log-concentration space (if the PCA was based on the variance-covariance matrix) or standardized log-concentration space (if the PCA was based on the correlation matrix). Displaying both objects and variables on the same plot makes it possible to observe the contributions of specific elements to group separation and to the distinctive shapes of the various groups. Such a plot is commonly referred to as a “biplot” in reference to the simultaneous plotting of objects and variables. The variable inter-relationships inferred from a biplot can be verified directly by inspecting bivariate elemental concentration plots. [Note that a bivariate plot of elemental concentrations is not a biplot.]

Whether a group can be discriminated easily from other groups can be evaluated visually in two dimensions or statistically in multiple dimensions. A metric known as the Mahalanobis distance (or generalized distance) makes it possible to describe the separation between groups or between individual samples and groups on multiple dimensions. The Mahalanobis distance of a specimen from a group centroid (Bieber *et al*. 1976, Bishop and Neff 1989) is defined by:

$$D^2_{y,X} = [y - \overline{X}]^t I_x [y - \overline{X}]$$

where y is the 1 x m array of logged elemental concentrations for the specimen of interest, X is the n x m data matrix of logged concentrations for the group to which the point is being compared with $\overline{X}$ being it 1 x m centroid, and I_x is the inverse of the m x m variance-covariance matrix of group X. Because Mahalanobis distance takes into account variances and covariances in the multivariate group it is analogous to expressing distance from a univariate mean in standard deviation units.

Like standard deviation units, Mahalanobis distances can be converted into probabilities of group membership for individual specimens. For relatively small sample sizes, it is appropriate to base probabilities on Hotelling's T^2, which is the multivariate extension of the univariate Student's t.

When group sizes are small, Mahalanobis distance-based probabilities can fluctuate dramatically depending upon whether or not each specimen is assumed to be a member of the group to which it is being compared. Harbottle (1976) calls this phenomenon "stretchability" in reference to the tendency of an included specimen to stretch the group in the direction of its own location in elemental concentration space. This problem can be circumvented by cross-validation, that is, by removing each specimen from its presumed group before calculating its own probability of membership (Baxter 1994; Leese and Main 1994). This is a conservative approach to group evaluation that may sometimes exclude true group members.

Small sample and group sizes place further constraints on the use of Mahalanobis distance: with more elements than samples, the group variance-covariance matrix is singular thus rendering calculation of I_x (and D^2 itself) impossible. Therefore, the dimensionality of the groups must somehow be reduced. One approach would be to eliminate elements considered irrelevant or redundant. The problem with this approach is that the investigator's preconceptions about which elements should be discriminate may not be valid. It also squanders the main advantage of multielement analysis, namely the capability to measure a large number of elements. An alternative approach is to calculate Mahalanobis distances with the scores on principal components extracted from the variance-covariance or correlation matrix for the complete data set. This approach entails only the assumption, entirely reasonable in light of the above discussion of PCA, that most group-separating differences should be visible on the first several PCs. Unless a data set is extremely complex, containing numerous distinct groups, using enough components to subsume at least 90% of the total variance in the data can be generally assumed to yield Mahalanobis distances that approximate Mahalanobis distances in full elemental concentration space.

Lastly, Mahalanobis distance calculations are also quite useful for handling missing data (Sayre 1975). When many specimens are analyzed for a large number of elements, it is almost certain that a few element concentrations will be missed for some of the specimens. This occurs most frequently when the concentration for an element is near the detection limit. Rather than eliminate the specimen or the element from consideration, it is possible to substitute a missing value by replacing it with a value that minimizes the Mahalanobis distance for the specimen from the group centroid. Thus, those few specimens which are missing a single concentration value can still be used in group calculations.

Results

The small groups presented here (Groups 1, 3, and 4) have been identified through visual inspection of elemental scatterplots. These small groups are difficult to statistically validate because of their low number of members. Robust statistical tests such as Mahalanobis distance require more members than variables. While it is possible to use a reduced number of variables through techniques such as principal component analysis, the tests remain unreliable with such small groups. These small groups represent distinct clusters, but they are also more prone to including unrelated members that can only be detected when future sampling increases the group membership to the point of allowing more robust tests. Thus, these small groups should be considered tentative.

Figure C.1.1 shows all samples in the study except for the four outliers (two ceramic specimens, one clay, and one caliche). Group 1 has elevated concentrations of Na, K, Al, and most rare earth elements (Figure C.1.2). Group 3 represents a small distinct central cluster. Group 4 consists of only three members with particularly low concentrations of Fe and K. The Main group is the primary cluster of specimens after removal of the small groups and unassigned. The main group was further refined by calculating group membership probability by Mahalanobis distance. Any samples generally plotting with the main group but removed because of low group membership probability are designated as a special type of unassigned (Main Group unassigned) to indicate that they have greater affiliation with the Main group then the general unassigned specimens.

All five members of Group 1 are from the Merchant site. Given the current sample, it is not possible to determine if this group represents a smaller production recipe at the Merchant site, or Ochoa ceramics produced elsewhere and imported to the Merchant Site. Continued regional sampling may help to clarify the production location of Group 1. Only one member of Group 3 and none of Group 4 are from the Merchant site assemblage. Groups 3 and 4 are composed primarily of Ochoa ceramics from sites near Andrews Lake and may represent production in that area. The one member of Group 3 recovered from the Merchant site may have resulted from the rare long-distant movement of Ochoa ceramics. The Main Group clearly represents local production of Ochoa ceramics at the Merchant Site. None of the Main Group (even including the Main Group Unassigned) were included in the assemblages from any other site.

The caliche sample (MRM795) and one of the clays (MRM792) are clearly distinct from the rest of the specimens and classified as outliers in this study. The remaining clay samples (MRM791, MRM793, and MRM794) are generally similar to the main cluster, but statistically eliminated as members. Raw clay samples rarely match local ceramics, indication that ceramic paste preparation involved significant modification (mixing, tempering, and/or levigating) of local clays.

Conclusions

This study highlights two main points. First, Ochoa ceramics were most likely produced at the Merchant site as indicated by the overwhelming abundance of one main compositional group and the general similarity to multiple local clay samples. Second, Ochoa ceramics were not regularly moved around the landscape. The Merchant site production recipe does not occur in the limited sampling of other sites, and there is also little evidence of import of ceramic to the Merchant site.

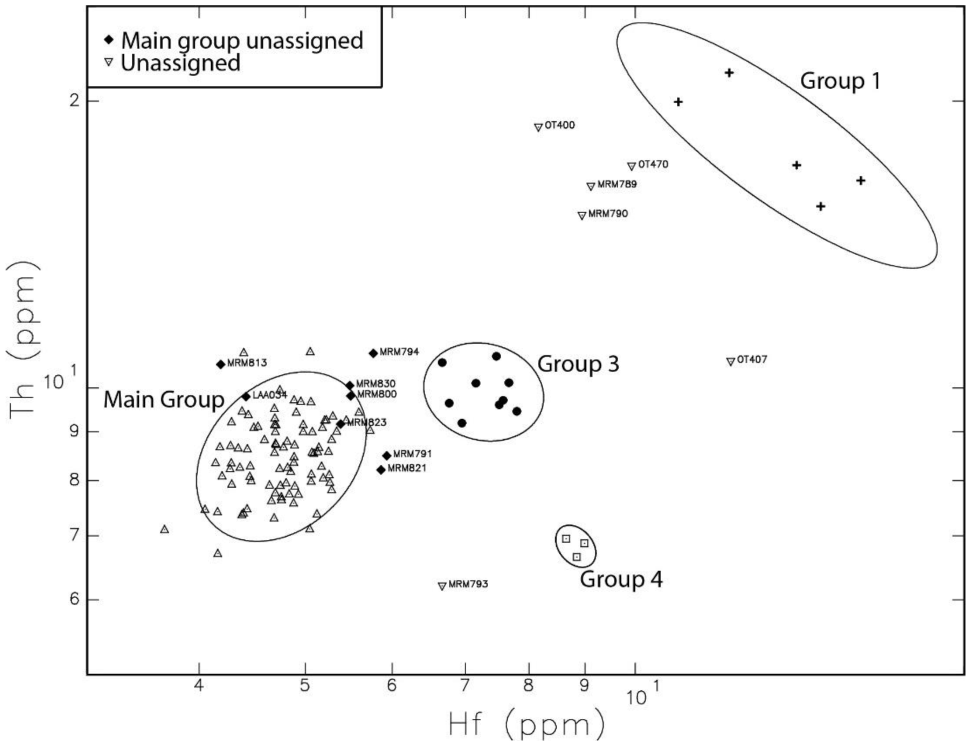

Figure C.1.1. Scatterplot of thorium and hafnium for all specimens in this study except for the four outliers. The ellipses represent 90% confidence intervals for membership in the groups. Unassigned specimens are individually labeled.

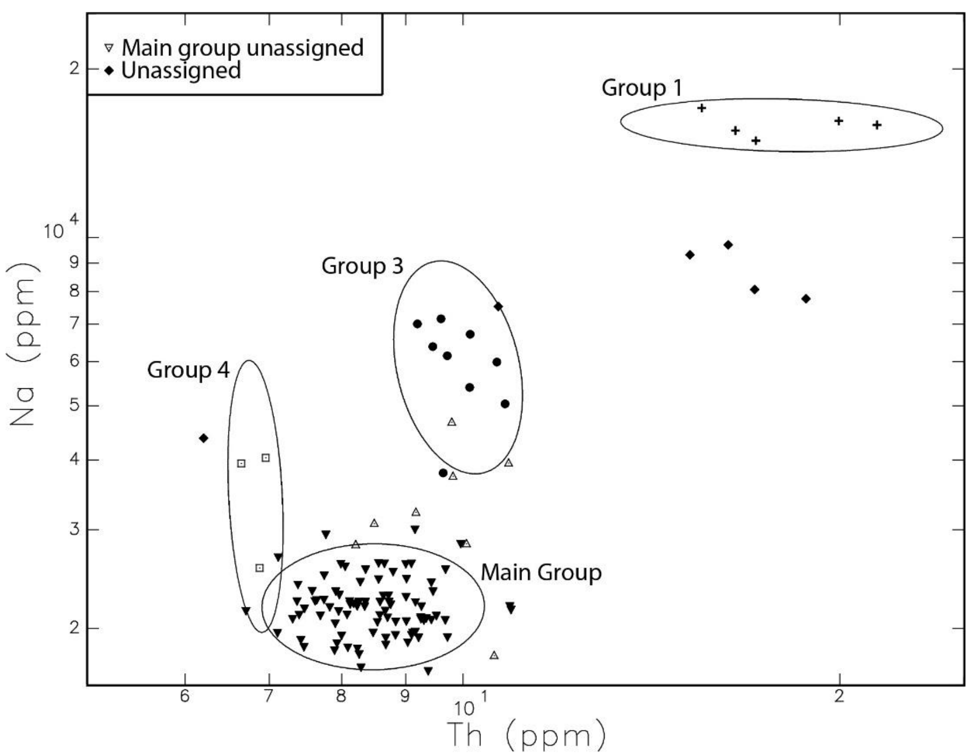

Figure C.1.2. Scatterplot of thorium and sodium for all specimens in this study except for the four outliers. The ellipses represent 90% confidence intervals for membership in the groups.

Table C.1.1. Compositional Group distribution by site

	Compositional Group							
Site	**Group 1**	**Group 3**	**Group 4**	**Main Group**	**Main Unas**	**Unas**	**Outlier**	**Total**
Merchant site	5	1		87	8	1	4	106
LA 121688						2		2
1N-8						1		1
Andrews Lake		6	2			1		9
L:3:5			1					1
Q:10:2		1						1
Q:10:8		1						1
Q:5:5						1		1
Total	**5**	**9**	**3**	**87**	**8**	**6**	**4**	**122**

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Appendix: Group assignment and other descriptive information

ANID	Comp Group	Investigator	Site_Name	Site_No	Ceramic_Type
LAA027	Main Group	Alvarado, Luis	Merchant site	LA 43414	Ochoa Indented
LAA028	Main Group	Alvarado, Luis	Merchant site	LA 43414	Ochoa Indented
LAA029	Main Group	Alvarado, Luis	Merchant site	LA 43414	Ochoa Indented
LAA030	Main Group	Alvarado, Luis	Merchant site	LA 43414	Ochoa Indented
LAA031	Main Group	Alvarado, Luis	Merchant site	LA 43414	Ochoa Indented
LAA032	Main Group	Alvarado, Luis	Merchant site	LA 43414	Ochoa Indented
LAA033	Main Group	Alvarado, Luis	Merchant site	LA 43414	Ochoa Indented
LAA034	Main Unas	Alvarado, Luis	Merchant site	LA 43414	Ochoa Indented
LAA035	Main Group	Alvarado, Luis	Merchant site	LA 43414	Ochoa Indented
LAA036	Main Group	Alvarado, Luis	Merchant site	LA 43414	Ochoa Indented
LAA037	Group 1	Alvarado, Luis	Merchant site	LA 43414	Ochoa Indented
LAA038	Main Group	Alvarado, Luis	Merchant site	LA 43414	Ochoa Indented
LAA039	Main Group	Alvarado, Luis	Merchant site	LA 43414	Ochoa Indented
LAA040	Main Group	Alvarado, Luis	Merchant site	LA 43414	Ochoa Indented
LAA041	Main Group	Alvarado, Luis	Merchant site	LA 43414	Ochoa Indented
LAA042	Main Group	Alvarado, Luis	Merchant site	LA 43414	Ochoa Indented
LAA043	Main Group	Alvarado, Luis	Merchant site	LA 43414	Ochoa Indented
LAA044	Main Group	Alvarado, Luis	Merchant site	LA 43414	Ochoa Indented
LAA045	Main Group	Alvarado, Luis	Merchant site	LA 43414	Ochoa Indented
LAA046	Main Group	Alvarado, Luis	Merchant site	LA 43414	Ochoa Indented
LAA047	Main Group	Alvarado, Luis	Merchant site	LA 43414	Ochoa Indented
LAA048	Main Group	Alvarado, Luis	Merchant site	LA 43414	Ochoa Indented
LAA049	Main Group	Alvarado, Luis	Merchant site	LA 43414	Ochoa Indented
LAA050	Main Group	Alvarado, Luis	Merchant site	LA 43414	Ochoa Indented
LAA051	Group 3	Alvarado, Luis	Merchant site	LA 43414	Ochoa Indented
LAA052	Main Group	Alvarado, Luis	Merchant site	LA 43414	Ochoa Indented
LAA053	Main Group	Alvarado, Luis	Merchant site	LA 43414	Ochoa Indented
LAA054	Main Group	Alvarado, Luis	Merchant site	LA 43414	Ochoa Indented
LAA085	Group 4	Alvarado, Luis	L:3:5		Ochoa Indented
LAA089	Group 3	Alvarado, Luis	O:10:2		Ochoa Indented
LAA090	Group 3	Alvarado, Luis	O:10:8		Ochoa Indented
MRM781	Outlier	Miller, Myles	MVS	LA 43414	Corona?
MRM782	Group 1	Miller, Myles	MVS	LA 43414	Ochoa
MRM783	Group 1	Miller, Myles	MVS	LA 43414	Ochoa
MRM784	Outlier	Miller, Myles	MVS	LA 43414	Caliche
MRM785	Main Group	Miller, Myles	MVS	LA 43414	Ochoa?
MRM786	Main Group	Miller, Myles	MVS	LA 43414	Ochoa
MRM787	Group 1	Miller, Myles	MVS	LA 43414	Ochoa?
MRM788	Group 1	Miller, Myles	MVS	LA 43414	Ochoa?
MRM789	Unassigned	Miller, Myles	PS	LA 121688	Ochoa?
MRM790	Unassigned	Miller, Myles	PS	LA 121688	Ochoa?
MRM791	Main Unas	Miller, Myles	Merchant site	LA 43414	clay

MRM792	Outlier	Miller, Myles	Merchant site	LA 43414	clay
MRM793	Unassigned	Miller, Myles	Merchant site	LA 43414	clay
MRM794	Main Unas	Miller, Myles	Merchant site	LA 43414	clay
MRM795	Outlier	Miller, Myles	Merchant site	LA 43414	caliche
MRM796	Main Group	Miller, Myles	Merchant site	LA 43414	Ochoa
MRM797	Main Group	Miller, Myles	Merchant site	LA 43414	Ochoa
MRM798	Main Group	Miller, Myles	Merchant site	LA 43414	Ochoa
MRM799	Main Group	Miller, Myles	Merchant site	LA 43414	Ochoa
MRM800	Main Unas	Miller, Myles	Merchant site	LA 43414	Ochoa
MRM801	Main Group	Miller, Myles	Merchant site	LA 43414	Ochoa
MRM802	Main Group	Miller, Myles	Merchant site	LA 43414	Ochoa
MRM803	Main Group	Miller, Myles	Merchant site	LA 43414	Ochoa
MRM804	Main Group	Miller, Myles	Merchant site	LA 43414	Ochoa
MRM805	Main Group	Miller, Myles	Merchant site	LA 43414	Ochoa
MRM806	Main Group	Miller, Myles	Merchant site	LA 43414	Ochoa
MRM807	Main Group	Miller, Myles	Merchant site	LA 43414	Ochoa
MRM808	Main Group	Miller, Myles	Merchant site	LA 43414	Ochoa
MRM809	Main Group	Miller, Myles	Merchant site	LA 43414	Ochoa
MRM810	Main Group	Miller, Myles	Merchant site	LA 43414	Ochoa
MRM811	Main Group	Miller, Myles	Merchant site	LA 43414	Ochoa
MRM812	Main Group	Miller, Myles	Merchant site	LA 43414	Ochoa
MRM813	Main Unas	Miller, Myles	Merchant site	LA 43414	Ochoa
MRM814	Main Group	Miller, Myles	Merchant site	LA 43414	Ochoa
MRM815	Main Group	Miller, Myles	Merchant site	LA 43414	Ochoa
MRM816	Main Group	Miller, Myles	Merchant site	LA 43414	Ochoa
MRM817	Main Group	Miller, Myles	Merchant site	LA 43414	Ochoa
MRM818	Main Group	Miller, Myles	Merchant site	LA 43414	Ochoa
MRM819	Main Group	Miller, Myles	Merchant site	LA 43414	Ochoa
MRM820	Main Group	Miller, Myles	Merchant site	LA 43414	Ochoa
MRM821	Main Unas	Miller, Myles	Merchant site	LA 43414	Ochoa
MRM822	Main Group	Miller, Myles	Merchant site	LA 43414	Ochoa
MRM823	Main Unas	Miller, Myles	Merchant site	LA 43414	Ochoa
MRM824	Main Group	Miller, Myles	Merchant site	LA 43414	Ochoa
MRM825	Main Group	Miller, Myles	Merchant site	LA 43414	Ochoa
MRM826	Main Group	Miller, Myles	Merchant site	LA 43414	Ochoa
MRM827	Main Group	Miller, Myles	Merchant site	LA 43414	Ochoa
MRM828	Main Group	Miller, Myles	Merchant site	LA 43414	Ochoa
MRM829	Main Group	Miller, Myles	Merchant site	LA 43414	Ochoa
MRM830	Main Unas	Miller, Myles	Merchant site	LA 43414	Ochoa
MRM831	Main Group	Miller, Myles	Merchant site	LA 43414	Ochoa
MRM832	Main Group	Miller, Myles	Merchant site	LA 43414	Ochoa
MRM833	Main Group	Miller, Myles	Merchant site	LA 43414	Ochoa
MRM834	Main Group	Miller, Myles	Merchant site	LA 43414	Ochoa
MRM835	Main Group	Miller, Myles	Merchant site	LA 43414	Ochoa
MRM836	Main Group	Miller, Myles	Merchant site	LA 43414	Ochoa

MRM837	Main Group	Miller, Myles	Merchant site	LA 43414	Ochoa
MRM838	Main Group	Miller, Myles	Merchant site	LA 43414	Ochoa
MRM839	Main Group	Miller, Myles	Merchant site	LA 43414	Ochoa
MRM840	Main Group	Miller, Myles	Merchant site	LA 43414	Ochoa
MRM841	Main Group	Miller, Myles	Merchant site	LA 43414	Ochoa
MRM842	Main Group	Miller, Myles	Merchant site	LA 43414	Ochoa
MRM843	Main Group	Miller, Myles	Merchant site	LA 43414	Ochoa
MRM844	Main Group	Miller, Myles	Merchant site	LA 43414	Ochoa
MRM845	Main Group	Miller, Myles	Merchant site	LA 43414	Ochoa
MRM846	Main Group	Miller, Myles	Merchant site	LA 43414	Ochoa
MRM847	Main Group	Miller, Myles	Merchant site	LA 43414	Ochoa
MRM848	Main Group	Miller, Myles	Merchant site	LA 43414	Ochoa
MRM849	Main Group	Miller, Myles	Merchant site	LA 43414	Ochoa
MRM850	Main Group	Miller, Myles	Merchant site	LA 43414	Ochoa
MRM851	Main Group	Miller, Myles	Merchant site	LA 43414	Ochoa
MRM852	Main Group	Miller, Myles	Merchant site	LA 43414	Ochoa
MRM853	Main Group	Miller, Myles	Merchant site	LA 43414	Ochoa
MRM854	Main Group	Miller, Myles	Merchant site	LA 43414	Ochoa
MRM855	Main Group	Miller, Myles	Merchant site	LA 43414	Ochoa
MRM856	Main Group	Miller, Myles	Merchant site	LA 43414	Ochoa
MRM857	Main Group	Miller, Myles	Merchant site	LA 43414	Ochoa
MRM858	Main Group	Miller, Myles	Merchant site	LA 43414	Ochoa
MRM859	Main Group	Miller, Myles	Merchant site	LA 43414	Ochoa
MRM860	Main Group	Miller, Myles	Merchant site	LA 43414	Ochoa
OT400	Unassigned	Creel, Darrell	1N-8		Ochoa Brown
OT401	Group 4	Creel, Darrell	Andrews Lake	41AD2	Ochoa Brown
OT402	Group 3	Creel, Darrell	Andrews Lake	41AD2	Ochoa Brown
OT403	Group 4	Creel, Darrell	Andrews Lake	41AD2	Ochoa Brown
OT404	Group 3	Creel, Darrell	Andrews Lake	41AD2	Ochoa Brown
OT405	Group 3	Creel, Darrell	Andrews Lake	41AD2	Ochoa Brown
OT406	Group 3	Creel, Darrell	Andrews Lake	41AD2	Ochoa Brown
OT407	Unassigned	Creel, Darrell	Andrews Lake	41AD2	Ochoa Brown
OT408	Group 3	Creel, Darrell	Andrews Lake	41AD2	Ochoa Brown
OT409	Group 3	Creel, Darrell	Andrews Lake	41AD2	Ochoa Brown
OT470	Unassigned	Creel, Darrell	Q:5:5		Ochoa Indented

Appendix C.2 NAA Analysis of Chupadero Black-on-White

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Neutron Activation Analysis of Chupadero Black-on-white Ceramics from Two Sites in Southern Lea County, New Mexico

ANIDS: MRM761 – MRM780

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Introduction

This report describes the preparation, analysis, and interpretation of 20 pottery specimens from two sites in southern Lea County, New Mexico. The sample is entirely Chupadero Black-on-white ceramics, although the compositional data suggest the type designation for one sample may be incorrect. Chupadero Black-on-white ceramics were produced in a relatively limited area but exchanged across much of southern NM and parts of Texas (Creel et al. 2002). The majority of the specimens match groups linked to production in the Capitan Mountains, while a few were likely produced in the Salinas area.

Sample Preparation

Pottery specimens were prepared for NAA using procedures standard at MURR. Fragments of about 1cm^2 were removed from each specimen and abraded using a silicon carbide burr in order to remove slip, paint, and adhering soil, thereby reducing the risk of measuring contamination. The samples were washed in deionized water and allowed to dry in the laboratory. Once dry, the individual sherds were ground to powder in an agate mortar to homogenize the samples. Archival samples were retained from each sherd (when possible) for future research.

Two analytical samples were prepared from each source specimen. Portions of approximately 50 mg of powder were weighed into clean high-density polyethylene vials used for short irradiations at MURR. At the same time, 200 mg samples were weighed into clean high-purity quartz vials used for long irradiations. Individual sample weights were recorded to the nearest 0.01 mg using an analytical balance. Both vials were sealed prior to irradiation. Along with the unknown samples, Standards made from National Institute of Standards and Technology (NIST) certified standard reference materials of SRM-1633a (coal fly ash) and SRM-688 (basalt rock) were similarly prepared, as were quality control samples (e.g., standards treated as unknowns) of SRM-278 (obsidian rock) and Ohio Red Clay (a standard developed for in-house applications).

Irradiation and Gamma-Ray Spectroscopy

Neutron activation analysis of ceramics at MURR, which consists of two irradiations and a total of three gamma counts, constitutes a superset of the procedures used at most other NAA laboratories (Glascock 1992; Neff 1992, 2000). As discussed in detail by Glascock (1992), a short irradiation is carried out through the pneumatic tube irradiation system. Samples in the polyvials are sequentially irradiated, two at a time, for five seconds by a neutron flux of 8 x 10^{13} n cm^{-2} s^{-1} The 720-second count yields gamma spectra containing peaks for nine short-lived elements aluminum (Al), barium (Ba), calcium (Ca), dysprosium (Dy), potassium (K), manganese (Mn), sodium (Na), titanium (Ti), and vanadium (V). The samples are encapsulated in quartz vials and are subjected to a 24–hour irradiation at a neutron flux of 5 x 10^{13} n cm^{-2} s^{-1}. This long irradiation is analogous to the single irradiation utilized at most other laboratories. After the long irradiation, samples decay for seven days, and then are counted for 1,800 seconds (the "middle count") on a high-resolution germanium detector coupled to an automatic sample changer. The middle count yields determinations of seven medium half-life elements, namely arsenic (As), lanthanum (La), lutetium (Lu), neodymium (Nd), samarium (Sm), uranium (U), and ytterbium (Yb). After an additional three- or four-week decay, a final count of 8,500 seconds is carried out on each sample. The latter measurement yields the following 17 long half-life elements: cerium (Ce), cobalt (Co), chromium (Cr), cesium (Cs), europium (Eu), iron (Fe), hafnium (Hf), nickel (Ni), rubidium (Rb), antimony (Sb), scandium (Sc), strontium (Sr), tantalum (Ta), terbium (Tb), thorium (Th), zinc (Zn), and zirconium (Zr). The element concentration data from the three measurements are tabulated in parts per million

Interpreting Chemical Data

The analyses at MURR, described above, produced elemental concentration values for 33 elements in most of the analyzed samples. Data for Ni in many samples was below detection limits (as is the norm for most New World ceramics) and was removed from consideration during the statistical analysis.

Use of log concentrations rather than raw data compensates for differences in magnitude between the major elements, such as calcium, and trace elements, such as the rare earth or lanthanide elements (REEs). Transformation to base-10 logarithms also yields a more normal distribution for many trace elements.

The interpretation of compositional data obtained from the analysis of archaeological materials is discussed in detail elsewhere (e.g., Baxter and Buck 2000; Bieber et al. 1976; Bishop and Neff 1989; Glascock 1992; Harbottle 1976; Neff 2000) and will only be summarized here. The main goal of data analysis is to identify distinct homogeneous groups within the analytical database. Based on the provenance postulate of Weigand *et al*. (1977), different chemical groups may be assumed to represent geographically restricted sources. For lithic materials such as obsidian, basalt, and cryptocrystalline silicates (e.g., chert, flint, or jasper), raw material samples are frequently collected from known outcrops or secondary deposits and the compositional data obtained on the samples is used to define the source localities or boundaries. The locations of sources can also be inferred by comparing unknown specimens (i.e., ceramic artifacts) to knowns (i.e., clay samples) or by indirect methods such as the "criterion of abundance" (Bishop *et al*. 1992) or by arguments based on geological and sedimentological characteristics (e.g., Steponaitis *et al*. 1996). The ubiquity of ceramic raw materials usually makes it impossible to sample all potential "sources" intensively enough to create groups of knowns to which unknowns can be compared. Lithic sources tend to be more localized and compositionally homogeneous in the case of obsidian or compositionally heterogeneous as is the case for most cherts.

Compositional groups can be viewed as "centers of mass" in the compositional hyperspace described by the measured elemental data. Groups are characterized by the locations of their centroids and the unique relationships (i.e., correlations) between the elements. Decisions about whether to assign a specimen to a particular compositional group are based on the overall probability that the measured concentrations for the specimen could have been obtained from that group.

Initial hypotheses about source-related subgroups in the compositional data can be derived from non-compositional information (e.g., archaeological context, decorative attributes, etc.) or from application of various pattern-recognition techniques to the multivariate chemical data. Some of the pattern recognition techniques that have been used to investigate archaeological data sets are cluster analysis (CA), principal components analysis (PCA), and discriminant analysis (DA). Each of the techniques has its own advantages and disadvantages which may depend upon the types and quantity of data available for interpretation.

The variables (measured elements) in archaeological and geological data sets are often correlated and frequently large in number. This makes handling and interpreting patterns within the data difficult. Therefore, it is often useful to transform the original variables into a smaller set of uncorrelated variables in order to make data interpretation easier. Of the above-mentioned pattern recognition techniques, PCA is a technique that transforms from the data from the original correlated variables into uncorrelated variables most easily.

PCA creates a new set of reference axes arranged in decreasing order of variance subsumed. The individual PCs are linear combinations of the original variables. The data can be displayed on combinations of the new axes, just as they can be displayed on the original elemental concentration axes. PCA can be used in a pure pattern-recognition mode, i.e., to search for subgroups in an undifferentiated data set, or in a more evaluative mode, i.e., to assess the coherence of hypothetical groups suggested by other criteria. Generally, compositional differences between specimens can be expected to be larger for specimens in different groups than for specimens in the same group, and this implies that groups should be detectable as distinct areas of high point density on plots of the first few components. It is well known that PCA of chemical data is scale dependent (Mardia *et al*. 1979), and analyses tend to be dominated by those elements or isotopes for which the concentrations are relatively large. This is yet another reason for the log transformation of the data.

One frequently exploited strength of PCA, discussed by Baxter (1992), Baxter and Buck (2000z), and Neff (1994, 2002), is that it can be applied as a simultaneous R- and Q-mode technique, with both variables (elements) and objects (individual analyzed samples) displayed on the same set of principal component reference axes. A plot using the first two principal components as axes is usually the best possible two-dimensional representation of the correlation or variance-covariance structure within the data set. Small angles between the vectors from the origin to variable coordinates indicate strong positive correlation; angles at 90 degrees indicate no correlation; and angles close to 180 degrees indicate strong negative correlation. Likewise, a plot of sample coordinates on these same axes will be the best two-dimensional representation of Euclidean relations among the samples in log-concentration space (if the PCA was based on the variance-covariance matrix) or standardized log-concentration space (if the PCA was based on the correlation matrix). Displaying both objects and variables on the same plot makes it possible to observe the contributions of specific elements to group separation and to the distinctive shapes of the various groups. Such a plot is commonly referred to as a “biplot” in reference to the simultaneous plotting of objects and variables. The variable inter-relationships inferred from a biplot can be verified directly by inspecting bivariate elemental concentration plots. [Note that a bivariate plot of elemental concentrations is not a biplot.]

Whether a group can be discriminated easily from other groups can be evaluated visually in two dimensions or statistically in multiple dimensions. A metric known as the Mahalanobis distance (or generalized distance) makes it possible to describe the separation between groups or between individual samples and groups on multiple dimensions. The Mahalanobis distance of a specimen from a group centroid (Bieber *et al*. 1976, Bishop and Neff 1989) is defined by:

$$D^2_{y,X} = [y - \overline{X}]^t I_x [y - \overline{X}]$$

where y is the 1 x m array of logged elemental concentrations for the specimen of interest, X is the n x m data matrix of logged concentrations for the group to which the point is being compared with $\overline{X}$ being it 1 x m centroid, and I_x is the inverse of the m x m variance-covariance matrix of group X. Because Mahalanobis distance takes into account variances and covariances in the multivariate group it is analogous to expressing distance from a univariate mean in standard deviation units. Like standard deviation units, Mahalanobis distances can be converted into probabilities of group membership for individual specimens. For relatively small sample sizes, it is appropriate to base probabilities on Hotelling’s T^2, which is the multivariate extension of the univariate Student’s t.

When group sizes are small, Mahalanobis distance-based probabilities can fluctuate dramatically depending upon whether or not each specimen is assumed to be a member of the group to which it is being compared. Harbottle (1976) calls this phenomenon “stretchability” in reference to the tendency of an included specimen to stretch the group in the direction of its own location in elemental concentration space. This problem can be circumvented by cross-validation, that is, by removing each specimen from its presumed group before calculating its own probability of membership (Baxter 1994; Leese and Main 1994). This is a conservative approach to group evaluation that may sometimes exclude true group members.

Small sample and group sizes place further constraints on the use of Mahalanobis distance: with more elements than samples, the group variance-covariance matrix is singular thus rendering calculation of I_x (and D^2 itself) impossible. Therefore, the dimensionality of the groups must somehow be reduced. One approach would be to eliminate elements considered irrelevant or redundant. The problem with this approach is that the investigator's preconceptions about which elements should be discriminate may not be valid. It also squanders the main advantage of multielement analysis, namely the capability to measure a large number of elements. An alternative approach is to calculate Mahalanobis distances with the scores on principal components extracted from the variance-covariance or correlation matrix for the complete data set. This approach entails only the assumption, entirely reasonable in light of the above discussion of PCA, that most group-separating differences should be visible on the first several PCs. Unless a data set is extremely complex, containing numerous distinct groups, using enough components to subsume at least 90% of the total variance in the data can be generally assumed to yield Mahalanobis distances that approximate Mahalanobis distances in full elemental concentration space.

Lastly, Mahalanobis distance calculations are also quite useful for handling missing data (Sayre 1975). When many specimens are analyzed for a large number of elements, it is almost certain that a few element concentrations will be missed for some of the specimens. This occurs most frequently when the concentration for an element is near the detection limit. Rather than eliminate the specimen or the element from consideration, it is possible to substitute a missing value by replacing it with a value that minimizes the Mahalanobis distance for the specimen from the group centroid. Thus, those few specimens which are missing a single concentration value can still be used in group calculations.

<u>Results</u>

The specimens in this study were directly compared to the Chupadero compositional groups. Creel et al. 2002 provide the most recent description of Chupadero reference groups, including assessments of likely production areas for the reference groups. They identify eleven Chupadero reference groups. Table C.2.1 is a list of some of the descriptive information along with group assignments for the specimens in this project.

Table C.2.1. Group assignment, production location, and other descriptive information

ANID	Comp group	Probable Production Location	Alt_ID	Site_No
MRM761	Chup1a	Capitan Mtns - Robinson Pueblo	12	LA 43414
MRM762	Chup1b	Capitan Mtns - Robinson Pueblo	64	LA 43414
MRM763	Chup1b	Capitan Mtns - Robinson Pueblo	235	LA 43414
MRM764	Chup1b	Capitan Mtns - Robinson Pueblo	285	LA 43414
MRM765	Chup1b	Capitan Mtns - Robinson Pueblo	326	LA 43414
MRM766	Chup1b	Capitan Mtns - Robinson Pueblo	328	LA 43414
MRM767	Chup1b	Capitan Mtns - Robinson Pueblo	381	LA 43414
MRM768	Chup2b	Salinas - Quarai Pueblo	429	LA 43414
MRM769	Chup1b	Capitan Mtns - Robinson Pueblo	455	LA 43414
MRM770	Chup1c	Capitan Mtns - Robinson Pueblo	456	LA 43414

MRM771	Chup1c	Capitan Mtns - Robinson Pueblo	102	LA 43414
MRM772	unas	Ochoa Indented? (Merchant Site)	338	LA 43414
MRM773	Chup1b	Capitan Mtns - Robinson Pueblo	12	LA 121668
MRM774	Chup1b	Capitan Mtns - Robinson Pueblo	23	LA 121668
MRM775	Chup2e/2b	Salinas - Quarai Pueblo	24	LA 121668
MRM776	Chup2b	Salinas - Quarai Pueblo	32	LA 121668
MRM777	Chup1b	Capitan Mtns - Robinson Pueblo	34	LA 121668
MRM778	Chup1a	Capitan Mtns - Robinson Pueblo	36	LA 121668
MRM779	Chup1b	Capitan Mtns - Robinson Pueblo	56	LA 121668
MRM780	Chup1a	Capitan Mtns - Robinson Pueblo		LA 121669

Although the Chupadero groups are compositionally distinct, it is difficult to show all the separation in a single plot. Figure C.2.1 shows all of the groups present in this study. The Chupadero data primarily split into two parts with the "1" groups having higher thorium than the "2" groups. Figure C.2.2 shows only the Chupadero "1" groups present in this study and the associated specimens individually labeled.

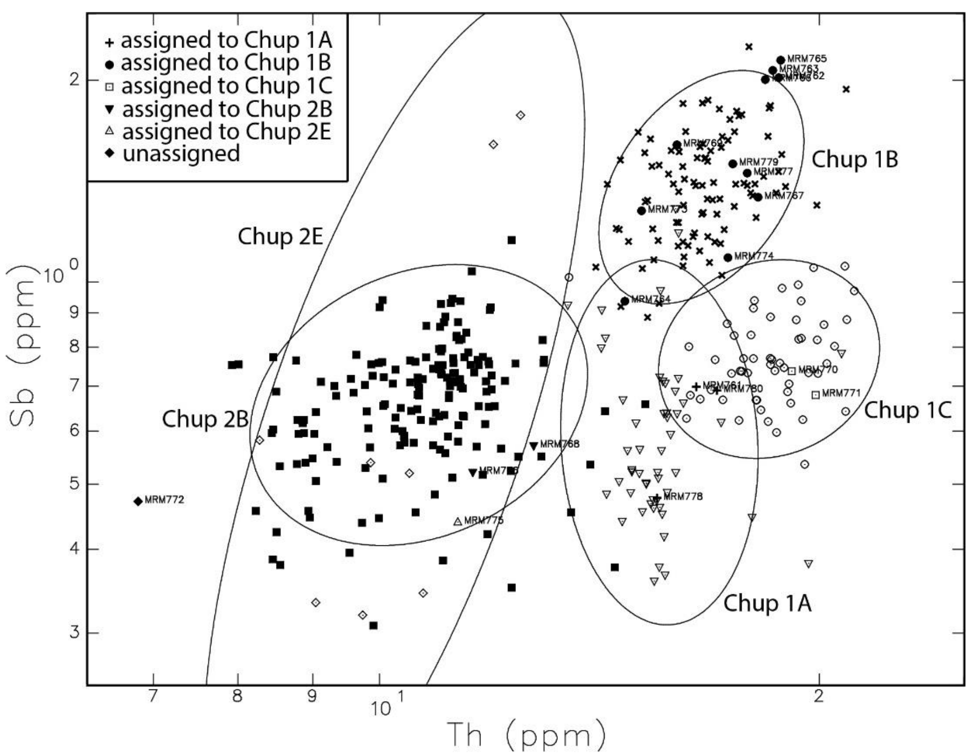

Figure C.2.1. Scatterplot of thorium and antimony for all Chupadero reference groups identified in this study. The ellipses represent 90% confidence intervals for membership in the groups.

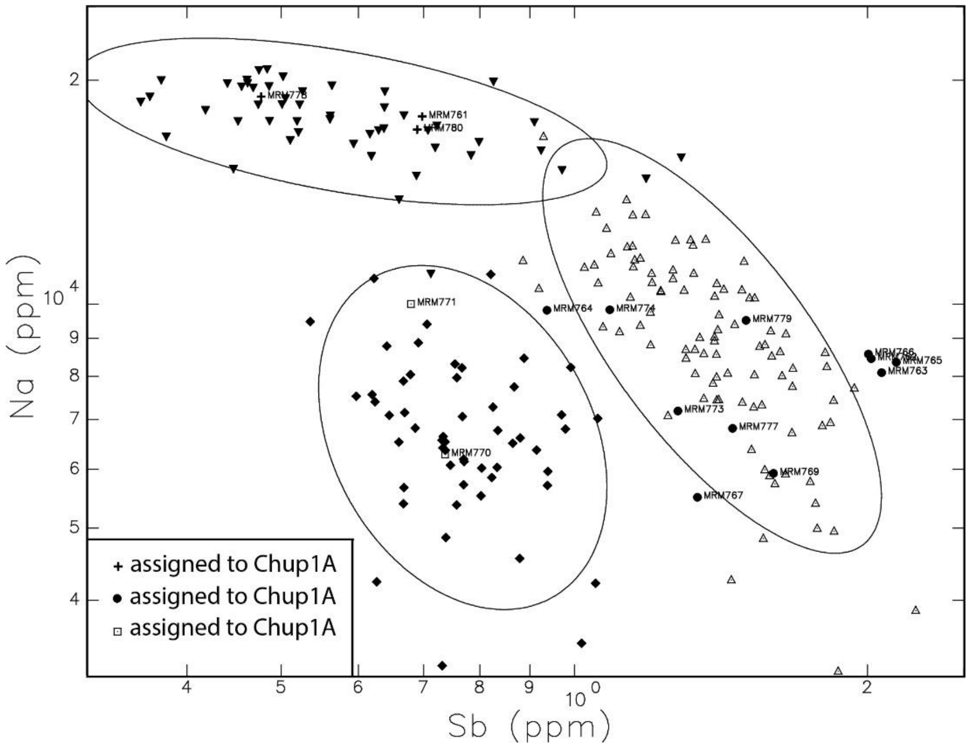

Figure C.2.2. Scatterplot of antimony and sodium for all Chupadero "1" reference groups identified in this study. The ellipses represent 90% confidence intervals for membership in the groups.

The reference group 2E is a provisional group that has been identified since the Creel et al. (2002) study. The one specimen (MRM775) tentatively assigned to this group could also be assigned to Group 2B. Figure C.2.3 shows the partial separation of these two groups.

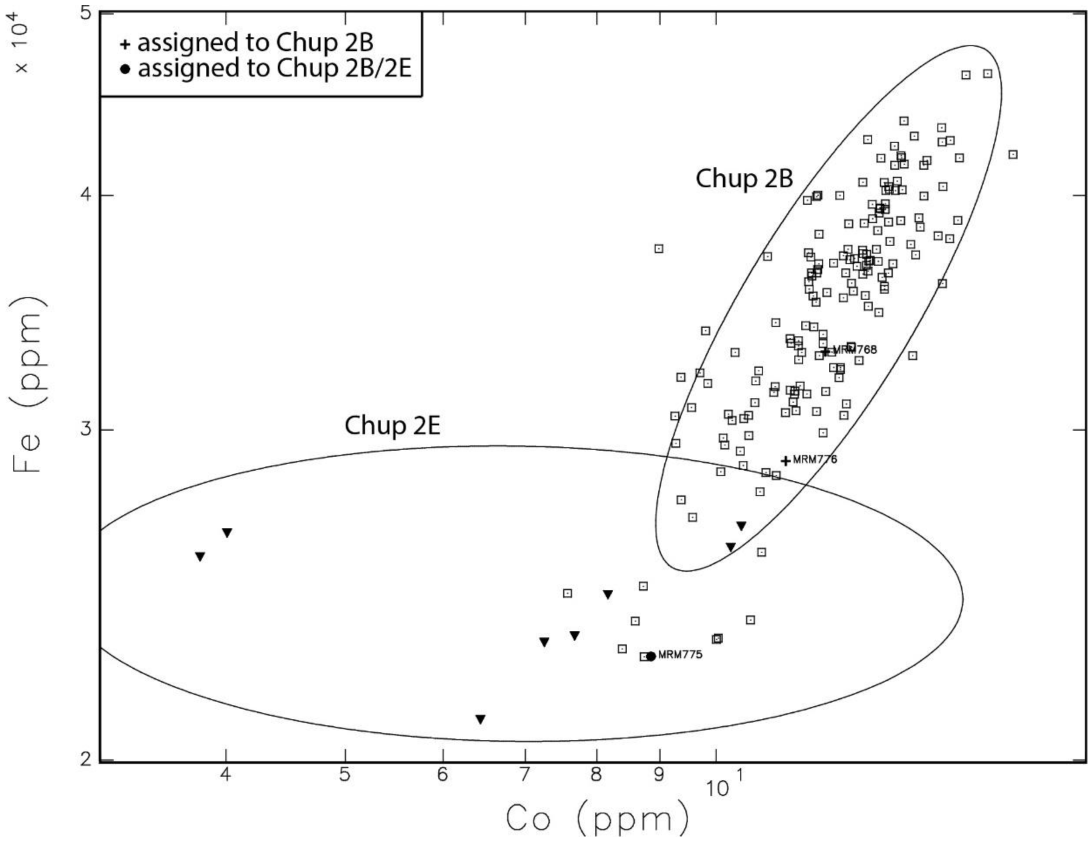

Figure C.2.3. Scatterplot of cobalt and iron for all Chupadero “2” reference groups identified in this study. The ellipses represent 90% confidence intervals for membership in the groups.

Most of the Chupadero groups have enough members to allow robust projections of group membership probabilities using Mahalanobis distance calculations. Table C.2.2 provides a list of each of the specimens in this study against each of the Chupadero compositional groups large enough for inclusion. In all cases, the group assignment made based on visual inspection of elemental scatterplots correlate with the group with the highest membership probability. MRM775 also overlap with Chup2E, but 2E is too small for inclusion in this statistical test.

Table C.2.2. Group membership probabilities for specimens in this study. Only the reference groups large enough for this test are included.

Membership probabilities(%) for samples in group: Assigned Chup 1A

ANID	CHUP1A	CHUP1B	CHUP1C	CHUP2A	CHUP2B	Best Group
MRM761	**0.414**	0.039	0.001	0.000	0.000	CHUP1A
MRM778	**13.895**	0.000	0.003	0.000	0.000	CHUP1A
MRM780	**73.324**	0.125	0.001	0.000	0.000	CHUP1A

Membership probabilities(%) for samples in group: Assigned Chup 1B

ANID	CHUP1A	CHUP1B	CHUP1C	CHUP2A	CHUP2B	Best Group
MRM762	0.000	**12.354**	0.051	0.000	0.000	CHUP1B
MRM763	0.000	**14.854**	0.181	0.000	0.000	CHUP1B
MRM764	0.022	**34.734**	3.231	0.000	0.000	CHUP1B
MRM765	0.001	**21.193**	0.116	0.000	0.000	CHUP1B
MRM766	0.005	**25.207**	0.095	0.000	0.000	CHUP1B
MRM767	0.000	**24.279**	0.072	0.000	0.000	CHUP1B
MRM769	0.000	**78.478**	0.000	0.000	0.000	CHUP1B
MRM773	0.026	**67.549**	0.623	0.000	0.000	CHUP1B
MRM774	0.000	**47.351**	0.788	0.000	0.000	CHUP1B
MRM777	0.005	**76.752**	0.192	0.000	0.000	CHUP1B
MRM779	2.414	**90.244**	0.688	0.000	0.000	CHUP1B

Membership probabilities(%) for samples in group: Assigned Chup 1C

ANID	CHUP1A	CHUP1B	CHUP1C	CHUP2A	CHUP2B	Best Group
MRM770	0.000	0.000	**99.707**	0.000	0.000	CHUP1C
MRM771	0.000	0.000	**93.981**	0.000	0.000	CHUP1C

Membership probabilities(%) for samples in group: Assigned Chup 2B

ANID	CHUP1A	CHUP1B	CHUP1C	CHUP2A	CHUP2B	Best Group
MRM768	0.001	0.000	0.007	0.000	**56.538**	CHUP2B
MRM776	0.000	0.000	0.000	0.000	**78.630**	CHUP2B

Membership probabilities(%) for samples in group: Assigned Chup 2B/2E

ANID	CHUP1A	CHUP1B	CHUP1C	CHUP2A	CHUP2B	Best Group
MRM775	0.000	0.000	0.000	0.000	**0.136**	CHUP2B

Membership probabilities(%) for samples in group: Unassigned

ANID	CHUP1A	CHUP1B	CHUP1C	CHUP2A	CHUP2B	Best Group
MRM772	0.000	0.000	0.000	0.000	0.000	

The split between the Chup 1 and 2 groups has significant cultural meaning. Creel et al. (2002) argue that the 1A, and 1B groups were likely produced in the Capitan Mountains region, and probably at or near Robinson Site. Group 2B was produced in the Salinas Area at or near Quarai Pueblo. The 16 specimens likely from the Capitan Mountains suggest a much stronger connection to that region than the three specimens from the Salinas region.

MRM772 presents an interesting problem. Chupadero B/W specimens rarely fall outside the compositional range for the established Chupadero reference groups. There are occasionally unassigned specimens (similar to MRM775) that might overlap multiple groups, but rarely clearly distinct chemistries. This further supports the idea that all Chupadero ceramics were made in the Capitan or Salinas regions with no production in distant areas. A Euclidian distance search of the entire MURR southwest database produced some interesting results. All of the ten closest matches for MRM772 were Ochoa Indented ceramics from the Merchant Site analyzed for Luis Alvarado (Ferguson and Glascock 2007). While it is possible that MRM772 represents an isolated case of local Chupadero production, the more likely scenario is that the specimen is really a locally-produced Ochoa Indented sherd mistakenly identified as Chupadero. Further analysis of Ochoa Indented production is underway and this specimen will be included in that ongoing analysis.

Conclusions

With the exception of one possibly mis-typed specimen, the Chupadero Black-on-White specimens from the Merchant Site (LA43414) and LA121668 reveal a strong connection to Chupadero production in the Capitan Mountains, with a small link the production in the Salinas region.

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Appendix C.3 Ochoa Ware Petrography

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Petrographic Analysis of Pottery from the Merchant Site, Southeastern New Mexico

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Petrographic Report No. 2021-02

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PETROGRAPHIC ANALYSIS OF POTTERY FROM THE MERCHANT SITE, SOUTHEASTERN NEW MEXICO

Petrographic analysis of nine sherds from the Merchant site, LA 43414, aimed to assess compositional variability and location of production. The site is considered as the “type site” for Ochoa ware, and seven sherds of Ochoa Indented Corrugated were examined in this study (Miller et al. 2016:319). Two sherds of Corona Corrugated were also examined. All sherds had also been subjected to Neutron Activation Analysis (NAA) at the University of Missouri Research Reactor. In combination, the results indicate likely local production of Ochoa Indented Corrugated, while the Corona Corrugated was likely produced elsewhere.

GEOLOGICAL SETTING

The Merchant site is located in southeastern New Mexico on the Mescalero Plain (Figure C.3.1). The site sits on the edge of Grama Ridge, to the northeast of the San Simon swale (Miller et al. 2016:Figure 2.3). This mesa is comprised of Pliocene/Miocene Ogallala Formation caliche (Bachman 1980:34–38). This is overlaid by Pleistocene Gatuna Formation of conglomerates, shale, and pisolitic caliche nodules. Within the Gatuna Formation at the Merchant site is a well-developed calcic horizon called Mescalero Caliche (Miller et al. 2016:16). Holocene eolian sand provides a thin cap, while washes downcutting the mesa contain Late Pleistocene and Holocene alluvium (Scholle 2003).

METHODOLOGY

The nine analyzed sherds included seven Ochoa Indented Corrugated and two Corona Corrugated (Table C.3.1). Ochoa ware has been documented throughout southeastern New Mexico and western Texas with a production dates likely between A.D. 1300 and A.D. 1450 (Leslie 1965; Miller et al. 2016:319). The vessels are coil and scrape with shapes ranging from jars to bowls. Corona Corrugated, a northern Jornada Brown Ware type, is mostly found in eastern New Mexico and appears after A.D. 1300 (Hayes et al. 1981:64–65; Wiseman 2016, 1982). Only jars appear in this ware having been made through the coil and scrape method. These sherds were selected from the NAA compositional study by Alvarado (2008, 2009). The group assignments are provided in Table 1. A discussion of these results and recent work on the NAA data base for ceramics from southeastern New Mexico and western Texas is in Miller et al. (2016:391–396).

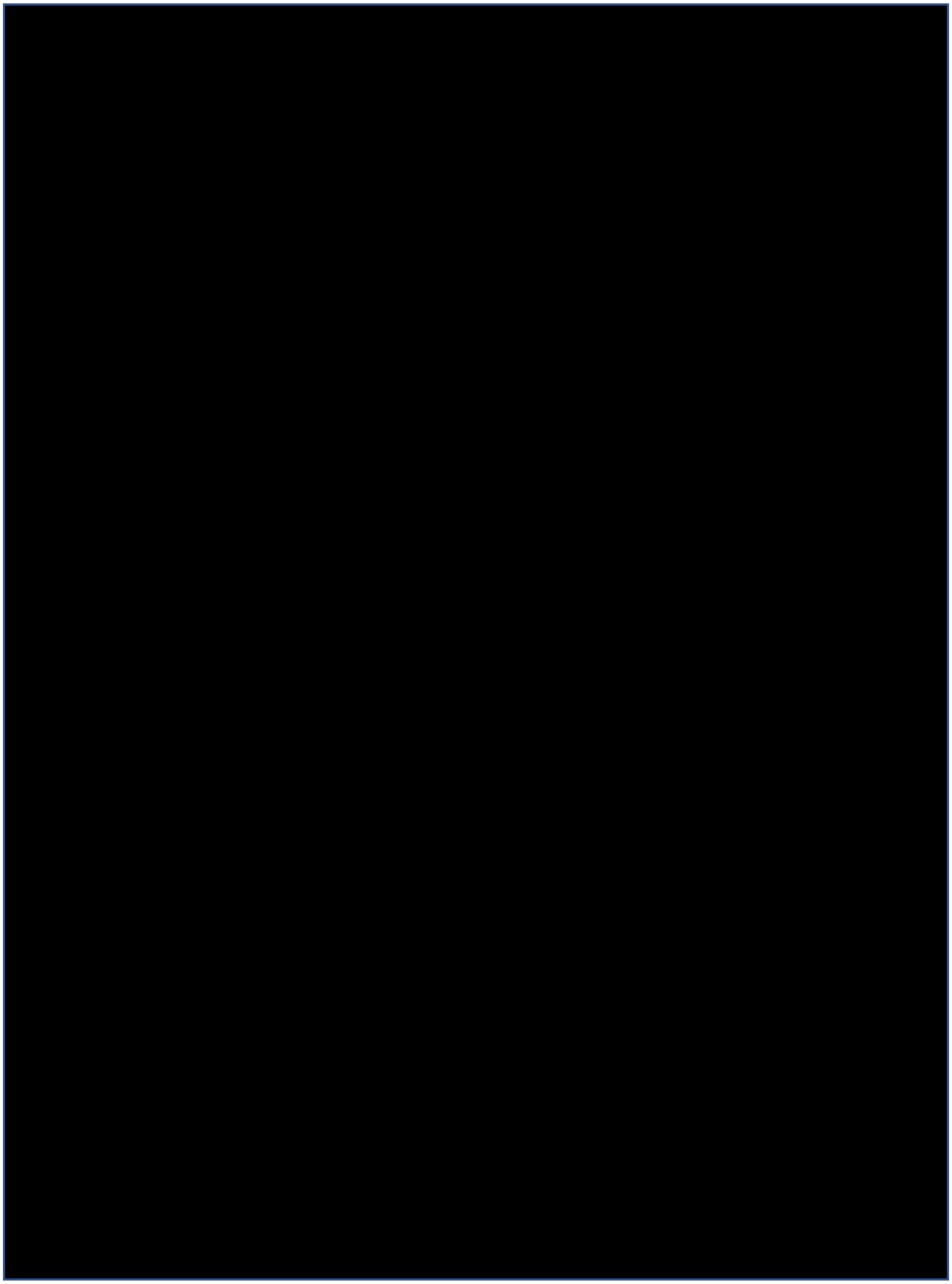

Figure C.3.1. Map showing geology and location of the Merchant site. Based on Scholle (2003).

Table C.3.1. Sample inventory

Sample No.	Ware	Type	NAA Group
1_30	Jornada brownware	Corona Corrugated	Corona Group 1
1_38	Ochoa ware	Ochoa Indented Corrugated	Texas Group 3
23	Ochoa ware	Ochoa Indented Corrugated	Merchant Main
153	Ochoa ware	Ochoa Indented Corrugated	Merchant Main
172	Ochoa ware	Ochoa Indented Corrugated	Merchant Main (Unas)
276	Ochoa ware	Ochoa Indented Corrugated	Merchant Main
382	Ochoa ware	Ochoa Indented Corrugated	Merchant Main
394	Ochoa ware	Ochoa Indented Corrugated	Merchant Main
468	Jornada brownware	Corona Corrugated	Corona Group 1

For each sample, a set of qualitative criteria were recorded along with notes on the clay, general appearance, inclusions, and similarities to previously examined samples (see Reedy 2008 for petrographic practices). The color of the sections in both plane and cross polarized light were described followed by an indication of the optical activity of the matrix, i.e., fired clay and inclusions. This information is important for a general estimate of firing temperature, as typically above 850°C the matrix will become vitrified and be optically inactive (Rice 1987:431). Along with temper type, the percentage of inclusions, their sorting, size range, and shape range was noted for both added and natural inclusions. Sorting was based on visual charts found in Matthew et al. (1991), size range is based on the Wentworth (1922) scale, and shape range utilizes Powers' (1953) scale of roundness. For the identified mineral grains and rock fragments, their presence was noted and a frequency was assigned based on four categories: very rare (1–5 grains), rare (approx. 10 percent), sparse (approx. 10–25 percent), frequent (approx. 25–50 percent), abundant (approx. 50–75 percent), and highly abundant (approx. greater than 75 percent). This information is important for characterizing the types of grains present and those that are dominant. The recorded data are provided in the appendix.

RESULTS

The petrographic analysis results are discussed by ceramic types. This facilitates the comparison of inclusions and clay within the types to establish any patterns. Figures C.3.2 and C.3.3 show microphotographs of selected thin sections.

Ochoa Indented Corrugated

The seven analyzed Ochoa Indented Corrugated sherds all had analogous pastes. The clay appears related to shale. The common inclusions are likely natural to the clay and are dominated by quartz grains. The other frequent components are caliche fragments (some with quartz, feldspar, and chert inclusions), quartzite, and chert. Less common are grains of potassium feldspar, plagioclase, and chalcedony. Rare are opaques, muscovite, pyroxene, zircon, tourmaline, glauconite, and sparry limestone.

Samples 23 and 153 have a dominance of medium to coarse-sized inclusions, while 172 has more common fine-sized grains including the caliche. Sample 276 has mostly medium-sized inclusions and rare plant material. The latter could be natural to the clay deposit. Sample 382 is similar to Sample 276, but lacks the plant material. However, some was noted in Sample 394 with mostly fine and medium-sized inclusions. Sample 1_38 has the same set of inclusions and a similar clay, but is dominated by fine-sized angular grains. A single grog fragment was noted.

The components of these pastes suggest a disaggregated sandstone provided most of the mineral grains. Based on their type and features, the sandstone(s) are subarkose to sublitharenite due to the presence of feldspars, chert, and quartzite (Adams et al. 1984:24). In none of the samples was intact sandstone with matrix observed, so information on that component cannot be acquired. However, the shape and sorting of the loose grains suggest the sandstone(s) were texturally submature. Mineralogically, the presence of silica rock fragments, zircon, and rare tourmaline indicates they are mostly mature.

Corona Corrugated

The two Corona Corrugated sherds analyzed had similar pastes. The clay is iron-rich and could be from the erosion of sandstone with hematite/clay matrix and common quartz and feldspar, i.e., arkosic. A few such fragments were seen in Sample 468. The paste contains common quartz and potassium feldspar (mostly perthite), with a few having granophric textures. These sometimes appear as alkali feldspar granite rock fragments with attached rare opaques and sphene. Also in the paste are some limestone/caliche fragments along with uncommon pyroxene, zircon, sphene, microcline, muscovite, and chert. All of the inclusions appear natural to the clay.

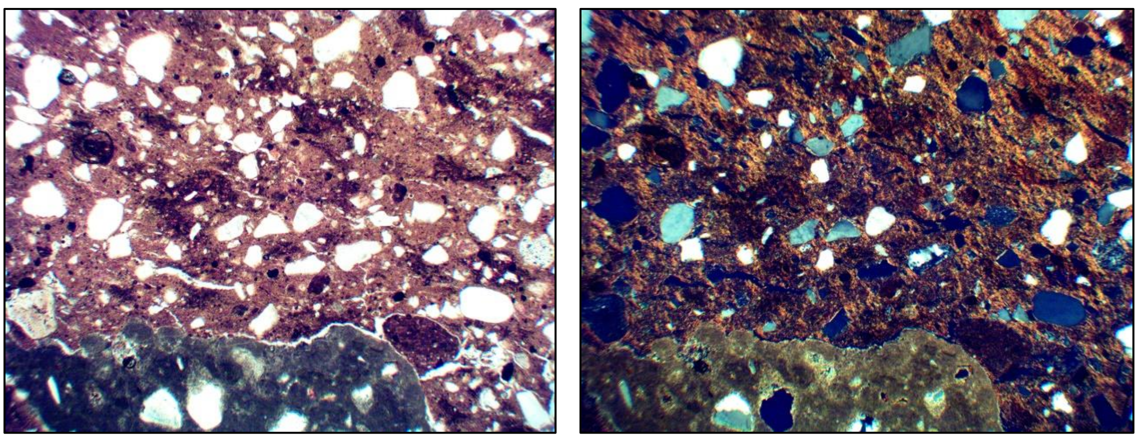

Figure C.3.2. Microphotographs of Sample 153, Ochoa Indented Corrugated. Image on left is in plane polarized light, image on right in cross polarized light. Both taken at 100x magnification.

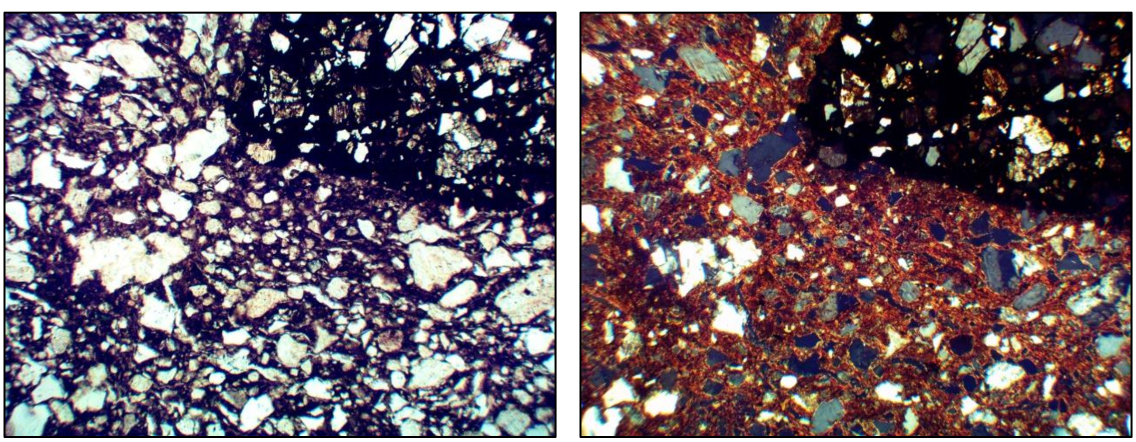

Figure C.3.3. Microphotographs of Sample 468, Corona Corrugated. Image on left is in plane polarized light, image on right in cross polarized light. Both taken at 100x magnification.

DISCUSSION

This small study of nine sherds of Ochoa Indented Corrugated and Corona Corrugated has provided data on their production. The most common paste comprises a likely shale clay with natural inclusions from disaggregated sandstone and larger fragments of limestone (Table C.3.2). Such a raw material was probably available near the site within washes downcutting the Ogallala Formation of the mesa. Along the mesa edge are exposures of sandstone, shale, and caliche that would be cut by washes whose material would form a secondary deposit of clay rich in disaggregated sandstone minerals and caliche fragments (Nicholson and Clebsch 1961:37–39). Such deposits have been described and the harder caliche may resist weathering producing larger fragments within the secondary clay (Miller et al. 2016:16). Unfortunately, no additional information on the specific mineralogical components of the Ogallala Formation was found.

Table C.3.2. Summary of petrographic results. "Local" means resources available within 3 km of the site

Sample No.	Pottery Type	Petrographic Description	Local
1_30	Corona Corrugated	Iron-rich arkosic sandstone	No?
1_38	Ochoa Indented Corrugated	Sandstone and limestone	Yes
23	Ochoa Indented Corrugated	Sandstone and limestone	Yes
153	Ochoa Indented Corrugated	Sandstone and limestone	Yes
172	Ochoa Indented Corrugated	Sandstone and limestone	Yes
276	Ochoa Indented Corrugated	Sandstone and limestone	Yes
382	Ochoa Indented Corrugated	Sandstone and limestone	Yes
394	Ochoa Indented Corrugated	Sandstone and limestone	Yes
468	Corona Corrugated	Iron-rich arkosic sandstone	No?

These vessels were not highly fired based on their optical activity and it was probably a short firing as the cores remain dark and unoxidized. The samples with finer and less angular inclusions suggest clay was also likely acquired in the swale some distance from the original outcrops. In this area, coarser fragments would have dropped out along the water course leaving only finer material, which would have become rounder due to the additional water action. Further, this raw material was probably not heavily processed as most samples contain clay pellets indicative that water did not fully hydrate all parts of the clay. The six samples with this paste correspond to the Merchant Main NAA Group. Sample 1_38 in NAA Texas Group 3 is petrographically related to the other Ochoa Indented Corrugated samples, though having finer inclusions. However, a slightly different raw material source for this vessel cannot be excluded given the geographic extent of the limestone and sandstone outcrops and their unknown heterogeneity.

Very little petrographic work has previously been conducted on Ochoa ware. Hill (in press) examined a few sherds and noted common limestone and sand inclusions. Hill (2019:168–171) further clarifies that Ochoa Indented Corrugated appears to be a rare example of possible local production of brownwares, while for most sites in southeastern New Mexico they are made of materials from the Lincoln County Porphyry belt that includes the Capitan and Sierra Blanca mountains.

The two Corona Corrugated sherds, both in NAA Group Corona 1, had identical pastes that could relate to the erosion of sandstone with an iron-rich matrix and granite inclusions of quartz and potassium feldspar (see Table 2). On the east side of Clayton Basin is a thick exposure of Gatuna Formation reddish brown sandstone (Bachman 1980:36–37). Other areas also have deposits of this material in the Pecos region (Nicholson and Clebsch 1961:39–45). Significantly, the formation can contain pisolitic caliche clasts and Tertiary igneous pebbles. These are believed to have originated from the erosion of the Sierra Blanca and Capitan mountains to the far northwest. Those mountains are dominated by granite, often feldspar rich and with sphene (Scholle 2003). If the Gatuna Formation in the area does not contain such deposits, these sherds could be non-local to the Merchant site. Further, older formations of red beds comprising sandstone, siltstone, and clay are known in the area so there is a chance those were exploited (Nicholson and Clebsch 1961:34–36). Both sherds appear to have been low fired in an incompletely oxidizing atmosphere.

Some Corona Plain sherds from Gran Quivira were previously examined petrographically by Warren (1981), who did not identify any produced with material described here. However, Hill (2012:10) mentions that some Corona Corrugated sherds grouped with others having igneous tempers. This study also included NAA data and it appears the Corona Corrugated sherds were mostly in Group 95 and from site LA149260, the southeastern most location sampled. These are described by Hill (2012:8) as having plutonic sediments of loose quartz, potassium feldspar, and plagioclase. This could be similar to what was observed currently. More recently, Hill (2016) analyzed Corona Corrugated sherds from a site near Glencoe and also identified what he termed "fine-grained leucocratic igneous rocks that might be characterized as monzonite and quartz monzonite". These were ascribed a source in the Capitan Mountains. How this material relates to what has been identified in the two Corona Corrugated sherds here is unclear, although the common theme of quartz and feldspar inclusions is apparent.

CONCLUSION

This small petrographic study has provided important clarity on the components of Ochoa Indented Corrugated and Corona Corrugated. For the former, the pastes appear to contain natural inclusions from caliche and sandstone. For the latter, a similar approach was taken, exploiting secondary deposits of clay possibly from the erosion of arkosic sandstone. In addition to the similarity in choice in raw materials, the firing regimes were probably the same with low temperatures and incompletely oxidizing atmospheres. This indicates a common approach to ceramic production in raw materials selection and technology of firing. Thus, while Ochoa Indented Corrugated reflects the southwestern tradition of textured ceramics made by coil-and-scrape, it also has its own unique features.

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APPENDICES: THIN SECTION RECORDED DATA

Table A.1. Frequency codes

Category	Code	Definition
Frequency	0	Does not exist
	1	Very rare (1-5 grains)
	2	Rare (c. 10%)
	3	Sparse (c. 10-25%)
	4	Frequent (c. 25-50%)
	5	Abundant (c. 50-75%)
	6	Highly Abundant (c. >75%)

Table A.2. Description of the paste

Sample No.	Color PPL[1]	Color XPL[2]	Optical Activity	Temper Type	% Inclusions[3]	Sorting	Size Range	Shape Range
1_30	Tan	Tan	Active	None	40	Good	V. fine to medium	Angular to subrounded
1_38	Dark brown	Dark brown	Active	None	40	Good	V. fine to medium	Angular to subrounded
23	Tan	Tan	Active	None	40	Poor	V. fine to v. coarse	Angular to subrounded
153	Brown	Brown	Active	None	40	Poor	V. fine to v. coarse	Angular to subrounded
172	Yellow	Yellow	Active	None	40	Good	V. fine to coarse	Subangular to subrounded
276	Tan	Tan	Active	None	40	Fair	V. fine to coarse	Subangular to subrounded
382	Brown	Brown	Active	None	40	Fair	V. fine to v. coarse	Subangular to subrounded
394	Brown	Brown	Active	None	40	Good	V. fine to coarse	Subangular to subrounded
468	Reddish brown	Reddish brown	Active	None	40	Good	V. fine to coarse	Angular to subrounded

[1] PPL: plane polarized light [2] XPL: cross polarized light [3] Percentage of inclusions, sorting, and size and shape ranges, includes natural and added inclusions such as grog.

Table A.3. Frequency of monomineralic inclusions (only those recorded are included)

Sample No.	QTZ[1]	KSPAR	MICR	PLAG	MUSC	PX	AMPH	OPAQ	ZIR	EPID	SPH	TOUR
1_30	4	5	0	0	0	1	0	1	0	0	1	0
1_38	4	2	1	2	1	1	0	1	1	0	0	0
23	4	2	1	2	1	1	0	1	0	0	0	0
153	4	2	1	2	1	1	0	1	1	0	0	0
172	4	2	1	2	1	1	0	1	0	1	0	1
276	4	2	1	2	1	1	0	1	1	0	0	0
382	4	2	1	2	1	1	0	1	1	0	0	0
394	4	2	1	2	1	1	0	1	1	0	0	0
468	4	5	1	0	1	1	1	1	1	1	1	0

[1] qtz=quartz, kspar=potassium feldspar, micr=microcline, plag=plagioclase, mus=muscovite, px=pyroxene, amph=amphibole, opaq=opaques, zir=zircon, epid=epidote, sph=sphene, tour=tourmaline

Table A.4. Frequency of rock fragments and grog (only those recorded are included)

Sample No.	LMF	LSS	LSCH	LSCA	GROG
1_30	0	0	1	1	0
1_38	3	0	3	2	1
23	3	0	3	2	0
153	3	0	3	2	0
172	3	0	3	2	0
276	3	0	3	2	0
382	3	0	3	2	0
394	3	0	3	2	0
468	0	1	1	2	0

[1] LMF= foliated quartz aggregate (e.g., quartzite), LSS= granular aggregates of equant subangular to rounded silt or sand sized grains (e.g., siltstone or sandstone), LSCH=microcrystalline aggregates of silica (e.g., chert), LSCA=very fine calcite crystals (e.g., carbonate), GROG=crushed pottery fragments

Appendix C.4 XRF Analysis of Obsidian Artifacts

M. Steven Shackley

Geoarchaeological C-Ray Fluorescence Spectrometry Laboratory

GEOARCHAEOLOGICAL XRF LAB
A GREEN SOLAR FACILITY

GEOARCHAEOLOGICAL 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 FOUR ARCHAEOLOGICAL SITES IN SOUTHEASTERN NEW MEXICO

20 August 2020

Lillian Ponce
Versar, Inc.
4725 Ripley Drive, A
El Paso, TX 79922

Dear Lillian and Myles:

The source provenance of the artifacts is dominated by Jemez Mountains sources (Table 1 and Figure 1; see Shackley 2016). Cerro Toledo Rhyolite obsidian is available as secondary deposits in Rio Grande Quaternary alluvium at least to Las Cruces, but Valles Rhyolite (Cerro del Medio) has not been found south of Albuquerque, and only as a few small diameter samples (Church 2000; Shackley 2005, 2013, 2020). One sample was at or below the optimal size for EDXRF non-destructive analysis so the elemental concentrations are somewhat below source standards, but the assignment is likely correct (Table 1 and Figure 1). Two samples were not obsidian. Specific instrumental methods can be found at http://www.swxrflab.net/anlysis.htm, and Shackley (2005) or Shackley et al. (2019). Source assignment was made by comparison to source standard data in the laboratory. Analysis of the USGS RGM-1 standard indicates high machine precision for the elements of interest (Table 1 here).

Sincerely,

M. Steven Shackley, Ph.D.
Director

VOICE: 510-393-3931
INTERNET: shackley@berkeley.edu
http://www.swxrflab.net/

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Table C.4.1. Elemental concentrations for the archaeological samples, and a USGS RGM-1 rhyolite standard. All measurements in parts per million (ppm)

LA#-F#-CN	Ti	Mn	Fe	Rb	Sr	Y	Zr	Nb	Ba	Ce	Pb	Th	Source
20166-30-5	1593	532	13122	189	15	44	160	47	0	13	37	32	Valles Rhy (Cerro del Medio)
43414-110-153	908	366	10157	157	18	46	159	56	45	52	24	15	Valles Rhy (Cerro del Medio)
43414-110-166	749	169	5604	0	37	8	19	7	18	20	3	8	not obsidian
43414-404-79	1067	549	11697	214	11	60	170	89	39	26	36	28	Cerro Toledo Rhy
43414-416-380	735	155	5900	0	38	7	16	1	144	20	0	4	not obsidian
43414-82-399	985	673	13629	218	10	58	154	77	3	18	47	28	Cerro Toledo Rhy*
132924-15-2	895	544	11487	229	9	60	182	100	35	35	44	29	Cerro Toledo Rhy
132962-8-1	1099	490	10774	208	11	62	179	93	6	12	35	22	Cerro Toledo Rhy
RGM1-S4	1598	297	13366	152	108	24	217	9	803	23	20	20	standard

* This sample is smaller than the optimal dimensions for confident source assignment by EDXRF, but likely from this source (Davis et al. 2011).

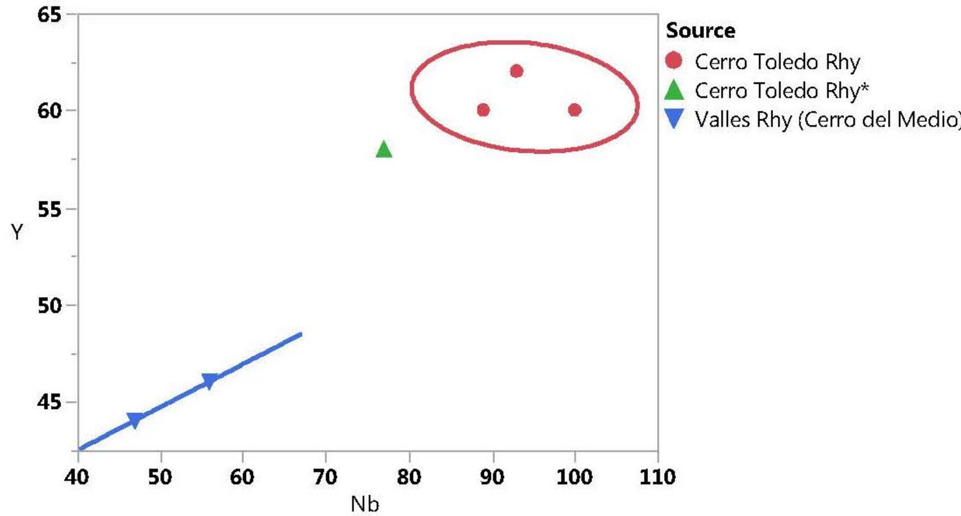

Figure C.4.1. Nb/Y bivariate plot of the archaeological samples. Confidence ellipse and line at 95%.