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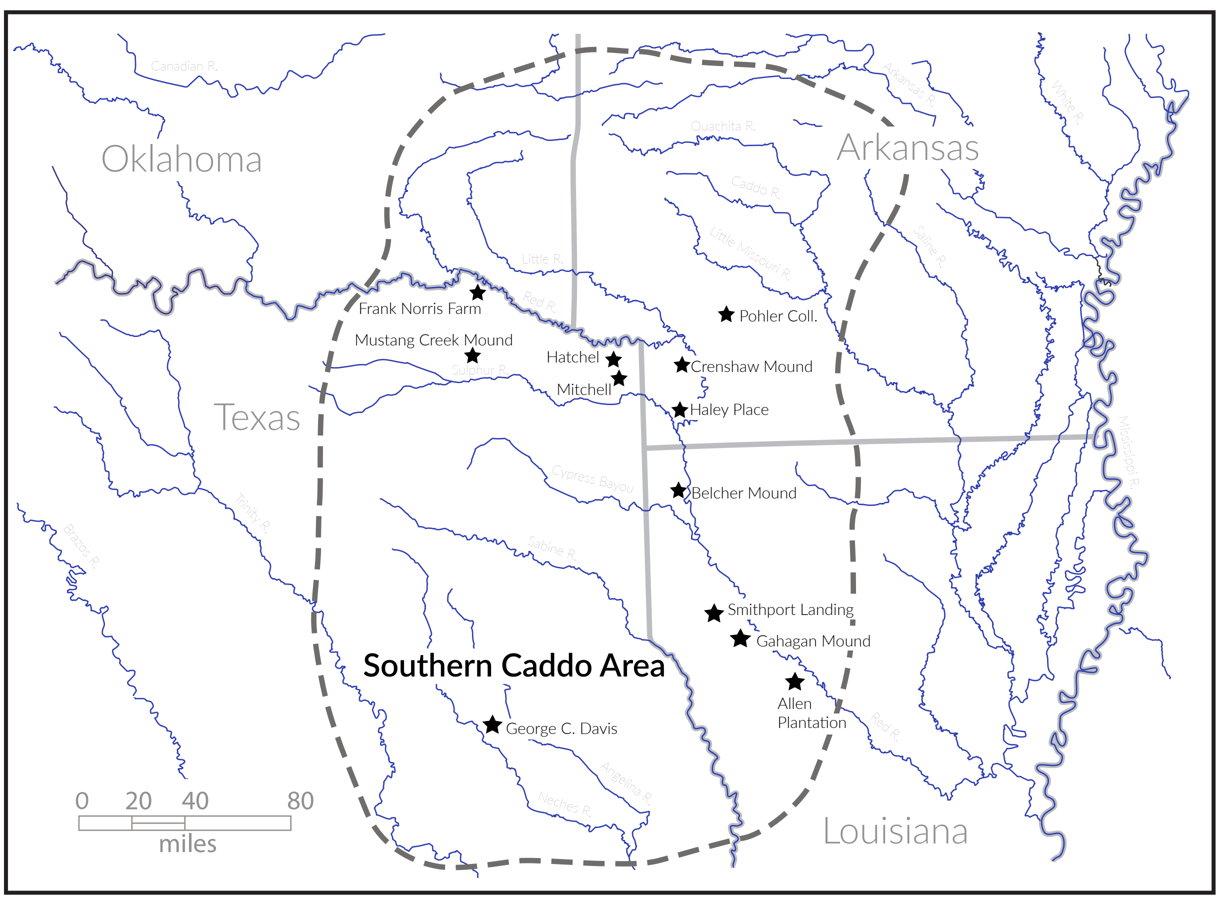

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Articles

Ancestral Puebloan Artifacts from North Central and East Texas Sites: Evidence of Trade Routes Across Texas During the Late Prehistoric Period

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Ancestral Puebloan cultural materials are rarely recovered from Texas archeological sites but small numbers have been reported from a number of sites across North Central and East Texas. In the mid-1990s, Jurney and Young (1995) attempted to identify all the known occurrences of Southwestern ceramic, obsidian, and turquoise artifacts in the area. During the intervening 20 plus years, a number of newly reported artifacts have come to light, and we have collaborated to catalog these finds in the two regions. In addition, we also document two Puebloan ceramic artifacts found in Hood and Falls counties in the Brazos River watershed. Together, these cultural materials suggest a spatially extensive west-to-east prehistoric exchange network that existed over 300-500 years after ca. A.D. 900. While this exchange of materials may have been spurred by many factors, including the interchange of knowledge and ideas, we suggest that trade for bois d'arc wood, known to be one of the finest raw materials for the manufacture of bows, was a major impetus for the long distance trade.

Introduction

Ancestral Puebloan ceramics, obsidian, and turquoise are some of the few cultural materials providing direct evidence of interaction between the Native American communities in the Southwest and the indigenous inhabitants of Texas. Krieger (1946) was the first Texas archeologist to study systematically the relationships between aboriginal Texans and Puebloan peoples. Such artifacts are rarely recovered from Texas archeological sites but nonetheless they have been reported across a wide area of North Central and East Texas. Jurney and Young (1995) made the first concerted attempt to identify North Central and East Texas sites with evidence of Southwestern Puebloan artifacts. Subsequently, Crook (2013, 2015, 2016, 2017a) and Crook and Hughston (2015a) detailed occurrences of Southwestern ceramics, obsidian, shell and turquoise from a number of Late Prehistoric sites (dating from ca. A.D. 800 to A.D. 1600) along the East Fork of the Trinity River in Collin and Rockwall counties. More recently, Perttula and Hester (2016) listed a number of Caddo sites in East Texas that contained pieces of worked obsidian, and Perttula and Walters (2017) have noted Puebloan ceramic sherds from other sites in the region.

In discussions about the relationship between aboriginal peoples in the Southwest and eastern Texas, we decided to collaborate and catalog all known occurrences of cultural materials of probable Puebloan origin from the North Central and East Texas regions. In addition, we have included a discussion about two Puebloan ceramic artifacts that were found further west, in Hood and Falls counties in the Brazos River watershed. Together, these occurrences suggest a spatially extensive west-to-east prehistoric trade network that, based on the ages of the ceramics, existed over at least 300-500 years after ca. A.D. 900. A few obsidian artifacts in East Texas sites, including one site in Northwest Louisiana, have been found in Paleoindian-Early Archaic and Woodland period contexts, and these finds are discussed below.

Puebloan Artifacts from North Central Texas

Puebloan artifacts are rare occurrences in North Central Texas, yet sites of the Late Prehistoric period along the East Fork of the Trinity River have a number of such artifacts (Lorrain and Hoffrichter 1969; Crook 1985, 2013, 2015, 2016;

Crook and Hughston 2015a). A few of these artifacts were recorded by Jurney and Young (1995) in their summary of Southwestern pottery and turquoise in Northeast Texas sites, but many of the finds from the East Fork were either not known to them or have been discovered and/or recorded only in the last 20 years. Archeological materials of Southwestern U.S. or Northern Great Plains origin include obsidian and chalcedony lithic artifacts, sherds or vessels of Puebloan ceramic types, turquoise, *Olivella* and other shell beads, and red coral. Other associated artifacts in the region, such as chalcedony drills and a piece of garnet-bearing schist, are also likely to be of Southwestern origin.

Over the last decade, Crook has had the opportunity to study the collections of the late R. King Harris curated at the Museum Support Center of the Smithsonian Institution, and all materials from the Forney Reservoir survey as well as those from the extensive Vance-Wilson-Housewright collection housed at the Texas Archeological Research Laboratory at the University of Texas at Austin. In addition, a large number of private collections from the East Fork have been studied extensively. Jointly, these collections comprise nearly 32,000 artifacts and include at least 98 of probable Puebloan origin.

Distribution Along the East Fork of the Trinity River

Sites belonging to the Late Prehistoric period along the East Fork of the Trinity River and its tributaries are confined to a relatively narrow north-south band from northern Collin County through Rockwall County and into parts of northwestern Kaufman and northeastern Dallas counties. To date, over 50 sites have been identified that share similar cultural traits. Of these, about 20 are considered village sites with the others being smaller seasonal campsites (Crook and Hughston 2015a).

Puebloan-related artifacts have been found at four of the region's largest sites, including Upper Farmersville (41COL34), Branch (41COL9), Upper Rockwall (41RW2), and Lower Rockwall (41RW1). In addition, several hundred meters west of the Branch site (Crook 1985) an apparent southwestern trader's campsite was found (Table 1). Despite extensive examination of the collections from other large East Fork sites, no additional definitive Southwestern artifacts have been identified.

Upper Farmersville (41COL34)

The Upper Farmersville site lies in north-central Collin County, near the upper part of the known range of Late Prehistoric settlements on the East Fork and its tributaries (Crook and Hughston 2009). The site is one of the largest occupations in the region in terms of both size as well as number of reported artifacts (see Crook and Hughston 2009, 2015a).

Fourteen artifacts of probable Puebloan origin were reported from the Upper Farmersville site. These include a triangular obsidian arrow point, a side-notched obsidian arrow point, a side-notched arrow point of white chalcedony, and 11 ceramic sherds of various black-on-white painted wares (see Table 1). Of the three lithic artifacts, X-Ray Fluorescence (XRF) analysis conducted by Crook indicates the obsidian is from the El Rechuelos area of New Mexico (Table 2). El Rechuelos is misrepresented frequently in the literature as Polvadera Peak. While a rhyolite dome, Polvadera Peak itself did not produce knappable-quality obsidian. Instead, this material is best sourced to El Rechuelos, the four small obsidian domes located north, west, and south of Polvadera Peak. XRF analyses of the chalcedony arrow point from the Upper Farmersville site and similar chalcedony points from the Taos-Santa Fe region, notably from Pot Creek Pueblo (29TA1) shows their trace element geochemistry to be almost identical.

The 11 Puebloan ceramic sherds include seven sherds of Santa Fe Black-on-white, three of general "Rio Grande Glaze," and one of Jemez Black-on-white (Table 3). One of the Santa Fe Black-on-white pieces was shaped intentionally by grinding on three edges and serrated on the fourth edge. The sherds are all relatively small (<50 mm) and represent at a minimum three vessels. All date from either the end of the Coalition Period (A.D. 1200-1355) or to the early Classic Period (A.D. 1325-1600), both fitting well within the combined two-sigma calibrated radiocarbon age range from the Upper Farmersville site of A.D. 1280-1395 (Crook and Hughston 2015a, 2015b). Figures 1 and 2 illustrate examples of Puebloan artifacts from the Upper Farmersville, Branch, and Branch #2 sites.

Table 1. Artifacts of probable Ancestral Puebloan origin, East Fork of the Trinity River, Collin, and Rockwall counties, Texas.

Site	Obsidian		Chalcedony		Turquoise	Shell[1]	Ceramics	Other[2]	Total
	Arrow Point	Other	Arrow Point	Other					
Upper Farmersville (41COL34)	2	-	1	-	-	-	11	-	14
Branch (41COL9)	9	3	-		3	32	5	-	52
Branch #2 (41COL259)	1	1	1	5	3	-	12	5	28
Lower Rockwall (41RW1)	1	—	-		-	2	-	3	
Upper Rockwall (41RW2)	-	1	-		-	-	-	-	1
TOTAL	13	5	2	5	6	32	30	5	98

[1] Carbon / Oxygen isotope analysis on 6 beads indicates that at least 3 originate from the Pacific Coast or Gulf of California and thus are probably of Puebloan origin. Three shell beads were made from Olivella dama which also originates along the Pacific Coast.
[2] Includes red coral (2), almandite garnet schist (1), crinoid bead (1) and a quartzite drill platform (1).

Table 2. Obsidian artifacts and probable sources from sites on the East Fork of the Trinity River, Collin and Rockwall counties, Texas.

Site[1]	Artifact Type	Probable Source Based on XRF Trace Element Geochemistry
Upper Farmersville	Triangular arrow point	El Rechuelos, NM
Upper Farmersville	Side-notched arrow point	El Rechuelos, NM
Branch	Alba-like arrow point	Browns Bench, ID/NV/UT
Branch	Catahoula-like arrow point	Owyhee Pass, ID
Branch	Alba-like arrow point	Massacre Lake/Guano Valley, OR
Branch	Side-notched arrow point	Timber Butte, ID
Branch	Catahoula-like arrow point	Browns Bench, ID/NV/UT
Branch	Catahoula-like arrow point	Valles Rhyolite, NM
Branch	Alba-like arrow point	Cerro Toledo, NM
Branch	Alba-like arrow point	Valles Rhyolite, NM
Branch	Alba-like arrow point	Cerro Toledo, NM
Branch	Worked flake / scraper	Cerro del Medio, NM
Branch	Worked flake / scraper	Cerro del Medio, NM
Branch	Worked flake /. Scraper	Cerro del Medio, NM
Branch #2	Triangular arrow point	El Rechuelos, NM
Branch #2	Worked flake / scraper	El Rechuelos, NM
Upper Rockwall	Worked flake / scraper	Cougar Mountain, Oregon
Lower Rockwall	Scallorn-like arrow point	McDaniel Tank, New Mexico

[1] Upper Farmersville (41COL34), Branch (41COL9), Branch #2 (41COL259), Upper Rockwall (41RW2), Lower Rockwall (41RW1).

Table 3. Puebloan ceramics from East Fork Late Prehistoric sites[1].

Site	Arboles B/W	Mimbres B/W	Chupadero B/W	Wingate B/R	Black Mesa B/W	Chaco B/W	Santa Fe B/W	Zuni Glaze	Jemez B/W	Rio Grande Glaze
Upper Farmersville	-	-	-	-	-	-	7	-	1	3
Branch	-	2	2	-	-	-	-	-	-	-
Branch #2	-	-	-	-	2	4	5	1	-	-
Upper Rockwall	-	-	-	-	-	-	-	-	-	-
Lower Rockwall	1	-	-	1	-	-	-	-	-	-
Totals	1	2	2	1	2	4	12	1	1	3
Tree Ring Age Date[2] A.D.	900-1100	1000-1140	1050-1150	1030-1175	1060-1180	1075-1150	1150-1425	1325-1400	1300-1750	1300-1750

B/W = Black-on-White; B/R = Black-on-Red

[1] Totals do not include one heavily worn Black-on-White shaped sherd from the Branch site which could not be identified.
[2] Tree ring age data from New Mexico Office of Archeology Studies Pottery Typology Classification System(http://www.ceramics.nmarcheology.org/index/the_classification_system.htm).

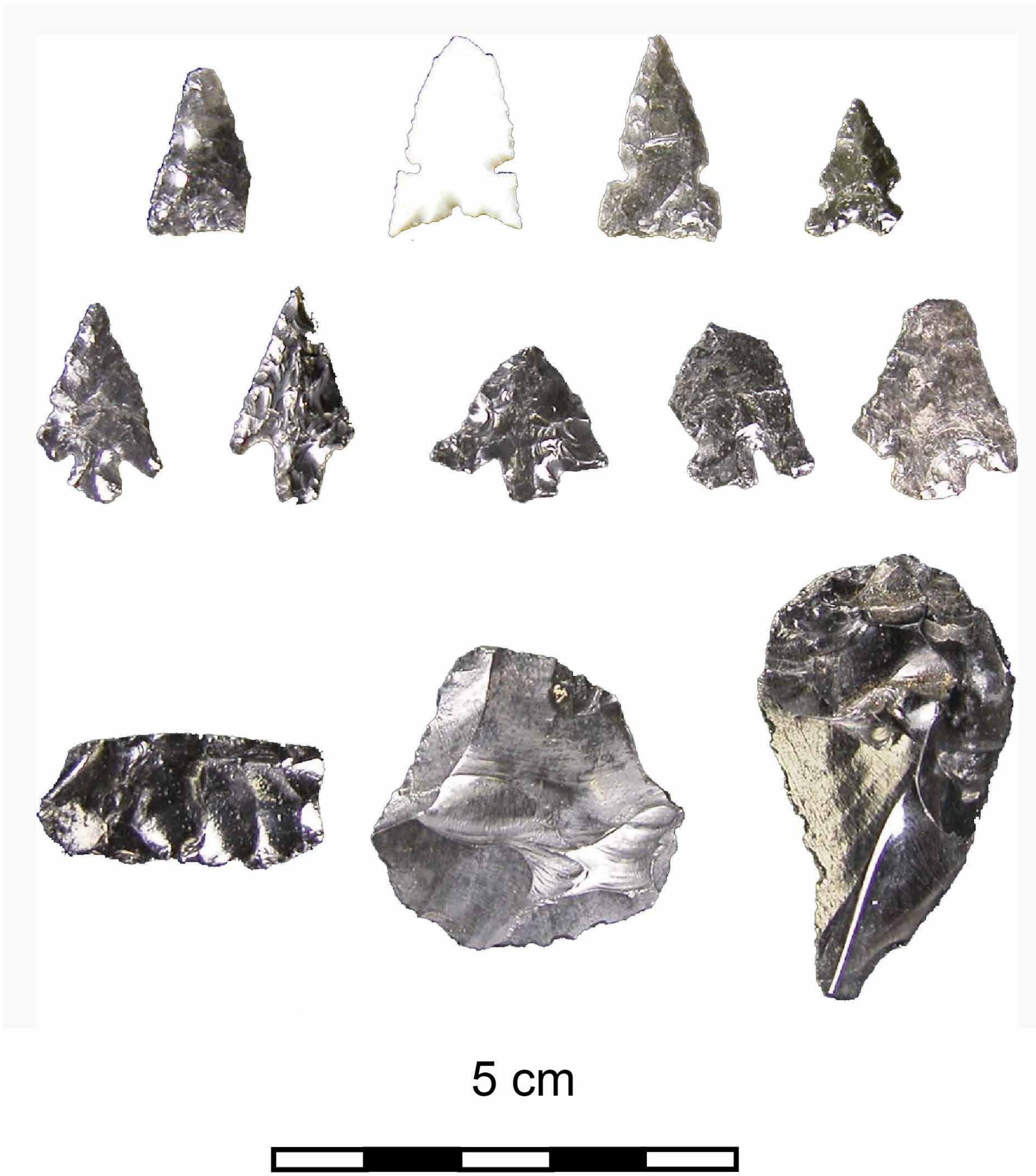

Figure 1. Ancestral Puebloan lithic artifacts from Late Prehistoric sites along the East Fork. Top Row: Arrow points from Upper Farmersville (n=3) and, Branch (n=1) sites (left to right); Middle Row: Arrow points from the Branch site; Bottom Row: Worked obsidian flakes/scrapers from the Branch site. All artifacts are made from obsidian except for the white arrow point in the top row which is chalcedony.

Figure 2. Ancestral Puebloan ceramics from Late Prehistoric sites along the East Fork. Top Row: Chupadero Black-on-white (n=2) and Mimbres Black-on-white (n=1) from the Branch site (left to right); Second Row: Chaco Black-on-white from the Branch #2 site; Third Row: Santa Fe Black-on-white from the Upper Farmersville site; Bottom Row: Rio Grande Glaze (n=3) and Jemez Black-on-white (n=1) from the Upper Farmersville site (left to right).

Branch (41COL9)

Approximately 18 km southwest of the Upper Farmersville site is the Branch site, located on a small rise on the eastern side of the East Fork (see Crook 2007). The Branch site and the neighboring Branch #2 site (41COL259) have the largest amount of Puebloan artifacts in the region. These include 52 artifacts of probable Puebloan or Northern Great Plains origin, including nine obsidian arrow points, three pieces of worked obsidian, two Chupadero Black-on-white sherds, one drilled pendant, one sherd of Mimbres Black-on-white, one unidentified type of Black-on-white worked circular sherd, two turquoise beads, one turquoise pendant, and 32 shell beads (see Figures 1 and 2). Only one of the arrow points is a typical Puebloan triangular (or notched triangular) shape. Instead, the obsidian points found at the Branch site are relatively thick (5 mm versus 2-3 mm typical of most Puebloan points) and are similar to Alba and/or Catahoula forms common to the East Fork (see Figure 1). Given the presence of three other pieces of worked obsidian, it may be that the inhabitants obtained a piece (or pieces) of unworked obsidian and fashioned their own preferred style of arrow point as opposed to trading for completed projectile points (as was apparently the case at Upper Farmersville).

XRF analysis of the 12 obsidian pieces recovered from the Branch site shows they come from multiple sources. Trace-element geochemical analysis of four arrow points and three worked flakes indicates an origin within the Jemez Caldera of North Central New Mexico, either from Cerro Toledo, Cerro del Medio, or the Valles Rhyolite. However, five other obsidian arrow points originate from more distant sources in Idaho (Brown's Bench, Owyhee Pass, and Timber Butte) and Oregon (Massacre Lake-Guano Valley) (see Table 2). These distant sources mirror those found by Hester (1986, 1991) in a number of obsidian artifacts from Central and South Texas from the Malad, Idaho, source.

Both the Chupadero Black-on-white and Mimbres Black-on-white (geometric) pottery suggest a time frame of A.D. 1000-1150 for the occupation of the site. This again fits well with the one calibrated radiocarbon age date from the site (two-sigma range of A.D. 1025-1165) (Crook and Hughston 2015a, 2015c).

The two turquoise beads and the turquoise pendant found on the south side of the rim-and-pit feature (Figure 3) present at the site were subjected to trace element geochemical analysis using XRF (Crook 2017a). While the results were not completely unambiguous, the three Branch artifacts most closely matched those of Chalchihuitl Hill (Los Cerrillos), New Mexico, a well-known source for much of the turquoise found in Puebloan sites of North Central New Mexico (Table 4). A Los Cerrillos source for the Branch site turquoise is consistent with a Jemez Caldera source for many of the obsidian artifacts recovered from the site (Crook 2017a).

Lastly, six of the shell beads recovered from the same provenience as the turquoise artifacts and some of the obsidian artifacts were analyzed by Dr. Deanna Grimstead of Ohio State University for both carbon and oxygen isotope data in an effort to determine their source. While the source for three of the shell beads could not be unambiguously determined, the other three beads yielded values that correspond to either a Pacific Coast or Gulf of California source (Table 5). Moreover, three beads made from *Olivella* shell were recovered from the same general provenience at the site. Based on their length-to-width ratios, the shells were identified as *Olivella dama,* which occur on the Pacific Coast and not in the Gulf of Mexico or Atlantic (see Figure 3). This is consistent with the beads having come from Puebloan sources (Crook 2015).

Branch #2 (41COL259)

In 1973-1974, Crook worked for the Heard Natural Science Museum conducting a detailed archeological survey of Collin County. This involved extensive ground searches for new sites, especially in the vicinity of known large occupations. As a result of the survey, a small site was found directly opposite the Branch site on a terrace above the western bank of the East Fork of the Trinity River. Due to its proximity, the site was given the designation of "Branch #2" (41COL259) (Crook 1985).

The Branch #2 site has occupational material covering only about 100 square meters. Twenty-eight artifacts were recovered, all of probable Puebloan origin (see Figure 2 and Figure 4). These included one obsidian triangular arrow point, one white chalcedony side-notched arrow point, one obsidian side scraper, one worked chalcedony flake, five sherds of Santa Fe Black-on-white pottery, four sherds of Chaco Black-on-white, two sherds of Black Mesa Black-on-white, one sherd of Zuni Glaze Ware, two nodules of unworked turquoise, one turquoise bead, one chalcedony bead, one crinoid columnal with red ochre staining, three microlithic chalcedony drills, one

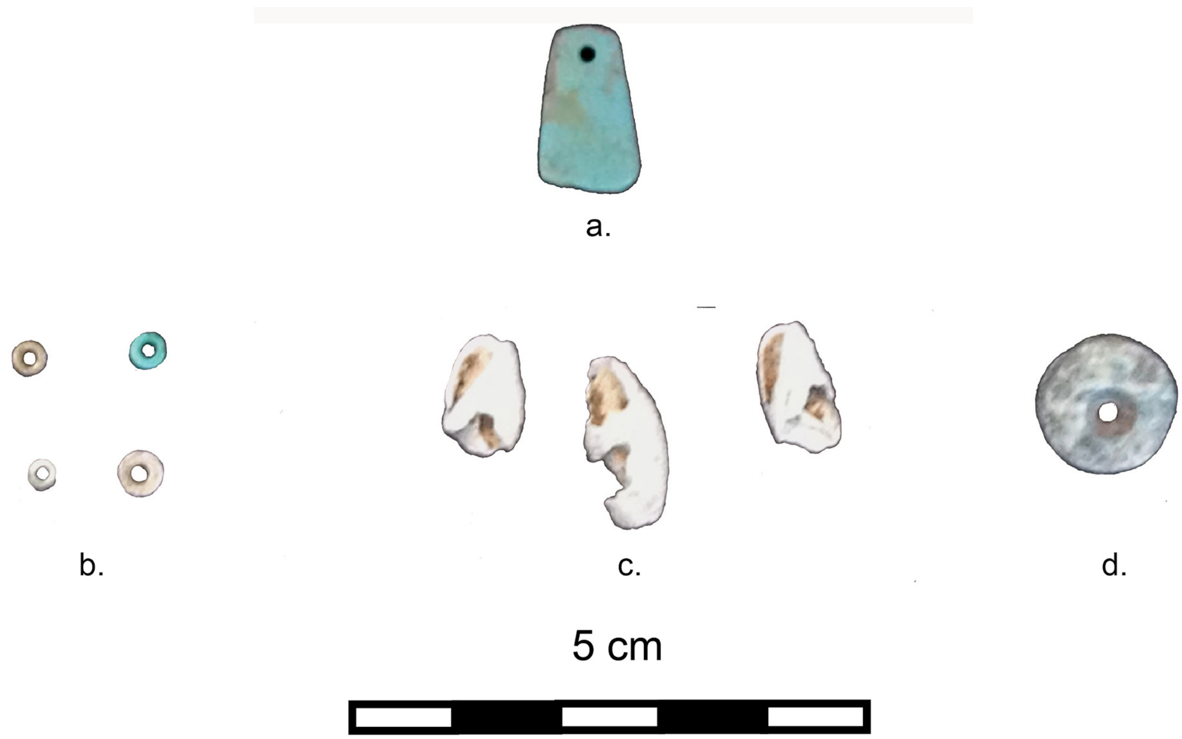

Figure 3. Bead cache found near the southern rim of the rim-and-pit structure at the Branch site: a, Turquoise pendant; b, three small shell beads and one turquoise bead; c, three perforated Olivella dama shells; and d, a larger turquoise bead.

Table 4. East Fork Turquoise artifacts and probable source.

Site	Artifact	Outside Diameter (mm)	Inside Diameter (mm)	Thickness (mm)	Probable Source Based on XRF Trace Element Geochemistry
Branch (41COL9)	Small Bead	2.2	1.2	0.8	Los Cerrillos (Chalchihuitl Hill)
Branch (41COL9)	Large Bead	12	2.4	5.5	Los Cerrillos (Chalchihuitl Hill)
Branch #2 (41COL259)	Small Bead	5	1.5	1.2	Unknown
		Length	Width	Thickness	Probable Source
Branch (41COL9)	Pendant	15.9	7.1-10.0	2.5	Los Cerillos (Chalchihuitl Hill)
Branch #2 (41COL259)	Raw Nodule	28.5	19	18.8	Los Cerillos
Branch #2 (41COL259)	Raw Nodule	24.7	19.8	18.1	Los Cerillos

Table 5. Branch site (41COL9) shell bead source analysis.

Artifact	Lab ID	Material	Outside Diameter (mm)	Thickness (mm)	Inside Diameter (mm)	δ^{13}C	+/—SD	δ^{18}O	+/—SD	Source
Bead 19	DG15-001	Shell	6.5 x 6.2	2.4	1.9	2.65	0.007	-0.58	0.091	Pacific
Bead 23	DG15-002	Shell	10.0 x 8.4	2	2.8	-8.08	0.012	6.25	0.045	Unknown
Bead 24	DG15-005	Shell	14.1 x 13.4	3	3.2	-13.06	0.009	-7.16	0.02	Gulf of California
Bead 26	DG15-004	Shell	14.0 x 12.9	3.6	2.2	-8.32	0.022	-6.41	0.066	Gulf of California
Bead 27	DG15-007	Shell	17.1 x 12.8	4	2.9					Unknown
Bead 28	DG15-006	Shell	16.2 x 16.0	4.2	2.7					Unknown
Bead 29	DG15-003	Shell	12.0 x 10.8	1.5	1.6	n.d.	n.d	n.d.	n.d.	Fossil Foraminifera

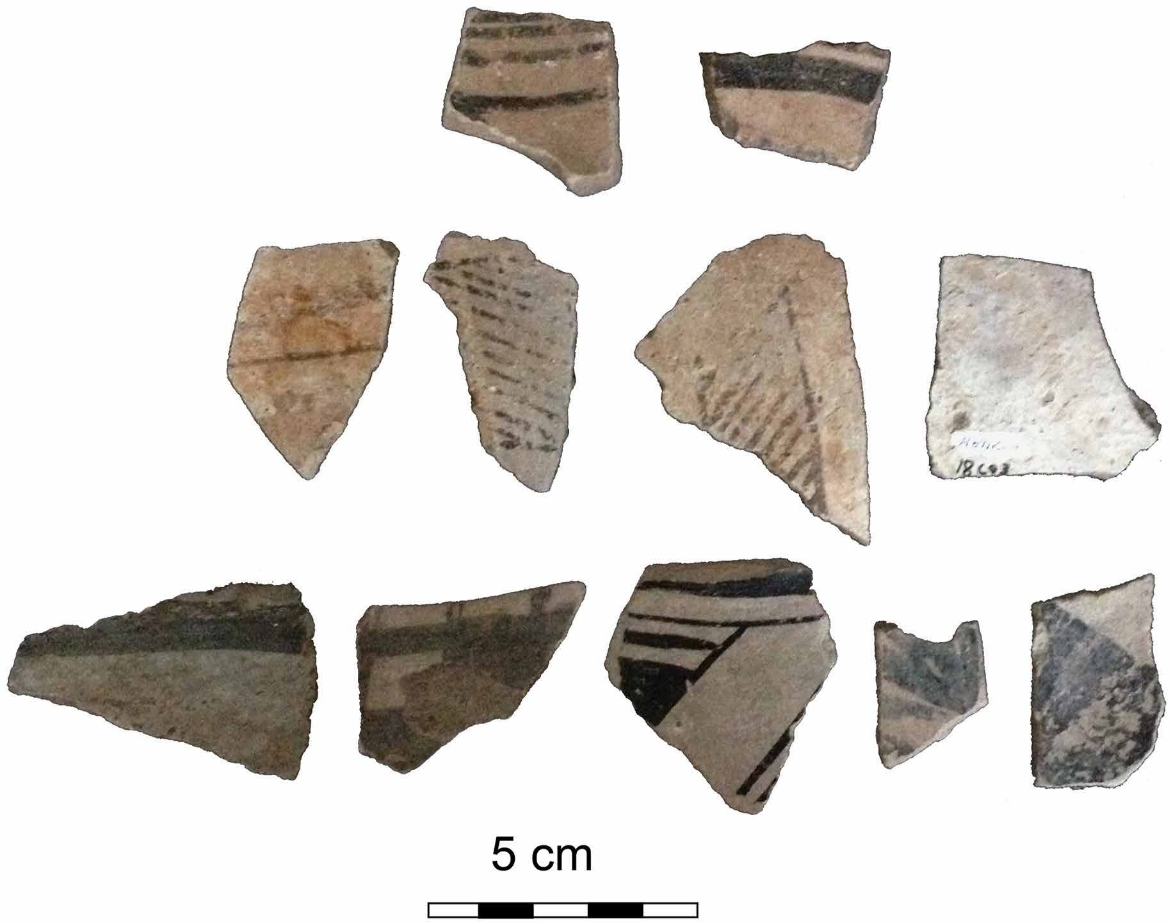

Figure 4. Ancestral Puebloan ceramic sherds from the Branch #2 site. Top Row: Black Mesa Black-on-white; Middle Row: Chaco Black-on-white; Bottom Row: Santa Fe Black-on-white.

large quartzite platform with numerous drill holes on the upper surface, two pieces of red coral, and a single piece of almandite garnet-bearing schist (see Table 1). Of particular note, despite detailed investigations, no artifacts of local origin were found at the site. As such, Crook (1985) suggested that the site represented the occupation of a trader, either of an intermediary from the west (such as from the Henrietta phase of the Southern Great Plains), or possibly Puebloan. The location so near the larger Branch site further suggests that it was the focus of trade (obsidian tool stone, beads, and ceramics). In addition, the presence of a relatively large number of Puebloan artifacts at the Branch site indicates that such trade took place.

The pottery from the Branch #2 site provides a relative age of A.D. 1050-1400, and indicates the site was utilized as an ephemeral and periodically occupied trading camp perhaps for a long period. The ceramics from the Branch #2 site are contemporaneous with the Puebloan ceramics found at both the Upper Farmersville and Branch sites.

In 2014, Crook visited the Heard Museum to photograph artifacts from the Branch #2 site. Twenty-two artifacts were located including the lithic tools, all but one of the sherds (see Figure 4), the chalcedony drills, and the turquoise nodules (Figure 5a). Unfortunately, the two pieces of red coral, the turquoise bead, the sherd of Zuni Glaze, the piece of almandite (garnet) schist, and the quartzite drill platform could not be found.

With the Heard Museum's permission, the two obsidian artifacts plus the two raw turquoise pieces were subjected to a detailed 24 element analysis using a Bruker Tracer III-SD energy dispersive XRF spectrometer. This is equipped with a rhodium

Figure 5. Other Puebloan artifacts: a, turquoise nodules from the Branch #2 site; b, ceramic sherd of probable Wingate Black-on-red from the Lower Rockwall site; c, Scallorn-like obsidian arrow point from the Lower Rockwall site; d, large worked flake of obsidian from the Upper Rockwall site; e, Scallorn-like obsidian arrow point from the Pecan Springs site; f, Ancestral Puebloan sherd from the Auction site. Photograph courtesy of Bo Nelson; g, possible Gallup Black-on-white body sherd from 41HE412.

target X-ray tube and a silicon drift detector with a resolution of ca. 145 eV Full Width at Half Maximum (FWHM) at 100,000 cps over an area of 10 mm^2. Data was collected using a suite of Bruker pXRF software, then processed using the Bruker's empirical calibration software add-on. The analyses were conducted at the Prehistory Research Project laboratory at Texas State University. All samples were rinsed in Milli-Q ultra-pure water to remove all external contaminants prior to analysis.

The XRF results showed that both obsidian artifacts are sourced to the El Rechuelos area of North Central New Mexico. Though sourcing the turquoise nodules proved more problematic (Crook 2017a), their trace element geochemistry closely matched the Los Cerrillos area of North Central New Mexico (high copper, minor iron, no zinc, trace barium, strontium, and arsenic). It should be noted that unlike the turquoise artifacts from the Branch site, the two nodules could not be sourced specifically to Chalchihuitl Hill.

Lower Rockwall (41RW1)

One of the more important finds of Puebloan cultural material along the East Fork was the discovery of a stirrup-spout pottery vessel by Lorrain and Hoffrichter (1968) at the Lower Rockwall site. Lower Rockwall is approximately 21 km south of the Branch site. The vessel was recovered in the eastern half of the site, outside the prominent rim-and-pit feature there, about 1 m below the surface. The vessel was nearly complete, missing only the neck portion of the stirrup spout. A detailed study of the vessel's temper confirmed the rock mixture (basalt with monocrystalline fragments of olivine, pyroxene, and plagioclase) was from North Central New Mexico (McIntyre and McGregor 1982). The vessel was subsequently identified as Arboles Black-on-white with an approximate date of A.D. 900-1100 AD (Pueblo II Period). This fits well with the calibrated radiocarbon age date ranges observed for most of the East Fork sites, in addition to an uncalibrated date of A.D. 1020 ± 90 (Tx-315) from the nearby Upper Rockwall site (41RW2) (Ross 1966; Valastro et al. 1967; Lynott 1978; Crook and Hughston 2015a).

Recently, a small collection of artifacts from the Lower Rockwall site was made available to Crook for study. The collection came from an experienced local collector and the provenance of the collection to the Lower Rockwall site was attested to by a series of hand-written notes provided with the artifacts. Included in this collection was an obsidian arrow point and a single rim sherd of Black-on-red pottery (see Figure 5b-c). The sherd has a light brown to orange-colored hard paste with temper consisting of similarly colored grog fragments and large sand grains (see Figure 5b). Both the interior and exterior surfaces were coated with a dull red slip that was decorated with an organic black paint. The black paint decoration consists of solid diagonal lines. A comparison to type specimens from a number of Puebloan ceramic types in Crook's possession from Pot Creek Pueblo in Northern New Mexico indicates the sherd is nearly identical to specimens of Wingate Black-on-red. As described by Carlson (1970) and Hays-Gilpin and van Hartesveldt (1998), Wingate Black-on-red dates from ca. A.D. 1030-1175, and is contemporaneous with many other Puebloan ceramics recovered from the Upper Farmersville, Branch, and Branch #2 sites (see Table 3).

Crook has diligently searched without success for the archeological collection containing the Arboles Black-on-white stirrup vessel from the Lower Rockwall site at both Southern Methodist University and at the Texas Archeological Research Laboratory (TARL). While other artifacts from Lorrain and Hoffrichter's excavations are present in the TARL collections, the Arboles Black-on-white vessel is missing.

The obsidian arrow point from the Lower Rockwall site is an extremely well made artifact measuring 33.1 x 13.9 mm in length and width, with a maximum thickness of 4.9 mm (see Figure 5c). Like other obsidian arrow points found at East Fork sites, the shape is very similar to that of a Scallorn point rather than the more typical triangle or side-notched triangle characteristic of many Puebloan points. The point was subjected to a trace element geochemical analysis using XRF and was sourced to McDaniel Tank, a unique outcrop within the Squaw Peak Volcanic Center in Central New Mexico (Bobrow et al. 1983).

Upper Rockwall (41RW2)

Another private collection from the East Fork was made available to Crook in the summer of 2017. Included in this was a box of material from the Upper Rockwall site in northern Rockwall County. The Upper Rockwall site is located about 5.5 km north of Lower Rockwall; both sites are currently submerged beneath Lake Ray Hubbard. In addition to typical East Fork Late Prehistoric materials, this collection contained a large worked flake of obsidian (see Figure 5d). The flake is 70.2 x 48.4 mm in length and width, with a maximum thickness of 9.1 mm. A bifacial edge has been flaked around the perimeter of the artifact suggesting its use as a scraper or knife. One surface of the artifact has a dull luster likely from long-term exposure resulting in dehydration. An XRF analysis of the shinier face of the artifact indicates a trace element composition consistent with obsidian from Cougar Mountain, Oregon. Because there are few reported occurrences of Cougar Mountain obsidian from Texas, the raw data was sent to Craig Skinner of the Northwest Research Obsidian Studies Laboratory for a blind test. The Cougar Mountain source for the obsidian was confirmed, making this artifact a unique addition to Texas obsidian studies.

Distribution of Southwestern Artifacts elsewhere in North Central Texas

As part of this research, Crook reviewed materials from extensive private collections (Wilson W. Crook, Jr., R. King Harris, Fred Wendorf, Housewright-Wilson-Vance, and Southern Methodist University) from Dallas, Denton, Tarrant, Kaufman, and Ellis counties. Collections from these counties curated at TARL were also studied, including the extensive collection donated by William Sorrow from the prolific Pecan Springs site (41EL11) (Sorrow 1966). In addition, a literature review was conducted of the major excavations and river basin surveys in these counties. A request was also made to Texas Chert, a large group of avid collectors on Facebook, for information on obsidian from North Central Texas sites. This group could not provide additional information about the occurrence of obsidian or Southwestern Puebloan ceramics associated with any of the private collections, or with collections associated with published literature from any of the counties listed above.

During Crook's review, a private collector informed him of an obsidian arrow point he had in his possession from the Pecan Springs site in Ellis County (see Figure 5e). The collector generously allowed us to borrow the artifact for measurement and analysis. The point is clearly a Scallorn type and measures 31.9 x 15.0 mm in length and width with a maximum thickness of 3.5 mm. In both shape and size, the point is very similar to the one described above from the Lower Rockwall site. A trace element geochemical analysis using XRF indicates the obsidian originated from the Cerro del Medio region (Valle Rhyolite) of the Jemez Caldera in North Central New Mexico.

Lastly, Todd (2014) notes the presence of obsidian flakes reported in Wise County at 41WS38 (Moseley 1996). No geochemical trace element analysis has been conducted on these flakes.

Southwestern Pottery from Caddo Sites in East Texas

Eleven Caddo sites in East Texas have Southwestern pottery, primarily vessel sherds. As a group, this pottery was made from the 11th to the 16th century, and later (1800s), in New Mexico and Arizona, by potters of the Mogollon and Upper Gila Salado cultures, along with a single 19th century Zuni vessel. The Caddo sites with Southwestern pottery occur in the Red (n=1), Sulphur (n=4), Big Cypress (n=3), Sabine (n=2), and Neches (n=1) river basins.

Unknown Site in Cass County

A corrugated rim sherd of Upper Gila ware comes from an unknown and unrecorded site of Late Caddo period age associated with the early part of the Titus phase (ca. A.D. 1430-1680) in Cass County, Texas, just west of the Louisiana state line (Krieger 1946:208 and Plate 6m). This sherd resembles a Cliff Indented or Cliff Patterned Corrugated vessel made between ca. A.D. 1300-1450. The construction of this vessel type was common in the Upper Gila area of southern and western New Mexico.

Galt (41FK2)

Krieger (1946:208 and Plate 6n) has identified a corrugated body sherd of Upper Gila ware in a Late Caddo, Titus phase surface collection from the Galt site in the Big Cypress Creek basin (see Thurmond 1990:152). This sherd also resembles a Cliff Indented or Cliff Patterned Corrugated vessel made between ca. A.D. 1300-1450 in the Upper Gila area in southern and western New Mexico.

Hayes Farm (41FK8)

According to Thurmond (1990:60), four sherds of Southwestern pottery were found at the Hayes Farm site (41FK8) in the Big Cypress Creek basin (one Gila Polychrome sherd, one Tonto Polychrome sherd, and two Maverick Mountain Redware sherds from one vessel). The site has a Caddo component of unknown age and affiliation. Puebloan potters in southern and western New Mexico and western and southwestern Arizona between ca. A.D. 1300-1450 produced these Mogollon-Salado ceramic wares (New Mexico Office of Archaeological Studies 2018).

Auction Site (41FK150)

A Puebloan ceramic vessel sherd from a jar (see Figure 5f) has been found at the Auction site (1FK50) north of Mount Vernon in Franklin County, in the White Oak Creek/Sulphur River basin. The kinds of Caddo artifacts found at this site is currently unknow.

Consultations with Southwestern archeologists suggest this sherd may be of the Dogoshizi style found in the northern Southwest between the late A.D. 900s and the early A.D. 1200s, and this style has different names depending on where the vessels were produced in the region (Mark Varien, personal communication, 2018). Regge Wiseman (Office for Archeological Studies at the Center for New Mexico Archeology, personal communication,

2018) and Kari Schleher (2018 personal communication) both suggest that the sherd is from a Gallup Black-on-white vessel made in the Chaco region of the southern Colorado Plateau between ca. A.D. 980-1150 (Mathien 1997: 313-324). It has also been suggested that the sherd is from a Kwahe'e Black-on-white vessel from the northern Rio Grande area of New Mexico; this type dates from ca. A.D. 975-1200 (Sev Fowles, personal communication, 2018; New Mexico Office of Archaeological Studies 2018; Schillaci and Lakutos 2017). Regardless, all Southwestern ceramic types mentioned here date to the Early Caddo period of East Texas, a time of considerable interregional exchange of prestige goods (Girard et al. 2014:54-63; Lambert 2017).

Harrison County

Hayner (1955:247) reports a sherd of Mogollon Brownware from a site on the southern shores of Caddo Lake in Harrison County, about 3 km west of the Louisiana state line. According to Hayner (1955) the sherd comes from a vessel likely made in the Salt River-Tonto Creek area of central Arizona, but given current evidence it more likely originated from peoples of the Palo Duro Complex (Boyd 2004). None of the other artifacts from the site is temporally or culturally diagnostic (Hayner 1955:248), but it is probable that the Mogollon Brownware sherd is from a Caddo component at the site.

41HE412

The Southwestern ceramic sherd from 41HE412 is in a private collection. This is a Caddo site in the Caddo Creek valley in the upper Neches River basin in Henderson County (Perttula and Walters 2017). It is from a jar or pitcher, has a whiteware or a washy slipped surface treatment with hachured black bands and solid black rectangular dividers between or surrounded by bands executed with a mineral/iron paint (see Figure 5g). This sherd probably belongs to the Gallup Black-on-white type associated with the Cibola Whiteware series (Hays-Gilpin and van Hartesveldt 1998; Mathien 1997; McKenna 1984:Figures 3.12-3.13). As such, this ceramic type has its origins in the Chaco Canyon area of the Central San Juan basin of northwestern New Mexico, and dates from ca. A.D. 980-1150.

Sanders (41LR2)

Krieger (1946:208 and Plate 6k) reports a polished and smudged Upper Gila ware sherd from the surface of the Sanders site at the confluence of the Red River and Bois d'Arc Creek. It is likely from the extensive Middle Caddo (ca. A.D. 1200-1400) component at the site (Perttula et al. 2015). Jurney and Young (1995:18) also reported Chupadero Black-on-white sherds, dating from ca. A.D. 1050-1550, at the Sanders site.

Auds Creek, Lamar County

Wright (1943:90) reports a 19th century Zuni vessel recovered in 1937 from a ditch along Auds Creek, a tributary of the North Sulphur River. This grog-tempered jar has painted decorative elements, including being painted white on both exterior and interior vessel surfaces. There are four painted horizontal black or medium brown bands dividing the vessel into sections, and between the bands are red and black stair-step elements and connecting diagonal painted lines (Figure 6) (see Perttula et al. 2017:29).

H. P. Mera of the University of New Mexico attributed this vessel to the Zuni, New Mexico ceramic tradition (Wright 1943:95). A recent examination of images of this vessel by Drs. Matt Peeples, Barbara Mills, and David Snow (July 2017 personal communication) led them to conclude that it may not be a Zuni vessel, but an early mid-19th century Keres Pueblo pottery. They note that the shape of the vessel is similar to Tewa vessels from the Rio Grande. "The painted lip is right for early to mid-19th century age for the vessel. Overall, 1800-1880 is the most likely date range," (Barbara Mills, 2017 personal communication) However, others argue that the use of grog temper and the character of the paste is more consistent with a 19th century Zuni ceramic vessel (Matt Peeples, September 7, 2017 personal communication).

Unknown Site in Red River County

Jack T. Hughes reported a corrugated sherd with rock temper from an unrecorded site in southern Red River County, Texas (Krieger 1946:208 and Plate 6l), in the Sulphur River basin. This sherd is likely Upper Gila ware from southern and western New Mexico dating from ca. A.D. 1300-1450.

Figure 6. Painted Southwestern jar from Auds Creek, Lamar County, Texas, GTW-297: a-b, various views.

Shelby County, Sabine River

One sherd of Chupadero Black-on-white pottery has been reported from a Late Caddo site in Shelby County, Texas (Krieger 1946:208 and Plate 6j), possibly in the Angelina River basin given that the site is reported to be "within 30 miles of the Texas-Louisiana boundary" (Krieger 1946:208). Puebloan groups made Chupadero pottery in central and southern New Mexico between ca. A.D. 1050-1550 (New Mexico Office of Archaeological Studies 2018).

Steck Site (41WD529)

The Steck site in the Lake Fork Creek valley in the upper Sabine River basin is a Late Caddo period Titus phase settlement dating to the 15th century A.D. One neck-banded sherd has a corrugated effect, identified by Andrew Lindsay (Northern Arizona University) as a sherd from an eastern Arizona Homolovi Corrugated vessel (1977 Bob D. Skiles personal communication; Perttula and Skiles 2014:4). Thus, it may be indicative of down-the-line exchange or trade between a western Puebloan group and an upper Sabine River basin Caddo group.

East Texas Archeological Sites with Obsidian Artifacts

At present, there are eight archeological sites known in East Texas with obsidian artifacts (Figure 7). One site is located in the Red River basin, two are in the upper Sulphur River basin, two are in the upper Sabine River basin, two occur in the upper Neches River basin (see Perttula and Hester 2016), and one is in the Angelina River basin.

41AN201 (A. S. Mann Site)

The A. S. Mann site (41AN201) is a Caddo habitation site with cemeteries along Caddo Creek in the upper Neches River basin. University of Texas archeologists first investigated this site in 1935, where two Caddo burials estimated to date between ca. A.D. 1480-1560 were excavated (Perttula 2015). Goodmaster (2015) as part of a Texas Department of Transportation (TxDOT)-sponsored archeological survey, recently relocated the site. TXDOT archeologists excavated a number of backhoe trenches at the site in early 2015 and found a piece of obsidian debris in the trench fill. Data recovery excavations initiated in late May 2015 recovered 17 more pieces of obsidian debris from an unknown number of 2 x 2 m units in Late Caddo period, Frankston phase, archeological deposits. In addition, an obsidian Perdiz point was recovered from a burial feature (Kelley et al. 2017). These obsidian pieces have not yet been sourced.

41BW35

A single obsidian flake of possible Archaic period age was recovered from 41BW35, although Williams Plain and Cooper Boneware sherds found there also suggests it was occupied during the Woodland period as well (ca. 500 B.C.-A.D. 800). The flake was found in a surface collection during the 1949 survey of the proposed Texarkana Reservoir on the Sulphur River, now known as Lake Wright Patman. Lawrence Berkeley Laboratory sourced this artifact (TOP 98) to Obsidian Cliff, Wyoming, a primary source in the Northwestern Plains.

Pine Snake (41CE467)

The Pine Snake site is one of several well-preserved Historic Caddo Allen phase (ca. A.D. 1680-1800) settlements that have been recently identified in a small portion of the Flat Creek valley in the upper Neches River basin (Perttula et al. 2013; Perttula and Nelson 2007, 2009), as well as in nearby Stone Chimney Creek (Walters and Perttula 2012). It is apparent from the number of sites that have been documented in this area that there was a considerable density of Caddo residential settlements on Neches River tributaries spanning the late 17th-early 18th centuries.

During test excavations at the Pine Snake site, two pieces of obsidian were recovered between 10-20 cm below surface (bs) in the archeological deposits (Perttula et al. 2013). The obsidian flakes (Texas Obsidian Project [TOP] No. 234a-c) are from Obsidian Ridge (Cerro de Toledo rhyolite) in the Jemez Mountains of northern New Mexico. According to Ferguson (2009), the University of Missouri Research Reactor Center, Archaeometry Laboratory analyzed the obsidian pieces with a hand-held portable Bruker XRF. The mean values in parts per million (ppm) for these elements are: Rb (196.3 $\pm$ 5.6 ppm), Sr (5.67 $\pm$ 0.44 ppm), Y (47 $\pm$ 2.67 ppm), Zr (153.7 $\pm$ 10.23 ppm), and Nb (71.3 $\pm$ 2.23 ppm).

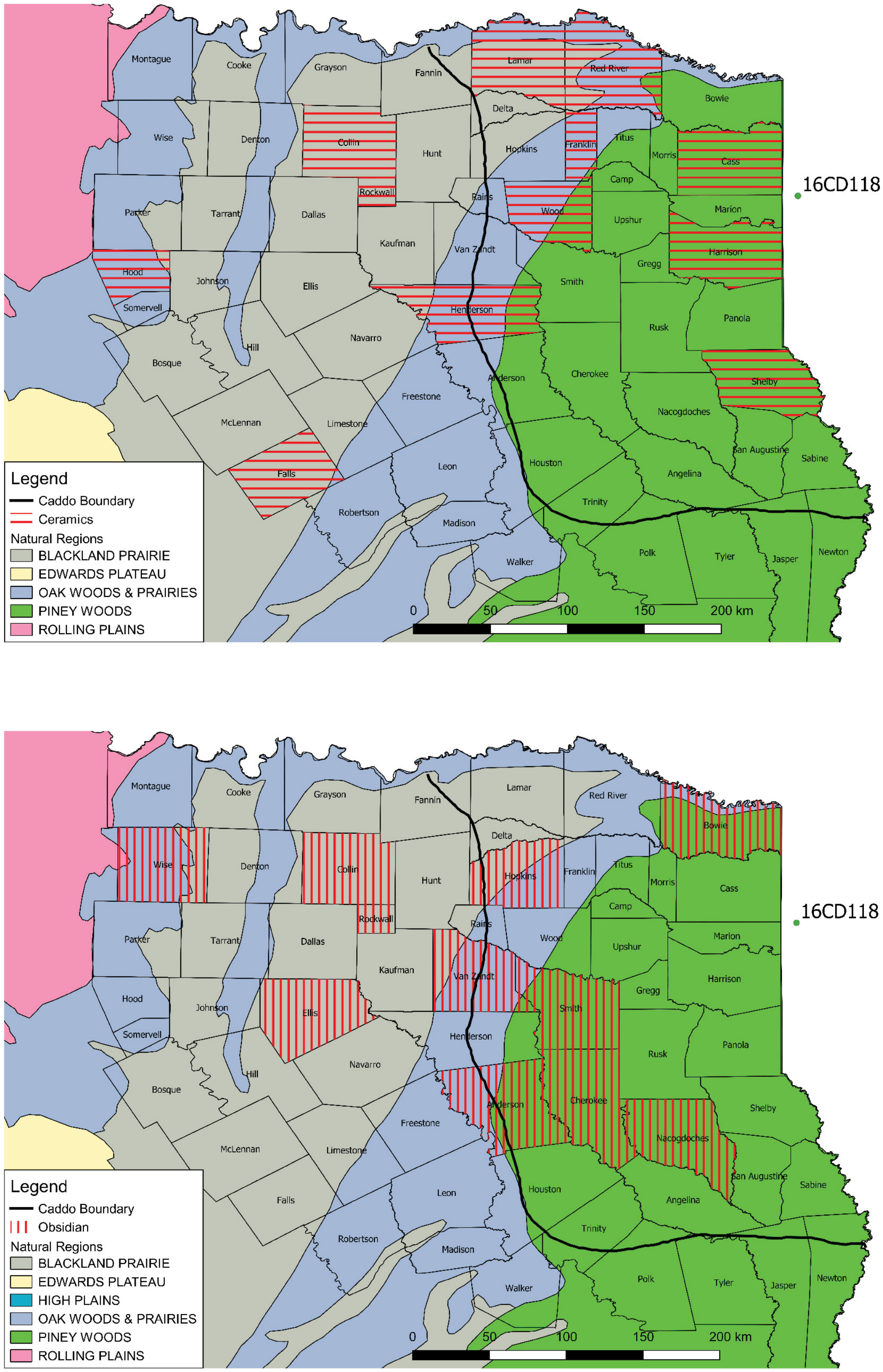

Figure 7. Distribution of counties in North Central and East Texas with sites that have obsidian, turquoise, and ancestral Puebloan ceramic artifacts.

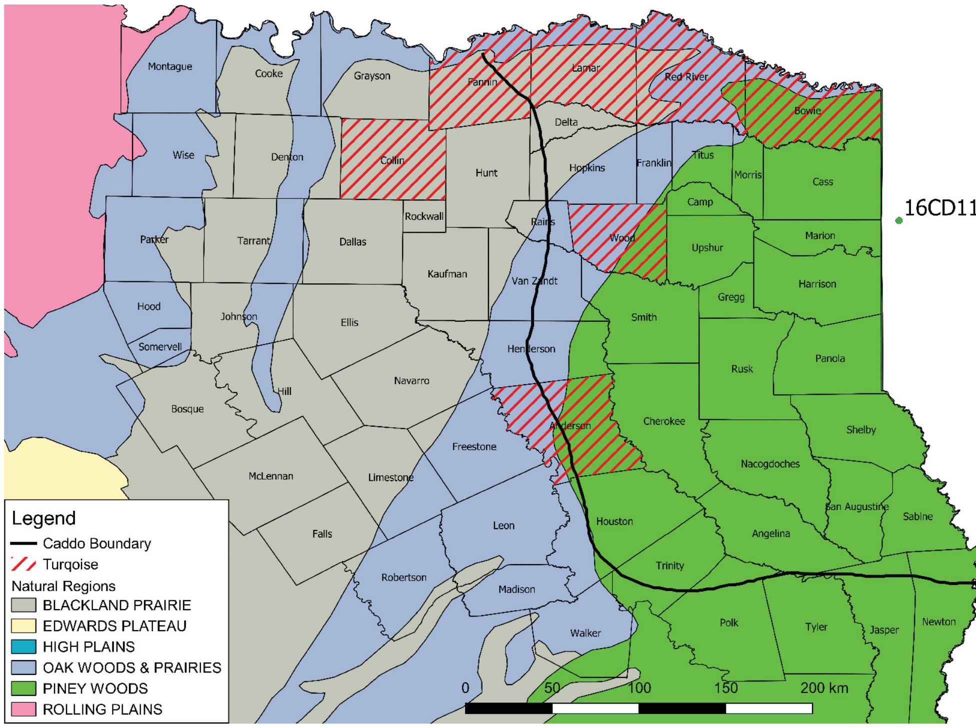

Figure 7. (*Continued*)

Hurricane Hill (41HP106)

In the upper Sulphur River basin, two non-cortical pieces of obsidian debris have been recovered from Early Caddo period (ca. A.D. 900-1200) archeological deposits on the North Rise at the Hurricane Hill site (Perttula 1999:182 and Table 8-14). They are among more than 44,000 pieces of lithic debris recovered in excavations there. These obsidian specimens have not been analyzed to determine their source.

41HP200

Rogers (2000:46, 49) recovered a single piece of obsidian debitage from a Woodland period component at 41HP200 in the White Oak Creek drainage in the upper Sulphur River basin. Four two-sigma calibrated radiocarbon dates from the site range between 172 B.C. and A.D. 90 (Rogers 2000:Table 3). The Wavelength Dispersive X-Ray Fluorescence Laboratory at the University of California-Berkeley sourced the flake to the Malad, Idaho, obsidian source. The mean values in parts per million (ppm) are Rb (119 ppm), Sr (72 ppm), Y (32 ppm), Zr (95 ppm), and Nb (15 ppm) (Rogers 2000:Table 7).

Cherokee County

A single obsidian artifact was recovered at an unrecorded prehistoric site in southeastern Cherokee County, Texas, in the Angelina River basin, (George Avery, January 2018 personal communication). The artifact is a triangular arrow point or arrow point preform (Figure 8a), likely from a Late Caddo or post-A.D. 1680 Historic Caddo occupation. This obsidian artifact (TOP 268) has been sourced to Little Glass Buttes in Oregon (Glascock 2018).

C. D. Meyer Collection, Camp Fannin, Smith County, Texas (TOP 94)

The C. D. Meyer collection represents a group of artifacts from Paleoindian to Late Prehistoric age collected in the 1940s from an unrecorded site at Camp Fannin, north of Tyler, Texas, in the upper Sabine River basin. C. D. Meyer found an obsidian artifact at the bottom of a deep gully, within a large prehistoric site at Camp Fannin. This is an obsidian biface or point tip with parallel flaking and grinding at the tip (TOP 94). At this time, the artifact has not been sourced.

Figure 8. Additional Puebloan artifacts: a, obsidian triangular arrow point or arrow point preform from a site in Northwest Nacogdoches County, Texas. Photograph courtesy of George Avery; b, reconstructed turquoise bead necklace from the Goss Farm site (photo by Lester Wilson); and c, likely Tularosa Corrugated Indented sherd from the Wyatt site.

Yarbrough (41VN6)

Excavations in 1940 at the Yarbrough site, a large prehistoric encampment in the upper Sabine River basin, recovered a single obsidian flake (specimen TOP 93) from a large sandy knoll (Area A) (Johnson 1962:196 and Figure 12l). Johnson (1962:196) noted that it shows "only very slight and indefinite indications of flaking." The majority of the archeological deposits in Area A date to the Late Archaic and Woodland periods, based on the large number of Yarbrough and Gary dart points found in the deeper deposits (Johnson 1962:Figures 17-18). Unfortunately, however, Johnson (1962:Tables 2-3) did not provide any information on the vertical provenience or estimated temporal age of the obsidian flake in Area A. Based on XRF analysis by the Lawrence Berkeley Laboratory, the geological source for the specimen (TOP 93) is the Cerro del Medio sources in the Jemez Mountains of northern New Mexico.

Twin Bird Islands site (16CD118)

A single obsidian flake tool has been recovered from the Twin Bird Islands site at Cross Lake in Caddo Parish in Northwest Louisiana (see Figure 7) (Boulanger et al. 2014; Pevny 2014). The site has a Late Paleoindian to Early Archaic component, and the tool may be associated with this component, but it was found exposed on the surface due to low water levels and lacks the provenience to confirm this association (Jeane 1984). Boulanger et al. (2014:84) have sourced the tool, through the University of Missouri Research Reactor, Archaeometry Laboratory, to the Mineral Mountain Range in western Utah, about 1800 km northwest of the Twin Bird Islands site.

Turquoise Artifacts on Caddo Sites in East Texas

Seven different Caddo sites in East Texas have turquoise artifacts. Five of these sites are on the Red River, with components that date from ca. A.D. 1200-1400 (n=2) in the Sanders phase of the Middle Caddo period or post A.D. 1400 (n=4). These latter four sites date to Late Caddo period Frankston (n=1), McCurtain (n=2), and Texarkana (n=1) phases. The other Caddo site in East Texas with a turquoise artifact has a post-A.D. 1600 Titus phase component in the Sabine River basin.

A. S. Mann Site (41AN201)

A single turquoise artifact was recovered during 2015 excavations at the A. S. Mann site (41AN201), a Late Caddo Frankston phase habitation site with cemeteries on Caddo Creek in the upper Neches River basin (Kelley et al. 2017).

Goss Farm (41FN12)

The Goss Farm site is a Caddo settlement on an alluvial landform, located on the western side of Bois d'arc Creek near its confluence with the Red River. The Sanders site lies east of Goss Farm on Bois d'arc Creek. The recovered artifacts from Goss Farm strongly suggest that its occupations are culturally related to that of the Sanders site (see Harris 1967; Jackson 2000; Krieger 1946), and date to the Middle Caddo period (ca. A.D. 1200-1400). It is likely that the Sanders phase settlement at the Goss Farm site is part of, or at least associated with, the extensive Sanders phase settlement at the Sanders site on the east side of Bois d'arc Creek (Perttula et al. 2015).

In the 1940s, Rex Housewright and his colleague, Lester Wilson, found a single red-slipped Sanders Slipped sherd of Middle Caddo period age above a small, oval area of gray clay that contained the burial of a juvenile with an approximate age of 5-6 years, buried in a flexed position facing east. A total of 260 very small tabular turquoise-colored beads and two small rectangular pendants were recovered in "short groups of 0.5-3 inches long" around the shoulders and neck of the individual (Housewright 1946:10; see also Jurney and Young 1995:Figure 4). The total length of the strung bead strand was 26 cm.

The turquoise beads range in diameter from 2.4-4.0 mm. The two turquoise pendants, both apparently strung along with the beads, are 14.0 x 9.5 x 2.4 mm and 14.0 x 8.0 x 2.4 mm in length, width, and thickness. Color of the turquoise ranges from pale blue-green (5BG 6/6) to light blue-green (7BG 7/2) to light green (5BG 7/4) (Housewright 1946; Crook 2017b). Figure 8b illustrates the reconstructed turquoise bead necklace with the two small pendants.

Two of the turquoise beads from the Goss Farm burial were selected for XRF analysis. Both are tabular and extremely thin (0.9-1.0 mm). As can be seen in Table 6, both Goss Farm beads have a very similar trace element geochemistry

Table 6. XRF results of trace element geochemistry of turquoise beads from the Goss Farm Site, Fannin County, Texas, compared to analyses of Morenci and Kingman turquoise as well as a range of analyses from the Chalchihuitl Hill Area, Los Cerrillos, New Mexico.

Element	Goss Farm Bead #1	Goss Farm Bead #2	Morenci, Arizona	Kingman, Arizona	Range Chalchihuitl Hill, Cerrillos, NM (5 analyses)
Sodium	613	626	64	35	1-206
Magnesium	1,708	1,744	1,142	1,482	738-1,753
Silica	2,337	2,924	3,161	3,021	4,452-10,679
Potassium	0	0	0	0	0-889
Calcium	0	0	0	1	1,130-5,091
Titanium	12	32	69	6	41-258
Vanadium	12	8	24	28	17-36
Chromium	5	5	13	13	16-Sep
Manganese	88	109	78	112	36-671
Iron	4,346	5,262	4,982	3,222	2,862-42,671
Cobalt	13	13	13	14	13-21
Nickel	96	102	9	117	37-114
Zinc	0	0	0	0	0
Arsenic	30	96	263	146	13-164
Rubidium	4	10	12	9	26-Jun
Strontium	12	18	8	9	17-158
Yttrium	5	6	3	5	7-Apr
Zirconium	11	12	6	1	Jul-40
Niobium	2	2	1	2	3-Jan
Molybdenum	21	22	26	21	21-Feb
Barium	0	0	0	0	59-272
Lead	5	9	14	11	10-Jul
Thorium	1	3	4	3	5-Feb
Uranium	1	1	1	1	0-9
Mineral	Turquoise	Turquoise	Turquoise	Turquoise	Planerite to Turquoise

characterized by relatively low iron (0.4-0.5 percent), anomalous silica (0.2-0.3 percent), and absolutely no zinc, calcium, or barium, and only trace levels of arsenic (30-96 ppm) and strontium (12-18 ppm). Moreover, the significant presence of copper conclusively shows that the Goss Farm beads are turquoise and not some other copper-bearing aluminum phosphate such as planerite or variscite.

When compared to 31 geologic samples from known prehistoric turquoise mining areas across the Southwestern U.S. and northern Mexico, the chemical composition of the Goss Farm beads most closely matches either Morenci or Kingman, Arizona, materials. It is significant that the analysis does not match samples taken from the southern end of the Los Cerrillos, New Mexico, district, specifically the area in and around Chalchihuitl Hill (see Table 6). Much higher levels of calcium, iron, silica, and a consistent presence of trace barium typically characterize the Chalchihuitl Hill turquoise. Crook (2017b) provides a more detailed description of the Goss Farm bead analysis, including the sourcing methodology.

Sanders (41LR2)

Collections by R. King Harris at the Sanders site, now located in the Smithsonian Institution's National Museum of Natural History, include a rounded but unmodified piece of turquoise (22 x

10 x 7 mm in length, width, and thickness), probably from the Los Cerrillos Hills source in North Central New Mexico (Hull et al. 2014:Figure 1). Jurney and Young (1995:23 and Figure 6) noted that a small turquoise bead, a pendant, and a piece of raw turquoise were collected from the surface of the Sanders site by the Bill Young family. Perttula et al. (2015) note that these were not found in any of the defined surface artifact clusters recognized at the Sanders site, but came from surface areas south and southeast of the East Mound.

Dan Holdeman (41RR11)

In the Red River basin on Mound Prairie, a single turquoise pendant was among the grave goods in Burial 21 at the Dan Holdeman site (Perino 1995:49-50). This McCurtain phase Caddo burial dates after ca. A.D. 1600. Unfortunately, Perino did not describe or illustrate the pendant recovered in Burial 21.

Sam Kaufman (41RR16)

The Sam Kaufman site is a large ancestral Caddo village and mound site on the Red River in the Mound Prairie area (Perttula 2008). Turquoise artifacts have been found in Late Caddo period McCurtain phase burial features at the site. As illustrated in Plate 3:9, Harris (1953:59) recovered two small turquoise pendants and five turquoise beads in Burial 8. Thirty disk-shaped turquoise beads were among the grave goods in Burial 17, an adult male, in the shaft tomb in the East Mound at the Sam Kaufman site (Skinner et al. 1969:33, 103 and Table 2). The beads may have been wrapped around a large biface placed by the right arm. These beads were ca. 1.0 mm thick, and range from 3.0-5.0 mm in diameter. A two-sigma calibrated radiocarbon age range of A.D. 1412-1511 was obtained on human bone from one of the burials in the shaft tomb (Perttula 2008:Figure 6).

Hatchel (41BW3)

Krieger (1946:207, footnote 32) noted that a single, "tiny" turquoise bead was found in the platform mound excavations at the Hatchel site on the Red River, in Late Caddo period Texarkana phase deposits. However, he does not mention what zone the bead came from in the stratified mound deposits, other than that it was from a midden deposit. Overall, the ceramic and lithic artifacts from the platform mound date between ca. A.D. 1500-1690 (Perttula 2018), but the midden deposit may be a part of Zone H, the most intensely used part of the mound zones, which is estimated to date from ca. A.D. 1500-1550.

Turquoise (41WD586)

In the upper Sabine River basin, a turquoise pendant was recovered from a Caddo burial feature in a Late Caddo period Titus phase cemetery on Caney Creek (Walters 2006). The turquoise pendant was found in the neck area of one individual (Burial 1). Ceramic vessels placed in the burial included a Taylor Engraved bowl and everted rim jars. Ceramic vessels from other burials in the cemetery indicate that these Caddo interments date after ca. A.D. 1600.

Walters (2006:Figure 1) described the turquoise pendant as triangular in shape, 12.5 mm in length, 10.1 mm in width at its widest point, and 2.4 mm thick. XRF analysis was done on the pendant, but it could not be sourced to any specific deposit in the Southwest.

Other Southwestern Pottery Finds

Two other finds of Southwestern pottery on sites in the general region are notable: a site in Hood County and a site in Falls County. Both sites are in the Brazos River basin.

The Southwestern pottery from the Wyatt site (41HD95) is a self-tempered body sherd with 7+ corrugated rows that may be from a Tularosa Corrugated Indented vessel (Dr. James Neely, November 2017 personal communication) (see Figure 8c). Puebloan peoples living in western New Mexico made such vessels between ca. A.D. 1200-1350 (Wood 1987:170). This sherd from the site is evidence of some form of contact, limited though it may be, between Brazos River aboriginal peoples and Puebloan peoples from New Mexico.

The second artifact is a complete vessel found along the banks of the Brazos River in Falls County, Texas. The vessel is a globular jar tempered with angular rocks and tuff. It stands 19.5 cm in height (Figure 9). The jar has a single row of rectangular tool impressions under the vessel lip, followed by seven horizontal incised lines on the remainder of the rim. There are three additional

Figure 9. Taos Incised jar found in Falls County, Texas.

horizontal incised lines on the vessel body, located 3.1 cm below the lines on the rim, but well above the circular, convex base.

The consensus of the Puebloan archeologists consulted about the Falls County ceramic jar is that it is most likely a Taos Incised vessel from the northern Rio Grande basin in northern New Mexico and southeastern Colorado (New Mexico Office of Archaeological Studies 2018; Levine 1994; Mera 1935; Peckham and Reed 1963; Wetherington 1968). This type of globular and incised vessel was manufactured and used in the Northern Rio Grande basin between ca. A.D. 950-1200/1250. Through interaction and exchange networks that existed at that time (Jurney and Young 1995:15-16) between Puebloan, Southern Plains, and Caddo peoples, Pueblo ceramic vessels ended up in both pre-and post-A.D. 1200 sites in Northern and Eastern Texas, including the likely Taos Incised vessel from Falls County, Texas.

Summary and Discussion

Aboriginal American groups were aware of other groups of people living far distant from them. There is substantial archaeological evidence for interactions between groups in the Southwest and the Plains, the Southwest and Mesoamerica, and Mesoamerica and the Southeast (Ericson and Baugh 1995; Spielmann

1991; White and Weinstein 2008). It is known that Native American groups moved obsidian, turquoise, marine shell, and ceramics hundreds and even thousands of kilometers across diverse environmental and cultural regions using both direct and down-the-line exchange networks (Dilian et al. 2010; Hull et al. 2014; Vokes and Gregory 2007). As outcrops of obsidian do not occur within the state of Texas, determining the source of obsidian is an important part of defining ancestral trade routes into North Central and East Texas (Renfrew 1977; Baugh and Nelson 1987; Brosowske 2004; Quigg 2010; Crook 2015, 2016, 2017a; Perttula and Hester 2016).

Established trade between the Puebloan Southwest and East Texas has long been recognized (Krieger 1946). Reciprocal resources in this exchange are thought to include bison hides, meat, turquoise, and textiles from the Plains, and bow-wood and salt from East Texas (Creel 1991; Schambach 2000:5). Previous evidence of this trade had been recorded from a number of ancestral Caddo sites in East Texas (Housewright 1946; Hayner 1955; Prikryl 1990; Jurney and Young 1995; Crook 2017b). These included items such as turquoise beads and pendants and various types of Puebloan ceramics. While present in sites widely distributed across East Texas (Figure 7), our summary of the archeological data indicates that they typically represent only a very small proportion of a site's total artifact assemblage, with usually only a few pieces reported per site.

As described in this article, a small but important number of Puebloan artifacts have now been recorded from a limited number of Late Prehistoric sites concentrated on the East Fork of the Trinity River in Collin and Rockwall counties (see Figure 7). Nearly 100 artifacts of probable Southwestern origin from five sites strengthens the case for established trade routes between the Puebloan and Caddo peoples over a long period. Moreover, recovered artifacts from East Fork sites indicate that beyond turquoise and ceramics, trade items likely included other bead material (red coral and *Olivella* shell), and exotic raw materials for tool production (obsidian and chalcedony). Concerning the latter, evidence from the Upper Farmersville and Branch sites suggest that both finished projectile points and raw materials were traded.

In East Texas, 11 sites are known to contain Puebloan ceramics, eight sites have artifacts made from obsidian, and seven sites have beads or pendants made from turquoise (see Figure 7). Unlike the East Fork sites, these materials are not concentrated at only a few site localities. While many of the sites containing Puebloan materials are associated with larger occupations in permanent villages, mound centers, and farmsteads, several are not. This suggests that Southwestern trade items came east into the major entrepôts downstream on the Red River such as the Sanders, Sam Kaufman, and Hatchel sites. These trade goods were further distributed along existing Caddo trails across East Texas (see Schambach 2000:5) and then between Caddo groups in the Red and Arkansas River basins, such as at the Spiro site in eastern Oklahoma (see Schambach 1993, 1995).

Obsidian artifacts, whether pieces of lithic debris or chipped tools, are very rare in the East Texas and Northwest Louisiana archeological record. They are from a variety of distant sources and obtained through exchange or likely transported by hunter-gatherer groups. Sources for obsidian identified within Texas archeological sites include Malad, Idaho, and Obsidian Cliff, Wyoming, in the Northwestern Plains, the Mineral Mountain Range in western Utah, Little Glass Buttes in Oregon, and the Cerro del Medio and Obsidian Ridge sources in the Jemez Mountains of northern New Mexico.

In the Caddo area of East Texas and Northwest Louisiana, obsidian artifacts are found on sites of different ages, including of Late Paleoindian-Early Archaic age from the Twin Bird Islands site (16CD118) originates from the Mineral Mountain Range, Utah, and the Archaic or Woodland period-aged obsidian artifact from 41BW35 originates from Obsidian Cliff, Wyoming. Other obsidian artifacts from the Late Archaic to Woodland period at 41HP200 and the Yarbrough site (41VN6) were sourced to Malad, Idaho, and Cerro del Medio in the Jemez Mountains in northern New Mexico, respectively. Only one of the two Late Caddo period (ca. A.D. 1400-1680) sites in the upper Neches River basin with obsidian artifacts have been subject to source analysis. Obsidian debris from the Historic Caddo period Pine Snake site (41CE467) came from Obsidian Ridge in New Mexico. While a variety of obsidian sources outside of Texas have been identified, Hughes and Hester (2009:82) note that obsidian sources in the Jemez Mountains are the most common origins of obsidian recovered from Texas archeological sites, particularly those dating after ca. A.D. 1000.

Caddo sites dating from ca. A.D. 800 to the 1800s have the majority of the Southwestern cultural materials, specifically occurring in Middle Caddo (ca. A.D. 1200-1400) and Late Caddo (ca. A.D. 1400-1680 times) components. These goods are widely distributed across East Texas Caddo sites, being recovered in equal frequency on sites in the Red, Sulphur, Big Cypress, Sabine, and Neches river basins, but are notably uncommon in the Angelina River basin (see Figures 7).

Helms (1991) suggests that long-distance forays into distant lands were undertaken to acquire foreign objects and esoteric knowledge from geographically and socially distant places as part of a pursuit of power and prestige. She argues that raw materials, such as obsidian and turquoise, could have connected people to faraway places that may have held significance as places. Additionally, Torrence (2005:366) suggests that unmodified pieces of exotic raw materials "are more easily linked to distant, unknown, unpeopled and mysterious places than are products that exhibit identifiable, known places or individuals." The presence of large worked flakes of obsidian, obsidian arrow points made in the styles native to North Central and East Texas, and pieces of unworked turquoise fit this model.

It should be noted that none of the exotic items found in either North Central or East Texas sites, including ceramics and artifacts made from obsidian, were really necessities for aboriginal inhabitants of the region. For example, the East Texas Caddo peoples did not need Puebloan ceramics since they made their own high-quality plain and decorated pottery. The same can be said for the obsidian and chalcedony artifacts as well as the shell beads. There seems to be an increasing desire to obtain more prestige items over time, where Puebloan ceramics, obsidian, shell, and turquoise would have been high on the list, as well as information from distant regions (Brown et al. 1990; Bradley 1999; Perttula 2002; Trubitt 2000, 2003).

Jurney (1994) postulates that one reason North Central and East Texas may have been a destination for trade with people from the Puebloan Southwest is the presence of bois d'arc trees commonly used for bow and arrow construction. Native bois d'arc stands are prominent within the range of Late Prehistoric sites of the East Fork and its tributaries, as well as within settlement areas of Caddo peoples in the Red, upper Sulphur, and upper Sabine River basins (Schambach 2000:4). Along the East Fork, the Lower Rockwall site is near the southern boundary of such a stand (Jurney and Young 1995). The Sanders site on Bois d'Arc creek is centered within the natural range of bois d'arc trees in Texas.

Crook and Hughston (2007, 2015a) have demonstrated that the inhabitants of the East Fork made extensive use of bois d'arc, even to the extent of crafting a specialized stone tool (the "East Fork Biface") for working the hard wood. It is plausible that some of this production could have been used in periodic trade in addition to local use. The Late Prehistoric peoples of the East Fork are known to have obtained ceramic wares from both the Henrietta phase peoples to the west along the Red River as well as from Caddo peoples to the east (Crook and Hughston 2015a). Further trade or exchange for Southwestern materials could have been accomplished through these groups, other intermediaries, or via direct contact. As such, the Upper Farmersville, Branch, and Lower Rockwall sites may represent entrepôts for traders traveling from the Puebloan Southwest. Moreover, the discovery of the small campsite of exclusively Puebloan cultural material (the Branch #2 site) suggests the possibility of such a direct contact.

Through interaction and exchange networks that existed from as early as the 10^{th} century A.D. to as late as the 19^{th} century (see Jurney and Young 1995:15-16; Baugh 1998) between Puebloan, Southern Plains, and Caddo peoples, Pueblo ceramic vessels, obsidian, and turquoise ended up in both pre-and post-A.D. 1200 sites in Northern and Eastern Texas. This includes the likely Taos Incised vessel from a site on the Brazos River in the Blackland Prairie in Falls County, Texas.

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Buried Relations: Aspects of Late Archaic Social Configurations in the Lower Pecos Region of Texas Inferred from Genetic and Biological Clues in the Mortuary Population

Solveig A. Turpin

The assumption that the Archaic inhabitants of the Lower Pecos region of Texas were nomadic was generally accepted, with their mobility seen as a response to patchy resources such as water, food, and shelter. Selected data generated in support of a DNA study contribute to a broader perspective on this aspect of Late Archaic social structure and settlement patterns. The arid climate and dry rock shelters of the Lower Pecos region of Texas provided the ideal conditions for the preservation of mortuary populations, especially during the Late Archaic period (ca. 2000 BP) when a common practice was to wrap flexed remains of the deceased in layers of woven matting followed by interment within the dry ashy matrix of their rock shelters. Osteological analysis by Dr. Doug Owsley of the Smithsonian Institution identified a genetic anomaly shared by six male burials in the cluster of caves overlooking the Rio Grande collectively known as the Shumla caves (Owsley 1999). In Fate Bell Shelter, the centerpiece of Seminole Canyon State Historical Park, one grave excavated in the 1930s contained four male skeletons. DNA analysis of these individuals indicates that two of the four men were so closely related that they were either siblings or father and son. The hypothesis presented here is that during the Late Archaic Period these sites were inhabited by families who established territorial claims to these sheltered living areas in part by shared ancestry. This tentative pattern can be tested by DNA studies at other sites with relatively large burial populations.

Introduction

Data generated in support of a DNA study of the mortuary population of the Lower Pecos River region are used to infer some aspects of Late Archaic social structure and settlement patterns. The concept of wandering nomads is replaced by a picture of semi-sedentary familial groups who occupied what might be categorized as prime real estate. Patrilocality and patrilineality, the accepted norms for hunter-gatherer societies, are evident in the genetic relationships and suggested by the intrasite distribution of graves. The members of individual families buried in specific areas of two shelters exert a form of territorial claim. The burial trappings and wrappings fit with a social structure where status was accorded to certain individuals with both spiritual and temporal influence.

The Lower Pecos Region

The arid lands surrounding the confluence of the Pecos River and the Rio Grande in southwest Texas and north-central Mexico hold a long record of human habitation preserved in the dry rock shelters that line the cliffs overlooking the major rivers and their entrenched tributaries (Figure 1). Radiocarbon dates document the advent of the big-game hunters of the Paleoindian period, followed by a long period of increasing aridity that promoted an Archaic adaptation (Turpin 1991; Turpin and Eling 2017). Sometime around 3000 years ago, there was a brief mesic interlude that allowed the expansion of the Great Plains grasslands and their migratory herd animals but a return to aridity saw the resurgence of a desert life style, perhaps originating in northern Mexico. It is this period that is of interest here because about two thousand years ago, the people of the Late Archaic so-called Blue Hills subperiod (Turpin 1991, Turpin and Eling 2017), bundled their dead and buried them in the dry rock shelter deposits. This practice led to partial and accidental mummification and the preservation of grave goods, both of which attracted relic hunters and archeologists. The Archaic period ended about 600 A.D. with the signal adoption of the bow-and-arrow, the introduction of the Red Monochrome rock art style (Gebhard 1965, Kirkland and Newcomb 1967), and possibly the preference for cairn burials on elevated bedrock ledges.

Figure 1. Map showing relative location of Fate Bell and the Shumla Caves.

Buried Relationships

The hypothetical model proposed here is largely based on the analysis of two burial locales that were originally excavated in the 1930s as part of a rush by various institutions to bolster their collections with the abundant, well-preserved artifacts found in the dry caves of the region. A group of seven sites collectively known as the Shumla caves were targeted by an expedition from the Witte Museum of San Antonio (Martin 1933; Eross 1933); two of those sites—41VV112 and 41VV113—are of particular interest here (Figure 2). About the same time, the University of Texas sponsored the excavation of 41VV74, Fate Bell Shelter, the largest site of its kind in the region, and now the centerpiece of Seminole Canyon State Historical Park (Pearce and Jackson 1933; Thomas 1933). Both sites had extensive, largely Archaic, dry ashy deposits of living debris that accumulated for at least eight millennia. Their dry, sheltered interiors enable the excellent preservation of organic materials, including the bundled burials discussed herein.

The Witte Museum has consistently maintained an extensive exhibit that presents the material culture and the elaborate rock art of the Lower Pecos, featuring the life's work of photographer Jim Zintgraff. Two collections of essays germane to the exhibit have been published, one in 1986 and another in 2013 (Shafer et al. 1986, 2013). Most importantly here, Dr. Douglas Owsley of the Smithsonian Institute analyzed the individuals from the Shumla caves, obtaining radiocarbon dates on two females and one male (Table 1). He noted a genetic anomaly that was evidenced in six of the men and infants, confirming George Martin's (1933) prescient observation that many of the burials in the Shumla Caves were part of one family.

Until the first survey was conducted in anticipation of the closure of Amistad Dam, these sites were known by name. In 1958, Graham and Davis did the first reconnaissance of the Amistad area, giving Fate Bell the trinomial 41VV74 and the Shumla Caves 41VV112-115[1]. By then, both sites were well known for the deep dry deposits

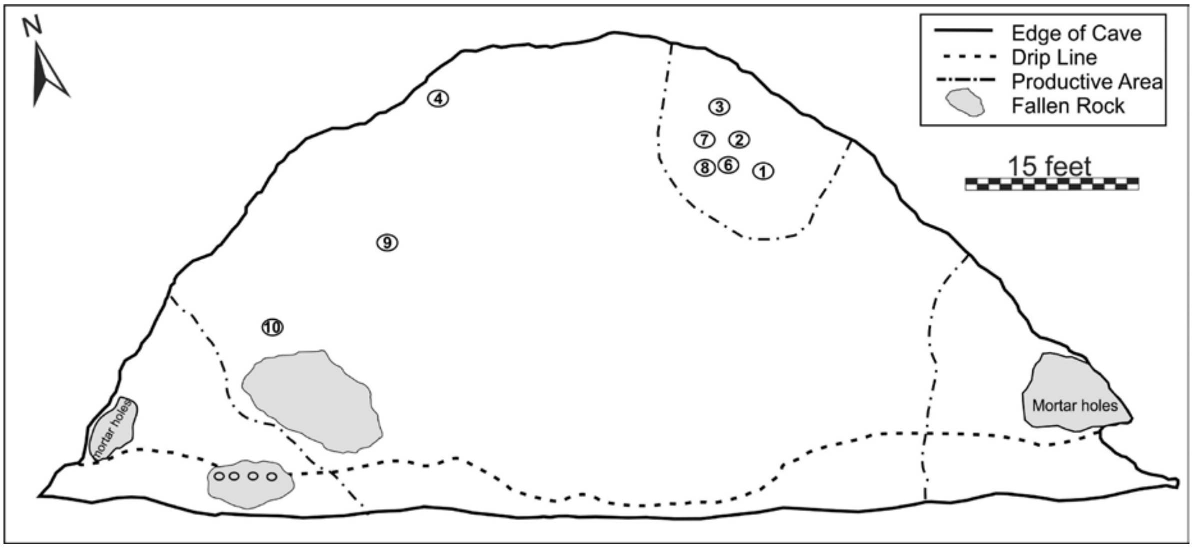

Figure 2. Distribution of graves in 41VV113, Shumla Cave 5 (Adapted from Martin 1933).

Table 1. Radiocarbon assays from the Shumla Caves.

Provenience	^{14}C (BP)	Calibrated 2-sigma Confidence Interval (BP)	Lab. No.	Description
41VV112. Shumla Caves, 1-4	2050±40	1902-2123	UCR3701	40-49 yr old female (Martin 1933 Owsley 1999)
41VV113 Shumla Caves, 5-7a	2130±30	2001-2299	Beta-466514	2-3 mo old infant (Martin 1933)
41VV113, Shumla Caves, 5-8	2390±35	2343-2683	SI0212	60 yr old male (Martin 1933, Owsley 1999)
41VV113, Shumla Caves, 5-1/10	2240±40	2153-2342	UCR3698	40-44 yr old female (Martin 1933, Owsley 1999)
41V113, Shumla Caves, 5-11, Martin 9	2150±40	2005-2307	Beta-465919	45-54 yr old male “shaman” (Martin 1933, Shafer 1986)
Shumla Caves, donated by G. Pickins	2290+30	2180-2354	Beta-475867	6 mo old infant, donated in 1937 (Owsley 1999)

left by their Archaic inhabitants of the region for over a millennia (Martin 1933; Pearce and Jackson 1933). The signal importance of Fate Bell Shelter was manifested in the extensive rock art that once lined the entire wall and extended onto its ceiling. Thanks to Forrest Kirkland, the paintings visible in the 1930s were documented in measured watercolors that were later described and analyzed by W.W. Newcomb, Jr. (Kirkland and Newcomb 1967). In preparation for the construction of Amistad Dam, Gebhard (1965) specifically studied the Fate Bell pictographs along with other sites in the Seminole Canyon system. In contrast, there are only two references to paint on the walls of the Shumla caves—Eross (1933) noted that a "rotten" burial in Cave 3 was beneath a red handprint and the 1965 site form mentions traces of red and yellow pigment on the wall of 41VV113.

The Shumla Caves

In 1933, the Witte Museum's archeological expedition to the Lower Pecos Region primarily sought Indian artifacts for display and study. The leader was George C. Martin (1933) who wrote the report in the Witte's Big Bend Basket Maker Papers, named after a cultural area some distance to the west. The field crew was made up of volunteers and their supervisor was John Eross whose field notes contain more detail than the official report.

The expedition extended its search to nine caves, seven of which are collectively called the Shumla Caves after the small defunct railroad stop on US 90 and an eponymous extreme meander of the Rio Grande called Shumla Bend. The other two were referred to as Old Shumla Cave (41VV186) and Pecos #1. The caves were so close together and shared so many characteristics that they were referred to as one huge site without regard for specific vertical or horizontal provenience within each cave, to the extent that many of the artifacts were not catalogued by provenience before or after excavation (McGregor 1992; Schuetz 1961) so the origin of much of the skeletal material remains murky (Stewart 1935).

Within the Shumla cave complex, Caves 1 and 2 (41VV112), and 3 and 5 (41VV113) produced 12 burials later analyzed by Owsley. Four additional adults and one infant bundle are of ambiguous provenience. The July 6, 1934 entry in the 7th Witte annual report describes the recovery of two infant burials from Cave 1, both of which were wrapped in rabbit skin robes, but they are not identified as such in the Witte collection. Scheutz (1961:197) attributes a necklace of olivella shells and two rodent tooth pendants to an infant burial from Cave 1 and Eross (1933) mentions others from Shumla 4 (one male found in a basket tied with cord)[2], Shumla 7 (two infants, one of which was wrapped in coyote skin)[3], Pecos 1 (a cremated infant), and from Old Shumla Cave (an infant in a basket). None of these are further described by Martin. The focus here is on two burials from Caves 1 and 2 (41VV112), and ten burials from Caves 3 and 5 (41VV113). Four men and two infants share a genetic anomaly that is so far only found in males; a fifth adult male of dubious provenience is also included in this group.

41VV112 (Shumla Caves 1 and 2)

Originally, site number 41VV112 referred to both Caves 1 and 2 but much later the National Park Service confounded the situation by amending the site records to attribute this trinonial exclusively to Cave 1, and Cave 2 was renumbered as 41VV1429. Here, I stick with the original designation, as it is no longer possible to differentiate between the two collections. Two burials from 41VV112 are described by Owsley (1999)[4]. The first burial, listed as1-4, is the incomplete skeleton of a 40 to 49-year old female. Her cranial morphology is typical of the group as a whole—a long narrow vault, a moderately wide, flat face, and heavy zygomatic processes (cheek connections) which gives her face a rectangular form. Both upper and lower jaws show usual tooth loss and extreme wear. A fracture of her left wrist had healed. Further relevance to this study is an associated radiocarbon date of 2050±40 BP obtained by Owsley which calibrates to a range between 1902 and 2123 years ago (Table 1).

The second grave from 41VV112 (2-5) contained the remains of a male with an age of 45 to 54 years. His skull morphology was consistent with others in the collection in that the vault was long and narrow. The poor condition of both his upper and lower teeth is typical of Lower Pecos dentition in the Shumla caves and elsewhere (Marks et al. 1988; Hartnady 1988). He has two small round healed depression fractures on his cranium and a healed fracture of his left radius. Most importantly, "the proximal third of his humerus is rotated medially resulting in a posteriorly oriented head"

(Owsley 1999). This genetic anomaly is the basis for a hypothetical reconstruction of Lower Pecos Late Archaic familial relationships and mobility.

41VV113 (Shumula Caves 3 and 5)

Nine burials were uncovered in a 6-ft-wide trench dug along the wall of Shumla Cave 5, beginning at the eastern entrance (see Figure 2), and two burials of uncertain provenience are attributed to Cave 3.

Burial 1, Cave 5, contained the remains of a young adult female who was flexed and wrapped in worn mats tied with twisted strips of netting. The only artifact possibly associated with this burial was a metate. Owsley (1999) determined that this female was between 40 and 49 years old. Her cranial morphology is similar to others in this series; her skull is long and narrow and her face delicate. Some reddish hair still adheres to the right side of her skull. Blunt force trauma caused fracturing in a left rib that was in the process of healing. Her sacrum shows symptoms of spina bifida occulta, a common birth defect that is not always apparent on the exterior and that only rarely results in impairment. Here too, her contribution to this study is a radiocarbon assay obtained by Owsley which places this burial at ca. 2240±40 BP or between 2153 and 2342 years ago (Table 1).

The second burial recovered from Shumla Cave 5 was an infant wrapped in a fur robe and bundled in matting tied with a fiber cord. The entire grave was covered by a metate with the grinding surface facing up, and with a small mano in its depression. Beneath the ground stone, a twilled mat covered a thick bed of twigs, under which was a broken cradleboard. All of this had been placed upon another bed of twigs that lay on the bedrock floor of the shelter. Parts of the infant had been naturally mummified. Owsley's analysis determined that the child was one to three months old and had been laid on its right side. The fur blanket was thought to be red fox and a small fringed rectangular leather pouch may have once held the baby's umbilical cord (Schuetz 1961:186).

According to Martin (1933), the third grave recovered from Shumla Cave 5 was that of a cremated infant lying on bedrock wrapped in a coarse mat but Owsley saw no evidence of burning to indicate cremation. No other artifacts were noted and no material from this burial is catalogued as such in the Witte collection. Burial 4 was a premature infant in a shallow grave encountered in the second trench. The body was not wrapped and no artifacts were associated with it. Martin thought that this was the most recent burial in the cave. It is perhaps noteworthy that it was recovered well outside the area of concentrated cultural materials Martin (1933) associated with "the productive area."

Burial 5 was inexplicably assigned to an isolated atlatl foreshaft that still had the residue of jaugilla gum that once held a dart point in place. Martin (1933:20) attached some importance to this find which was identical to a similar specimen removed from another of the Shumla caves, thus explaining its elevation to feature status, but it lay on bedrock and was not associated with a burial.

Burial 6 was also reported to be a cremation and contained the remains of an adult wrapped in matting tied with fiber cords and twisted netting. At the top of the grave, a mano and metate rested upon a folded robe or blanket made of twisted hair cordage thought to be bison, but it was so fragile it powdered at a touch. A bed of prickly pear leaves lay above the bundle. The deceased wore a bracelet made of fiber and twisted cord. Owsley saw no evidence of burning to indicate cremation, only bone discoloration from the long period of interment. Based on the skull and most of the post-cranial skeleton, he determined that the bones were those of an adult male between 55 and 65 years old. The cranium was high-vaulted, long and so narrow it suggested scaphocephaly which can be caused by premature fusion of the sagittal suture, the joint that connects the front and side plates of the skull. The left frontal bone had a healed, round depression fracture; similar depressions were found in an adult male from 41VV112 (2-6). The postcranial skeleton was small for a male (Owsley 1999).

Burial 7 was thought by Martin (1933) to be almost identical to Burial 2. This infant was three to six months old and retained traces of tissue which held some of the bones in anatomical position. Grave goods consisted of a broken cradleboard, rope to bind it, fur cloth and a wrapping of fawn skin, a metate, and mano. The bundle was encased in matting and tied with a twisted net cord. According to Owsley (1999), "the proximal humeri are rotated medially so that the heads would have been oriented posteriorly." This infant demonstrates that this morphological anomaly was inherited and because it has only presented in males thus far, this child is probably biologically male. One radiocarbon assay placed the time of this burial at 2130 BP which intercepts the calibration curve between 2001-2299 BP (Table 1).

Burial 8 is a well-preserved male, aged 60-70 years, who had been covered by a layer of prickly pear leaves. Some hair still adheres to the side of his skull, which is long and narrow in keeping with the general morphology of this group of people. His dental condition was poor to the point of maxillary tooth loss and mandibular abscesses typical of Lower Pecos oral health (Hartnady 1988). His right tibia had been afflicted by periostitis, an inflation of tissue around the bone that may have been caused by stress. Expectably, given his age, he exhibited arthritic changes to vertebrae and many joints. Once again, "the proximal thirds of the humeri are rotated about 65 degrees… resulting in posteriorly oriented heads" (Owsley 1999). A radiocarbon assay obtained by Owsley from the Smithsonian laboratory places this interment ca. 2390+35 BP or in the range between 2343-2683 in calibrated years BP (Table 1).

Burial 9, which is listed in Owsley's notes as 41VV113-5-11, is considered the most famous bundle burial from the Lower Pecos (see Martin 1933, Shafer 1986, 2013). His elaborate grave furnishings give rise first to the nickname "Fisherman" because his kiaha (carrying basket) was interpreted as a conical fishing net (Martin 1933:11; Woolford and Quillen 1966:205). He was later renamed "Shaman" because of the numerous and exotic grave goods interred with him. His bundle contained some 50 artifacts including a purposefully broken carrying basket (kiaha), mats, additional baskets, a fur robe tied with cords made of fiber, and other furs and feathers. He was also buried with a pouch containing two rattlesnake vertebrae necklaces ca. 2-meters long, painting paraphernalia, chert and wooden tools or raw material, buckeye beans, and a "pencil" made of deer bone with a piece of manganese inserted in its marrow cavity. His special status may also be mirrored in the location of his grave, which was situated at the opposite end of the shelter from the rest of his purported family (see Figure 2).

An Ensor dart point which fell from the wrappings has been used to assign this mummy to the Late Archaic Blue Hills period, an estimate that was confirmed by a conventional radiocarbon date of 2150+40 BP (Table 1) which calibrates to a 2-sigma confidence level between 2005 to 2307 years ago or 98-230 BC. Owsley determined that he was between 45 and 54 years old, perhaps accounting for the variable degree of arthritic changes noted on his joint surfaces. His cranium is long and narrow, his face flat, moderately wide, and rectangular. His hair was dark brown with reddish tones and interspersed with gray. The mandible, which was used in his facial reconstruction now on display at the Witte, exhibited a different wear pattern than the maxilla and seemed to Owsley to be a little heavy for this skull. His post-cranial elements are larger than those of the other males in this sample. At some time, he had fractured his left ulna which healed but with some overlapping. His left tibia also exhibited a healed incomplete fracture of the lateral proximal condyle. The unequal development of his humeri indicated a preference for the right arm, but more importantly for this report, "the proximal thirds of the humeri are rotated resulting in posteriorly oriented humeral heads."

The grave listed as Burial 10 was thought to be that of a 3-year-old child found in a moist ashy context that apparently caused much of the body to decay. There were no grave goods but Martin (1933) saw great similarities between this child's jaw and one that was excavated from Cave 7 and mentioned by Eross (1933). Martin thought both were late intrusions attributable to relatively recent Plains Indians. Discrepancies in the documentation of this burial make its provenience difficult to determine. Owsley listed the partial remains of a 1.2-2.0-year-old child as 41VVShumla 5-7C which was correlated to Burial 10. Martin said the burial had been stuffed under a rock with no accompanying grave goods. A note in the box where the remains were stored indicated that these were of a child buried in Cave 3, while another note reads, "Infant bones, Cave 5 and 7, June and August 1933." The collections manager at the time thought that the attribution to Cave 3 was probably correct because the identifying tag was older. However, Eross (1933) discusses an infant burial in Cave 7 where another item of interest, a woven screen or partition, was recovered (Martin 1933: Plate XXXVII).

Burial 11 contained the partial remains catalogued as 41VVShumla 3-1 and is the flexed interment of a newborn who presumably was buried in Cave 3. Rabbit fur covered part of one leg, the probable evidence of a rabbit skin robe wrapping. Most importantly for this analysis, Owsley (1999) determined that "the proximal humerus is rotated medially so that the head would have been oriented posteriorly," thus linking this child to the men from caves 1-2 and 3-5 and indicating that gender was probably male.

Unprovenienced Burials

An adult male skeleton with the same genetic mutation is attributed to an unspecified cave on the Pecos River near the (Fate) Bell Ranch that now comprises a large part of Seminole Canyon State Historical Park. However, the drawer in which the remains were stored was tagged as Jacal Cave (41VV674), a rock shelter located in Harkell (Jacal) Canyon over 3 km west of the Pecos River. Based on his skeletal characteristics, these remains likely originated on the Pecos River and even more specifically, in the vicinity of Shumla Caves. The original catalog number was Witte 1, Univ. of Texas 2228; two other skeletons in the collection—2229 and 2230—are labeled Jackal Cave but are also shown to be from a cave on the Pecos River where they were removed without permission of the landowner.[5] Owsley determined that the Witte 2228 remains were those of a 33 to 38-year-old man whose post-cranial bones were gracile for a male. His cranial vault is long and narrow like the others from the Shumla Caves. His dentition shows heavy wear, caries, and tooth loss; characteristics commonly identified on the remains of Lower Pecos Archaic people. However, Owsley thought the wear patterns resulted from an abrasive diet whereas other researchers have attributed tooth loss to high sugar intake from desert succulents (Hartnady 1988; Marks et al. 1988). His cranial frontal bone has four healed depression fractures and his left nasal bone had been broken some time during life. Most significantly, Owsley (1999) determined that "his humeral heads are oriented medially and posteriorly, typical of proximal humeri from Shumla Cave."

In addition, in 1938 the San Antonio Light announced that a baby bundle from a cave near Shumla was donated to the Witte by George Pickens who was then a principal at Westmoreland, now Trinity University. This bundle is catalogued as 41VVSHUMLA-0-37110. The January 2, 1938 issue of the San Antonio Light attributes the donation to Pickins who supposedly "collected" it from a cave at Shumla. This leaves in limbo another infant bundle that was supposedly donated to the museum by Guy Skiles and Filo McNutt, collectors from the Langtry area. The Pickins infant, estimated to be just over 6 months old (Owsley 1999), was wrapped in a reed mat and tied with cordage that looped the bundle at least four times. Another mat made of narrower reeds was also associated with the child as was a thicker cord which probably held the second mat in place. One radiocarbon date generated by an assay on fiber from the wrappings was consistent with the burial population in general, placing the interment at 2290±30 B.P (Table 1) or 2217-2343 cal BP. There is a 70.9% probability that its calendric age is between 350 and 400 B.C. and a 20.9% that it is between 250 and 290 B.C.

Discussion of the Shumla Caves

In the Witte mortuary population, six individuals exhibit a genetic anomaly that was manifested by the rotation of their humeri so the heads would be oriented posteriorly. This condition appears in four adult men and two infants, the latter demonstrating that this mutation is hereditary and transmitted along the male line. The gender differences are evident in the two women—one from 41VV112 and the other from 41VV113—who are free of this defect. Futhermore, they are not related maternally (Raff et al. nd). One of the adult males is from Cave 2 (41VV112), one is of dubious provenience, and two are from Cave 5 (41VV113) as is one of the infants. The other child is probably from Cave 3. Without acknowledging the twisted humeri, Martin (1933) based his opinion that the caves were "one-family dwellings" on physical similarities between the remains, such as the extreme doliocephaly and worn dentition, and clustered burial placements. Similarly, in his 1935 analysis of the skeletal remains from Shumla and other sites, Stewart (1935) discusses the dentition or lack thereof, the number of healed fractures, and the doliocephalic skulls but does not mention the twisted humeri.

The distribution of graves inside Cave 5 is informative. Most of the interments came from an area that Martin (1933:18, Figure 2) called productive; an area against the rear wall just east of the cave's center. However, the most elaborate burial—No. 9—with its scores of grave goods, was instead placed on the western end, keeping it separate from the other burials even though the hypothesis here is that they were related. The two other graves on the western side of the shelter are No. 4, a premature infant who Martin thought was the most recent burial in Cave 5, and No. 10, a 3-year-old child that he attributed to the Plains Indians who were late arrivals in the region. Neither of these children was accompanied by any offerings nor were they bundled in the classic sense of the word. So in essence, the intrasite distribution of burials reflects some separation between the purported leader and the rest of his family.

Six radiocarbon dates were obtained over the decades. Owsley submitted samples from two women and the most elderly male. Subsequently, various donors supported the acquisition of three more dates—one adult male and two infants, two of which have twisted humeri. The infant demonstrates that the defect is hereditary and apparently was transmitted through male descent. A reasonable hypothesis is that the family of one high-status male occupied the Shumla Caves for an extended period of time, spanning at least two and possibly three generations. The same structure is shown, although less clearly, by a mass grave in Fate Bell Shelter that contained the remains of four adult males, at least two of whom were closely related.

Fate Bell Shelter

When A.T. Jackson came to the Lower Pecos in search of a dry rock shelter that would yield a treasure trove of artifacts for the University of Texas, he opted for Fate Bell Shelter (41VV74) because it was the least vandalized of all the shelters in Seminole Canyon (Pearce and Jackson 1933). Whether there, like the Shumla caves, the nearby shelters were tied to Fate Bell by kinship bonds can no longer be determined. Immediately downstream, 41VV75 had been extensively looted, producing all manner of artifacts, but most specifically a number of prehistoric burials. Further downstream, at the confluence of the canyon and the Rio Grande, the once-deep deposits of Panther Cave, 41VV83, were reduced to pockets of sand and rocks although one burial was eventually turned in to the University some 60 years later (Turpin and Lippert 1997). The smaller sites in between were eventually looted as well, especially after Amistad Reservoir provided easier access than the land routes. Fate Bell Shelter became a property of the state shortly after Amistad Reservoir was impounded in 1969 by damming the Rio Grande, Pecos, and Devil's rivers. Now all these sites are within Seminole Canyon State Historical Park and managed by the Texas Parks and Wildlife Department (Turpin 1982).

The 1932 excavations, led by A.T. Jackson, concentrated in two trenches that exposed only a very small portion of the deep dry deposits (Figure 3). The skeletal remains exhumed by Jackson have been catalogued and measured for various studies but no detailed analysis such as those conducted of the Shumla mortuary population by Owsley have been done.

Although Fate Bell had been punched full of holes by relic hunters—rumor has it that one foreman rented digging rights for 50 cents a day—the site was selected for excavation "because it was the least disturbed and largest shelter in Seminole Canyon" (Pearce and Jackson 1933:14) and for that matter, in the region. According to Pearce and Jackson (1933), the site is 515 ft (157 m) long, 454 ft (138 m) deep along the wall, and 110 ft (34 m) along the drip line. The overhang ranges from 12 ft (4 m) to 39 ft (12 m) high and the deposits are maximally 29 ft (9 m) deep.

The only other formal excavations that ever took place at Fate Bell were part of the overall Amistad (then Diablo) Reservoir studies prior to impoundment of the dam in 1969. Mark Parsons (1965) carried out test excavations in 1963, placing excavation units on either side of the trench Jackson had dug perpendicular to the rear wall (see Figure 3). Test Pit (TP) I was 6 ft (1.8 m) x 4 ft (1.2 m) and TP II 5 ft (1.5 m) x 6 ft (1.8 m). An attempted extension to TP I, called TP III (0.9 x 2.4 m; 3 x 8 ft), was vandalized over a weekend when the field crew was absent. A single radiocarbon date from Zone II, a blackened stratum which started 2 ft (60 cm) below the surface and was less than 1 ft (30 cm) thick, provided an uncalibrated date of 2330±90 BP which has a 68.7% probability of falling between 2220-2570 cal BP (TX192; Parsons 1965). The report goes on to detail the characteristics of the artifacts, in keeping with the tenor of the times. Parson's most important conclusion was that the site had deep, some undisturbed, deposits that should be further excavated. The information potential of the vast majority of the site still lies in wait for future examination.

Pictographs in the polychromatic Archaic Pecos River style look down from the ceiling and line the wall of the shelter but now, those just above the ash beds have been reduced to a long linear blur by exfoliation. The most famous images are the "Triad" at the downstream end of the wall (Figure 4). Two anthropomorphic figures stand beneath the outspread black wings of third larger horned person. A fourth anthropomorph behind the central figure seems extraneous. One interpretation might be that the dominant figure is a very powerful leader who has subsumed those of lesser importance. A smaller version, painted just upstream, on the rear wall, is the truncated torso and head of a very similar

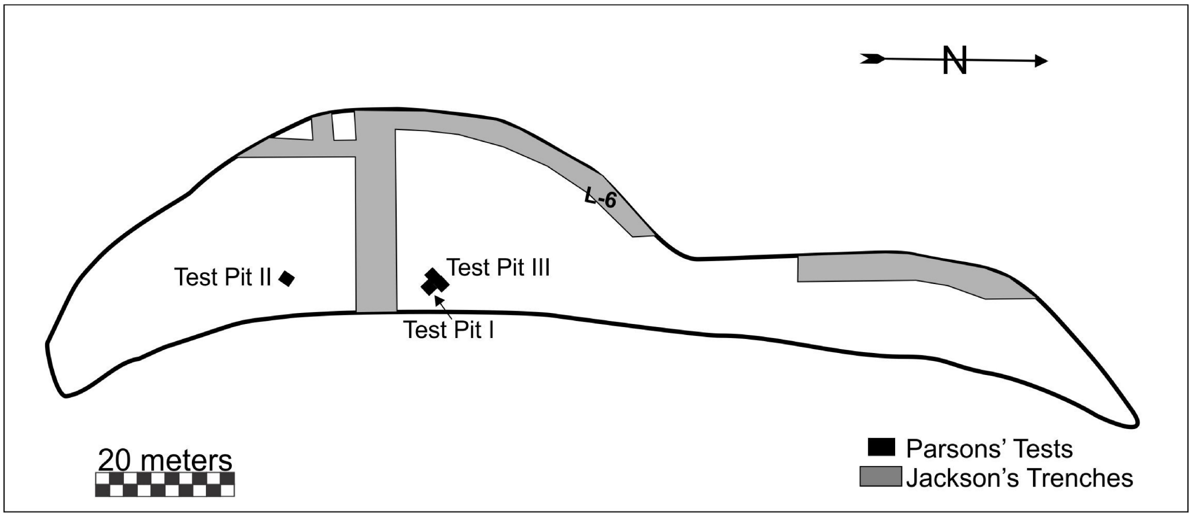

Figure 3. Excavated areas of Fate Bell showing location of grave L-6 (adapted from Parsons 1965).

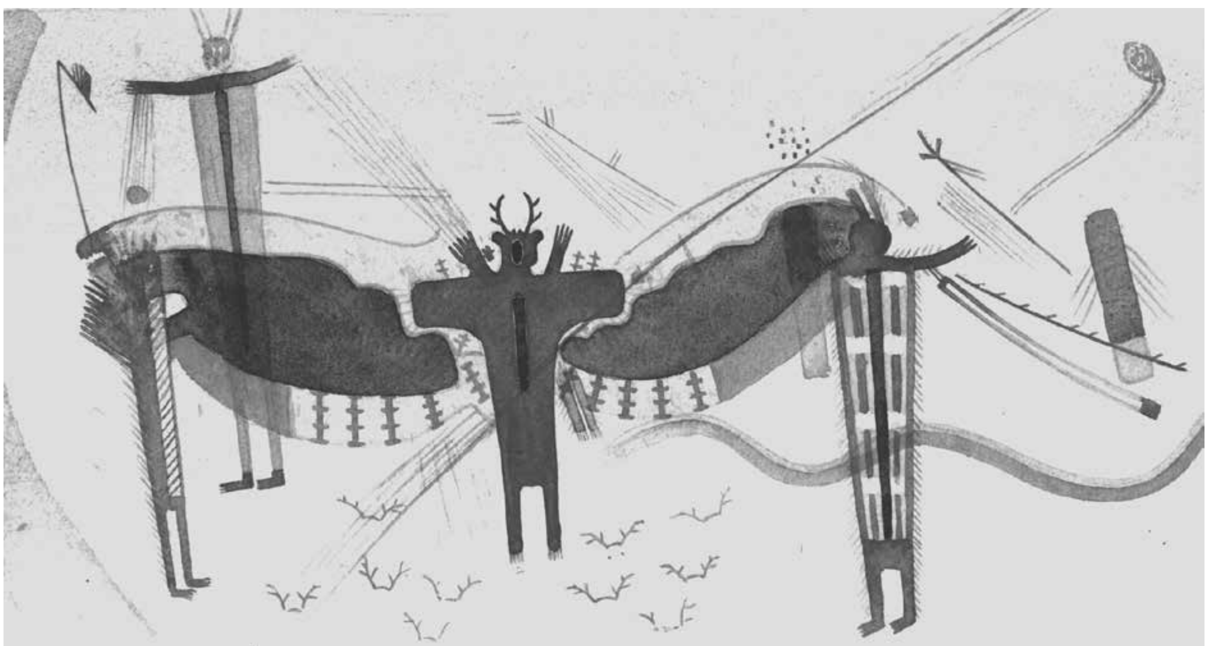

Figure 4. The so-called Triad, the largest and best preserved pictograph in Fate Bell Shelter. The fourth figure in the background is not considered part of the larger composition. Note the claws on the central figure as opposed to human feet on the other anthropomorphs. The free-floating antlers may be short-hand for spirit companions in keeping with the antler headdress; the barred lines on his wings are an abstracted representation of feathers (Kirkland and Newcomb 1967:46, courtesy of the Texas Archeological Research Laboratory).

composite of human, deer, bird, and other animal characteristics[6] (Figure 5). These and the several vignettes picturing emergence scenes reflect the preeminent role Fate Bell played in spiritual and economic lifeways of the Pecos people.

A.T. Jackson and crew began excavations on October 20, 1932 and finished on November 18, of the same year. Initially, a 20-ft (6.1 m) wide trench was dug from the drip line perpendicular to the rear wall in "the most promising area of the site," which reached a maximum depth of 8 ft (2.4 m). Narrower trenches branched off; upstream hugging the rear wall and downstream a shorter T-shape joined the trench to the curve that formed the upstream edge of the living

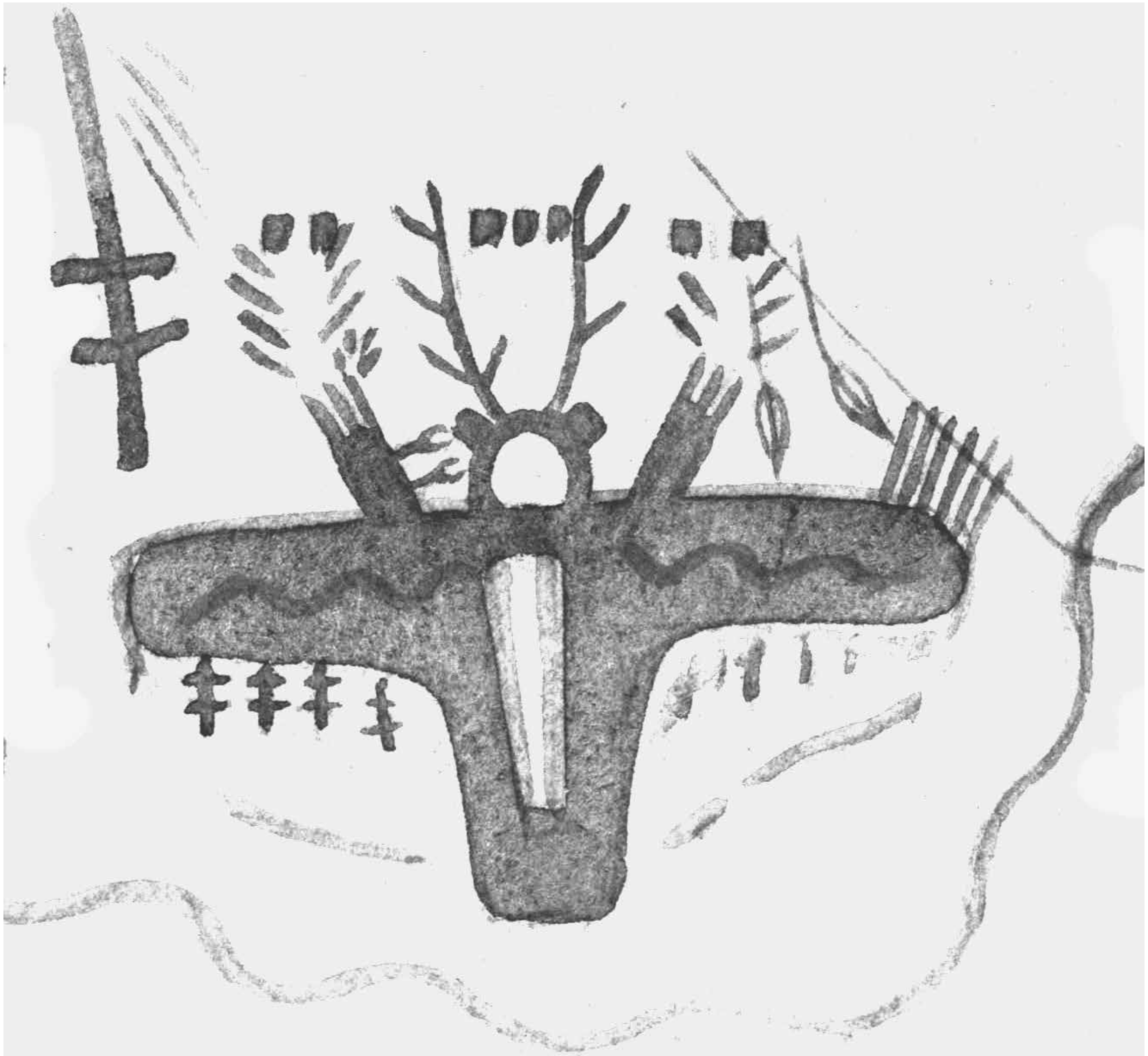

Figure 5. A truncated version of the central member of the Triad from Fate Bell complete with antlers, wings, feathers and blank rather than black face and body marking (Kirkland and Newcomb 1967:46 (courtesy of the Texas Archeological Research Laboratory).

deposits. Another trench followed the lower part of the S-curved rear wall in the downstream segment. The huge inventory of recovered artifacts, both mundane and exotic, are described in Pearce and Jackson (1933) and Thomas (1933). The focus here is on one of the eight graves that were reported, although the unexcavated part of the cave deposits undoubtedly contains more. Three burials (L1, L2, L3) were identified in the main perpendicular trench, two (L4, L5) were located in the downstream wall trench and three (L6, L7, L8) were found along the rear wall in the upstream trench. Each grave contained the remains of a single individual with the exception of Grave L6, which held the remains of four adult males and one infant.

In the main trench, the first grave was that of an infant (L1) that was "probably" encased in a skin bag, then buried beneath a woven mat and a brush pad. All burial goods were badly decayed. L2 contained tiny fragments of infant bones in an advanced state of decay under two limestone rocks. The authors thought this was a very early burial left by the first occupants of the shelter (Pearce and Jackson 1933:58). L3 consisted of pieces of grass, sotol and lechguilla fibers, pieces of cording and matting, and snail shells under a covering of stones. No skeletal material was evident, but the authors considered the material to be the remnants of an infant grave.

L4 was found shortly after excavations of the upstream trench along the back wall where the shelter began. A cluster of stones above a brush layer seemingly protected two mat fragments, a small mano, a piece of skin, a small scraper, 100 snail shells and a few charred and broken bones whose species could not be determined. The possibility that this was the grave of a cremated infant was considered. No indisputable human bones were found in L5 but, like L4, a decayed mat of grass and a piece of sotol matting rested atop a layer of brush that obscured two projectile points, snail shells, fiber quids, and small bones. The excavators likened this setting to burials L3 and L4.

L7 was the grave of a child between 8 and 10 years old, whose body was arranged in a flexed position and placed against the shelter wall. Artifacts probably buried with the child were a flint knife, a rubbed pebble, and an egg-shaped concretion of calcium carbonate. L8 contained a flexed skeleton whose long bones were in good condition but whose skull was not. The body was covered by two large metates. Also associated with L8 were a shell gorget that lay immediately beside a small metate, two projectile points found near the skull, and another small metate with red paint stains on one side.

Grave L6

The main object of study here is Grave L6 that was located slightly upstream of L7 and L8 in the trench that was excavated against the rear wall of the shelter, positioned roughly under one of the more complicated pictographs, although that association is possibly coincidental. L6 contained the remains of four adult males numbered FB-1 through FB-4 in order of emergence. Scattered amid the more articulated skeletons were the remains of a small child who was thought to be a later, intrusive burial.

FB-1 was positioned on the west end of the grave, FB-2 was in the center, FB-3 was on the east end, and the legs of FB-4 overlaid the torso of FB-1 (Pearce and Jackson 1933:66-67). Radiocarbon assays imply that 2 and 3 are the oldest, their uncalibrated ages only 10 years apart (Table 2). FB-1 and FB-4 are younger. There could be as much as 447 years between the extremes of all the calibrated ranges but perhaps as little as 154 years (or as few as four generations) in the 2-sigma ranges. The calibrated ages for all the radiocarbon samples from Shumla Caves and Fate Bell are shown in Figure 6 where the summed age distributions for each site are plotted in the shaded band, and individual calibrated age distributions shown below. The distribution of the date ranges supports the idea that the subject individuals may represent generations within each site.

The teeth of FB-1 and FB-4 were worn and broken, apparently in accord with the pattern exhibited by most of the Lower Pecos mortuary population. The dental status of 2 and 3 is not reported but Sidney J. Thomas (1933) commented that all the burials in Fate Bell shared the same poor dentition exhibited on other remains found throughout the region. FB-3 was lying on his back, an unusual position for a flexed burial. His skull had been cracked as though from a blow.

Thomas (1933) counted 160 artifacts in proximity to L6 but he could not definitively link them with a specific interment. No perishable materials, such as the mats, sandals and basketry, often deposited in flexed bundles, accompanied any of the men. This is probably a matter of preservation and not neglect. Several manos, projectile points, and

Table 2. Radiocarbon Assay from Grave L6, Fate Bell Shelter.

Provenience	^{14}C (BP)	Calibrated, 2-sigma Confidence Interval (BP)	Lab No.
41VV74 Fate Bell L6-1	1980±30	1873-1994	Beta-368689
41VV74 Fate Bell L6-2	2200±30	2141-2315	Beta-457378
41VV74 Fate Bell L6-3	2210±30	2148-2320	Beta-449747
41VV74 Fate Bell L6-4	2150±30	2010-2305	Beta-368660

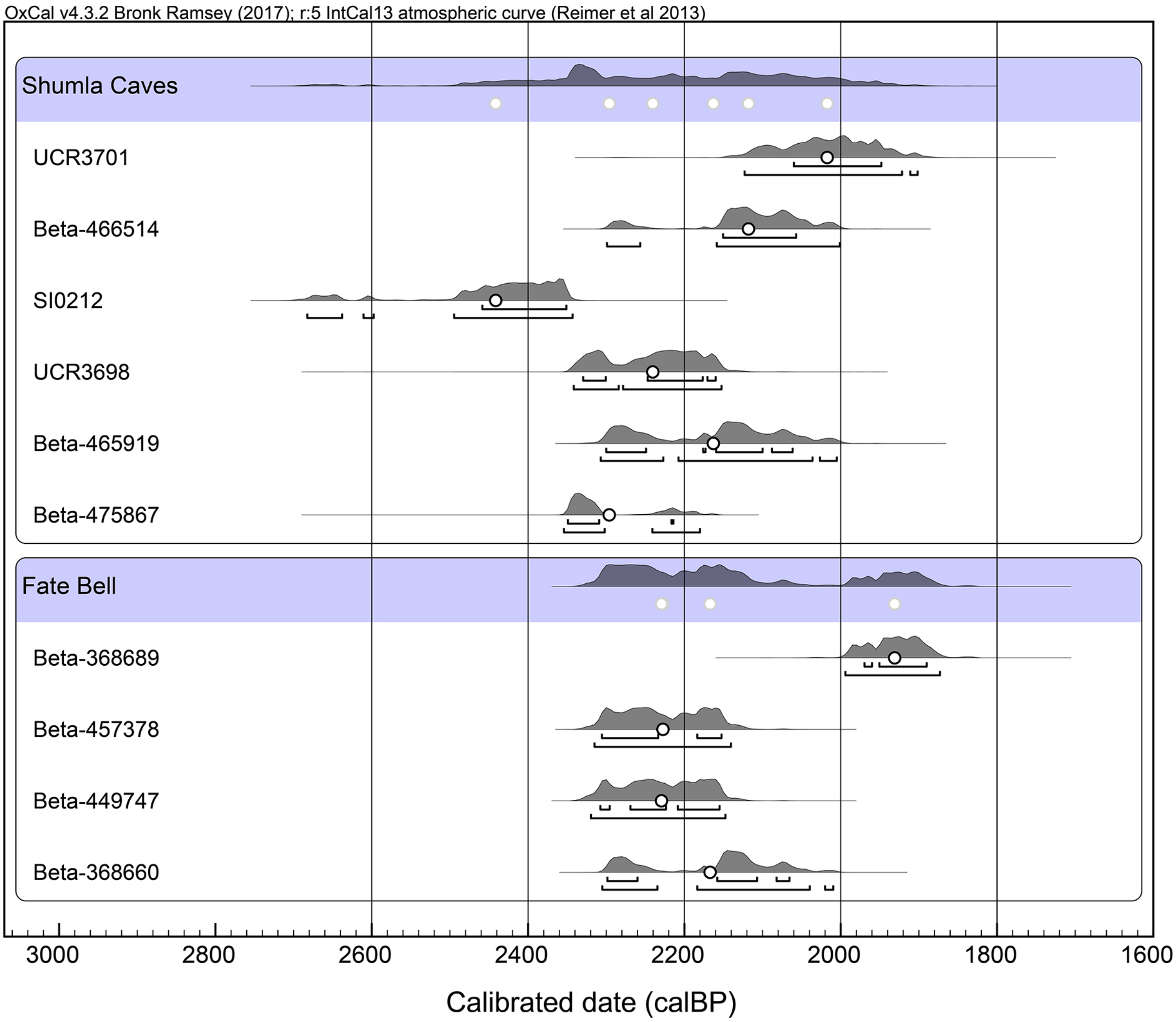

Figure 6. Calibrated radiocarbon dates from Shumla Caves and Fate Bell Rockshelter. Calibration was performed on OxCal. Summed age probability density functions (pdf) for each site are in the shaded bands and individual age calibrations are below. One- and two-sigma age ranges with the mean age is plotted below each pdf.

miscellaneous artifacts recovered from the other burials may or may not have been included in the graves. The artifacts that are grave goods include a gorget, two projectile points, grinding stones found with L8, and the metates that covered the bundles in L8.

DNA analysis indicates that FB-1 and FB-4 are closely related either as siblings or as father and son (Raff et al. nd). Ancient DNA could not be extracted from FB-2 and FB-3 but, for the purposes of this paper, they are hypothetically part of the same family, following the pattern set forth in the Shumla caves[7]. If that assumption is true, a familial claim to Fate Bell would be justified by the vastness of the cavern, the location between upland and lowland resources, the proximity to water ponded in the canyon below, and the short distance to the Rio Grande. All of the Seminole Canyon system was prime real estate as evidenced by the deep deposits left in 41VV74, Fate Bell, its downstream neighbor 41VV75 as well as smaller sites down canyon, and by the density of rock art which includes panels in all the major regional styles. Also convincing are the number of mortar holes, especially in upstream 41VV72, Flooded Shelter, and the many upland camps that fringe the canyon rim. Even the sites located low in the canyon that have suffered from massive flood events and subsequent erosion exhibit signs of intensive occupation—the above-mentioned mortar holes and elaborate rock art in Panther Cave (41VV83), Black Cave (41VV76), Flooded Shelter (41VV72), Red Linear (41VV201), Lookout Cave (41VV230), 41VV335 and others.

Discussion of Fate Bell Shelter

The Archaic people of the Lower Pecos region have long been considered nomads who moved between rock shelters and open camps, perhaps like their ethnographically known South Texas counterparts, on a seasonal round that took advantage of the ripening of various wild foods. Taylor's (1964) model of tethered nomadism, derived from his experience in northern Mexico, proposed that the exploitation patterns of the desert dwellers were a compromise between access to water and access to the plant foods that were the staff of life. However, his conjecture was based in the particular hydrology of an area where isolated springs and water holes were the norm, unlike the major rivers that transect the Lower Pecos north of the Rio Grande. Dering (1999) attributed mobility to the search for food and fuel in response to the exhaustion of local resources, discounting the deterministic role of water. Realistically, the procurement patterns were attuned to environmental conditions, shifting between what Binford (1980) called foraging and collecting in concert with the prevailing climatic conditions. During the period of major rock art production, society may have been configured around sacred sites, shifting between aggregation and dispersal (Turpin 2004). Since the Archaic period in the Lower Pecos lasted for 8000 years or more, there was certainly time and space for all these ideas.

The Shumla and Fate Bell burials are typical of the dominant mortuary practice that prevailed during the Late Archaic Blue Hills/Flanders period, ca. 2400 to 2000 years ago (Turpin and Eling 2017).[8] The chronology is somewhat biased by the preservation afforded by bundling and burial in the ashy, dry rock shelter deposits during what is generally considered an arid interval in the Lower Pecos climatic trajectory. The wealth of data conserved by natural mummification and the preservation of grave goods attracted considerable archeological interest as well as the unwanted attention of relic hunters.

Most of the radiocarbon dates relevant to the Lower Pecos mortuary population as a whole coincide with environmental changes that are thought to have affected settlement patterns and social organization. The Lower Pecos was coming off a mesic interval that incorporated the region into the Great Plains grasslands for perhaps 700 years, from 3000 to 2300 years ago, allowing for some overlap between subperiods. The grassland habitat permitted the influx of the mighty bison herds and their attendant hunters to the probable detriment of the indigenous people. The return to aridity might well have seen the return of desert-adapted people from northern Mexico, at least if one can interpret the spread of Shumla dart points from the south as evidence of population movements as suggested by Elton Prewitt (1990, personal communication). However, the few radiocarbon assays from Coahuila and Chihuahua burial caves are more recent than those from the Lower Pecos. Walter Taylor (1966) considered bundle burials a key characteristic of his Mayran complex which is based on distinctive mortuary practices that date between 1000 and 1300 years ago at sites such as Candelaria, Coyote, and Fat Burro caves in Coahuila (Aveleyra 1964, Aveleyra et al. 1956; Gonzáles 2003; Taylor 1968; Romero 1956), thus post-dating the Lower Pecos sites by several hundred years. Further afield, two bundled burials exhumed by relic hunters in far southwestern Chihuahua were analyzed in considerable detail at the San Diego Museum of Man (Tyson and Elerick 1985). The more intact mummy was a young pregnant woman who may have died in childbirth; the other the partial remains of a child. Fiber from a string apron-skirt produced a conventional radiocarbon date of 860 ± 40 B.P. which calibrates to the range between 1040-1260 A.D. (LJ5301), a span that is consistent with the Mayran complex sites but much later than the norm in the Lower Pecos population. A similar string apron was found on a young woman from Waterfall Cave, also in southwestern Chihuahua, where pottery styles led to an estimate of 1000 to 1600 A.D. Waterfall Cave produced 10 graves (Ascher and Clune 1960). In one of them, four individuals were buried together, leading the excavators to believe the two women and one man between 20 and 35 years old and an 8- to 10-year-old child were all members of the same family. Obviously, Waterfall Cave would have been a prime candidate for a study of potential familial relationships expressed in mortuary behavior.

The mortuary caves of Coahuila, and especially the naturally mummified human remains, were brought to the attention of American archeologists as early as the 1880's when Dr. Edward Palmer brought an extensive collection back to the Yale Peabody Museum in New Haven, Connecticut (Studley 1884). Taylor's excavations in the 1940s led to his unwrapping a bundle from Coyote Cave and publishing the results in 1968. Mansilla (2011) has written extensively about the mummies that are found throughout Mexico wherever the conditions are right. Much of the basic information on indigenous Mexican mortuary customs was destroyed by relic hunters and saltpeter miners before their true significance was registered but the limited available data show that in areas adjacent to the Lower Pecos, bundled burials interred in dry caves was a well-established practice during the last 1500 years of prehistory. However, it is not necessary to establish a direct connection since the rocky terrain and shallow soils of both areas would encourage burial in the soft, deep cave deposits or in subterranean natural sinkholes.

Certainly, the graves of the ancestors are a potent force for territorial ambitions; the two sites focused upon here provide ample evidence of the elevated status of individuals or families. The "Shaman" of Burial 9 in the Shumla caves must have been of great importance given the extent of his funerary offerings. His grave was also positioned apart from what were presumably the last resting places of members of his family.[9] Two of the other most elaborate male burials, both exhumed by relic hunters, are a man from Mummy Shelter (41VV656) on the Rio Grande and a youth from High and Dry Cave (41VV341), located far up the Pecos River near the Pandale Crossing (Turpin 2012; Turpin et al. 1986). Both burials were bundled with food, textiles, implements, and jewelry consistent with a belief in an afterlife where these material objects would have been accessible. Coincidentally, DNA analysis shows that these two men were closely related maternally (Raff et al. nd), thus the distance between their last resting places is consistent with the assumption that men were not constrained to living within their mother's kin network.[10]

Maslowski (1978:48), in his analysis of the Morehead Cave material in the Smithsonian Institution, thought that there might be more ceremonialism expressed in the women's graves. However, that idea is not sustained in the larger mortuary population where the paucity of grave goods buried with women stands in contrast to the men from Shumla, Mummy Shelter (41VV656) and High and Dry Cave (41VV341). In fact, taking the Lower Pecos as a whole, the attention given to infant interments exceeds that of most adults. Swaddling in layers of fur, skin or matting has probably contributed to the preservation of many of the baby bundles and their precious cargo. From a more esoteric perspective, Mansilla-Lory and Malvido (2002) have suggested that the tightly wrapped bundles resemble a chrysalis from which the infant may emerge. The symbolic interaction between butterflies, sexuality, and fertility is widespread but it is specifically expressed in the mobiliary art of northern Coahuila and the Lower Pecos region in both incised and painted pebbles (Turpin et al. 1996; Turpin and Eling 2003; see also Mock 2016 for examples from Central Texas).

Conclusion

Admittedly, the evidence used to suggest some of the fundamental motives for the disposition of what are demonstrably family members at Shumla and to a lesser degree at Fate Bell is fragmentary. The entire burial population of the Lower Pecos is small compared to the intensity of occupation during Archaic times and those that have been preserved were often originally exhumed by relic hunters or by archeologists using primitive recording methods in keeping with the times. The sample chosen for DNA analysis was admittedly biased toward well-preserved, relatively well-provenienced, and accessible specimens. Preservation alone resulted in a definite preference for bundled burials with, if possible, mortuary artifacts and some record of their exhumation.

Despite the shortcomings imposed by sample size, inaccurate provenience, and data lost since exhumations, there are ways to test this proposition. The initial DNA study by Raaf and Bolnick could be expanded to other sites in the Lower Pecos where group burials hold the key to genetic relationships. Sites such as Morehead Cave (41VV55, Maslowski 1978), Langtry Burial Cave (41VV258; Greer and Benfer 1963), and Seminole Sink (41VV620; Turpin 1988) produced multiple human remains that the excavators thought might be related due to proximity. Outside the well-defined Lower Pecos cultural area, another potential source of information about prehistoric relationships, Bering Sinkhole in Kerr County, was used as a cemetery for over 500 years, reflecting the persistence of group memories (Bement 1994).

Although the pilot sample was dominated by relatively intact bundled burials, there are many less tightly wrapped rock shelter interments that would benefit from radiocarbon dating and DNA analysis. However, the graves from the Shumla caves present the best evidence for a society structured on familial lines, headed by an esteemed leader, and bolstered by territorial claims vested in the graves of the ancestors. Fate Bell is less definitive but the true extent of the burial population there is unknown. It is clear, however, that the addition of the newly dead to a recognized family plot was guided by a group memory that spanned generations.

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Notes

1. Graham and Davis (1958) carried out the first archeological reconnaissance in anticipation of the closure of Amistad Dam as part of the Smithsonian's River Basin Surveys, Interagency Archeological Salvage Program, hence the original name of the Texas Archeological Salvage Project.

2. Martin (1933:89) quoted Eross' assessment of another burial from Cave 4 as "an old hag that the Indians thought they were better off without kicked into a shallow hole"—but Eross contradicts himself by describing her as flexed, tied with cord, and wrapped in worn matting.

3. The Witte annual report for 1934 attributes an infant burial wrapped in coyote skin and accompanied by a broken cradle board, one decorative and one simple mat, and a pouch fastened to the board, to Cave 5. Owsley separated the remains into two individuals.

4. The museum catalog attributes the remains of an adult woman to Cave 1 and those of an adult male to Cave 2. Eross' field notes assign two burials to Cave 2 but he makes no mention of Cave 1. The Witte annual report for 1934 lists two infant burials from Cave 1.

5. The true origin of these three burials is open to question. Davenport, on behalf of the Witte, carried out limited excavations at Jacal Cave in March 1935 but most of his attention was directed at Eagle Cave. Davenport mentions finding two adult burials and a badly burned baby bundle at Jacal Cave and notes that local collectors had extracted others. Another possibility is that they were donated by George Pickens who reportedly obtained three skeletons from a site on the Pecos near the (Fate) Bell ranch and later donated some 3000 artifacts to the museum (Woolford and Quillan 1966). Included in his donation was infant bundle 41VVSHUMLA-0-37110 which was attributed to a cave near Shumla. Burial UT-2229 is a partial cranial vault and some long bones and UT-2230 is an adult male, 60+ years old, with arthritis and severe joint pathologies. The consensus is that only UT-2230 is definitely from Jacal Cave.

6. Truncating of an anthropomorph's body is not uncommon; other examples are seen downstream at Lookout Shelter (41VV230), on the Pecos River at Kirkland's sites 2 (41VV90), 14 (41VV134), and Leaping Panthers (41VV237), and across the Rio Grande at Chumbla Cave.

7. As Newcomb noted, this is consistent with our general understanding of the development of social structure. Speaking specifically of the Lower Pecos pictograph era, Newcomb said, "In a general sense all life revolved in the orbit of kinship relationships, as it has for primitive man everywhere" (Kirkland and Newcomb 1967:64).

8. It is of course possible that other methods of disposing of the dead were also practiced—such as the cairn burials known from the Late Prehistoric (Flecha) period or the Early Archaic discards in convenient sinkholes. However —other than cremation—the evidence for contemporaneous alternatives is lacking (see Binford 1971 for a discussion of diversity in mortuary patterns).

9. See Binford 1971 for a discussion of status markers in hunter-gatherer mortuary practices, including the placement of the grave.

10. Newcomb presents a cogent explanation of the advantages of patrilocality in societies such as is presumed for the hunters-gatherers of the Lower Pecos (Kirkland and Newcomb 1967:64).

The Context of Tema LeClerc Eyerly's 1907 Wolf Creek Archeological Expedition to the Buried City in Ochiltree County, Texas

Christopher Lintz
Rolla Shaller

Professor T. L. Eyerly conducted and published the results of one of the earliest archeological excavations in Texas. Although initially trained as a geologist and educator, Tema LeClerc Eyerly's Wolf Creek expedition to the Buried City in Ochiltree County on behalf of the Canadian Academy constituted his only archeological exploration. Although affiliated with the Academy for less than two years, he published and republished seven articles over a span of six years about the archeological expedition, the layout of the Buried City ruins, and the kinds of artifacts present in the Texas Panhandle. The timing of the issuance of these reports is inextricably tied to his activities and the promotion and financial health of the Canadian Academy. Even though Eyerly changed careers shortly after his departure from the Canadian Academy in 1908, his publication efforts drew many renowned archaeologists and historians, including J. Walter Fewkes, Fred Sterns, Warren K. Moorehead, Joseph Thoburn, and W. Currie Holden to the Buried City area over the subsequent two decades. Eyerly's publications firmly established the existence of substantial prehistoric ruins of semi-sedentary peoples on the High Plains of Texas that predate the nomadic equestrian Indian cultures. This paper provides a context for the 1907 expedition to the Buried City by examining Eyerly's early life and commitment to the Canadian Academy, his impetus for publishing so many notices about his Buried City project, the professional response to these reports, and Eyerly's contribution to Texas and Plains archeology.

Introduction

Next year, Texas archaeologists can contemplate celebrating the century-long milestone of prehistoric site investigations and reporting since J. E. Pearce became the first professional archeologist hired by the University of Texas, Austin, and for his receipt of a $500.00 grant from the Bureau of American Ethnology on April 19, 1919 to initiate research on Native American remains (Tunnell 2000:4). While recognition of such an achievement is no doubt valid, it is also perhaps appropriate to recall that Tema LeClerc Eyerly directed and first published the results of his 1907 archeological expedition to the Buried City along Wolf Creek in Ochiltree County, Texas, more than a decade before Pearce began his fieldwork. Professor Eyerly promoted his brief 10-day investigation through several archeological publications printed between 1907 and 1912. His articles called attention to the existence of prehistoric stone ruins on the High Plains of the Texas Panhandle and prompted such archaeologists as J. Walter Fewkes in 1915 (Anonymous 1917; Hodge 1923) from the Smithsonian Institution, as well as field agents hired by Warren Moorehead of the Phillips Academy in Andover, Massachusetts, to visit the Buried City and conduct excavations on the site between 1917 and 1921. These agents included Dr. Fred Sterns and Joseph Thoburn (1917), C. B. Franklin (1919) and Warren King Moorehead himself (1920, 1921) who visited the Buried City site along the headwaters of Wolf Creek and each contributed information published in Moorehead's status report and final monograph (Moorehead 1920, 1931; Lintz and Hughes 2006). Even Dr. Currie Holden from McMurry College in Abilene dug at the Buried City in 1929 before joining the faculty at Texas Technical College in Lubbock (Tunnell 2000:12). Eyerly was instrumental in calling attention to the existence of the stone structures which stimulated these research projects designed to investigate the "advanced or high civilizations located between central Mexico, the Mississippian Cultures of the Southeast, and the Puebloan cultures of the Southwest" (Lintz and Hughes 2006).

Whereas Pearce sustained an interest in conducting archeological investigations in central and eastern Texas, Eyerly's life and career took a much different path. The Buried City Expedition was his only foray into archeology. This article sketches the biographical context of Tema LeClerc Eyerly's early life and the intertwined relationship of Eyerly to the Canadian Academy that prompted him to publish so many articles on this very early archeological project in the northeastern corner of the Texas Panhandle. The professional response to Eyerly's articles are also examined.

The Early Years

Tema LeClerc Eyerly was the youngest of three children born on August 20, 1877 to Erastus (1844-1919) and Sirilda/Serilda (Nowell) Eyerly, near Watson, Missouri, situated on the Missouri River floodplain in the extreme northwestern part of the state (Anonymous 1914). Before Tema was born, his father, Erastus Eyerly attended Iowa Wesleyan University near Keokuk, and eventually served as the Superintendent of Schools in Holt County, Missouri, from 1872-1875. However, by 1880, the national census lists the family as living in Franklin, Nebraska, and Tema's father's occupation is listed as a farmer. This is similar to Tema's grandfather, Samuel Minsker Eyerly (1803–1871), who made his living as a farmer and carpenter in Keokuk, Monroe, and Jasper, Iowa. Thus, Tema L. Eyerly was raised with an agrarian background, with a strong emphasis on education (Anonymous 2018).

Records indicate that Eyerly graduated high school before his 17th birthday from the Nortonville Kansas Public Schools in 1894 (Barnhill 1972). Shortly thereafter, he moved to Effingham, Kansas, located about a dozen miles away. His activities for the next seven years remain unclear. The 1900 national census lists his occupation as a schoolteacher, although he had yet to enter college for an advanced degree. Other biographical sketches mention that he served as a member of a "government geological survey" before 1906 (Jamison 1906a). At some point, he also became a member of the Kansas Academy of Science with special affiliation with the Math and Science Divisions. In 1901, at the age of 24, he enrolled in the Liberal Arts program at the University of Kansas, Lawrence. During the fall of 1904, he was hired as a part-time principal of the Marysville Unified School System in northeastern Kansas, before receiving his B.A. degree (Brown 1972). School records mention that Tema Eyerly ran for an unspecified public office for one year and "came out of the political process unscathed" (University of Kansas 1905).

Eyerly graduated before the age of 28, from the University of Kansas, Lawrence, but apparently also took classes at Ottawa University, a Baptist institution. Both universities list Tema Eyerly as graduating from their institutions with A.B. degrees in 1905 (Anonymous 1905; Barnhill 1972). A year later, in September 1906, he was hired as the principal of the Canadian Academy in Canadian, Texas. The appointment to a new position allowed him to resign from his part-time principal job with the Marysville School System (Jamison 1906a; Brown 1972). His move to the Texas Panhandle might have also been prompted by a desire to reside in a healthier environment, as he reportedly had contracted tuberculosis (Stoker 1972:7). Thus began Tema Eyerly's two-year whirlwind affiliation with the Canadian Academy in Hemphill County, Texas.

The Canadian Academy Years

The Canadian Academy forms an integral part of understanding Eyerly, not only because this is the institution that launched the archeological project, but also because the range of his energies and activities during his short residence there attests to the breadth of his interests. Additionally, his commitment to aiding the financially floundering school long after his departure underlies his release of several archeological publications long after he left the Texas Panhandle. A summary of the Canadian Academy provides the context for the publication records on the 1907 expedition.

The idea for creating the Canadian Academy arose in 1900 from concerns over inadequate educational facilities, as the growing populous of Canadian, Texas had only a single two-room building for a schoolhouse (Jamison 1927). The school was intended to be a private, Christian-based, coeducational academy. A public fundraising program selling building script amassed some $16,000 to $17,000 necessary to initiate construction of a three-story brick building and basement in 1900 (Jamison 1927). The remaining $3,800 construction shortfall was raised by six Canadian Businessmen, who formed the Canadian Educational Association.

The Canadian Academy opened in 1903 or 1904 as a non-denominational public school that offered kindergarten through some collegiate courses (Farmer 1996; Anonymous 1908). Primary disciplines offered included literature, Latin and German, music, elocution, math, science, chemistry, physics, biology, geology and physical culture. In November 1905, the Academy was accepted as a member of the Baptist Correlated Schools of Texas (Anonymous 1908, Jamison 1927).

In September 1906, Eyerly began serving as the Principal and Professor of Science and Mathematics, overseeing the natural history disciplines (Figure 1) under the direction of the first Canadian Academy President, J. F. McDonald. Eyerly's energies in this new institution were boundless. By October 1906, he established a volunteer weather station that provided daily observations on climate and stream flow of the Canadian River to the U.S. Department of Agriculture (Jamison 1906b). He also initiated a series of weekend field trips with students that culminated in a report privately published the following year by the Academy on a geological survey of Hemphill County (Eyerly 1907a).

Eyerly strongly promoted the science departments. His conviction of conducting rigorous science at the Baptist-sanctioned academy is clearly articulated in one of his later publications:

> "The time has long passed when denominational schools can afford to be less thorough (in science) than State Institutions. It has long been demonstrated that neither they nor the doctrines of the churches they represent have anything to fear from the true teaching and unprejudiced of science. But on the contrary, it is to these denominational schools that we must look for the exposition that will harmonize the Great Truths revealed to man in the written word with those so deftly hidden in every material object of the created world." (Eyerly 1908).

Professor Eyerly also made great strides in improving the scientific resources of the school. He initiated a library at the Academy by donating 64 volumes of geological survey books and other "official gazettes," and encouraged the local public to enhance the academy's library (Carr 1908:12). He encouraged students and teachers to write for free government publications, which yielded copies of Congressional Records and reports from the Smithsonian Institution. By February 1908, the library boasted nearly 500 books and magazines on a wide range of topics to help students understand the world around them (Jamison 1908b).

In February 1907, Eyerly used his connections

Figure 1. Portrait of Tema LeClerc Eyerly during his Canadian Academy years.

and the help of his representative, the Honorable J. H. Stevens, to obtain 268 non-metallic minerals and fossils and two display cases from the Smithsonian Institution for teaching purposes (Eyerly 1908: 44). These materials were supplemented by Native American artifacts, paleontological remains and rocks obtained during various Canadian Academy expeditions, as well as specimens loaned or donated by people in Hemphill and surrounding counties (Eyerly 1908; Anonymous 1908).

In March 1907, he gave a talk summarizing the Geology of Texas to the "Teacher's Institute for Roberts, Wheeler and Hemphill Counties" in the town of Miami, Texas (Jamison 1907a), followed by immediate departure to conduct fieldwork at the Buried City. Eyerly and his students were accompanied by Hollis Barclay Spiller, the Hemphill County Land Surveyor, to launch the ten-day Canadian Academy archeological exploration at Jim Fryer Ranch along Wolf Creek (Eyerly 1907b, 1907c, 1907d).

The Wolf Creek Expedition

The Wolf Creek archeological project was initiated on March 7, 1907. Ten boys accompanied Spiller and Eyerly on the expedition. Mr. Spiller had a degree in civil engineering from Virginia

Military Institute and was involved in surveying both the U.S.-Mexican border and delineating many counties in the panhandle (Stanley 1953: 369-370). The ten Canadian Academy students involved in the Wolf Creek Expedition consisted of two from the Senior class, two from the Sophomore Class, four from the Freshmen Class, and two from the "Preparatory Department" whom sought admittance the following year as Freshmen (Eyerly 1907c:14). One fifteen-year-old freshman was Floyd V. Studer who later claimed credit for arousing Professor Eyerly's interest in the Indian ruins and initiating the field expedition (Studer 1955: 88). Floyd Studer later became a well-known banker and insurance agent with a passion for archeology and paleontology. His efforts to preserve the panhandle's historical and natural resources was acknowledged following his appointment as the honorary Director of Archeology and Paleontology of the Panhandle-Plains Historical Society, which was a position he held from 1931 to 1951.

Four goals were established for the Wolf Creek Expedition: 1) provide students an opportunity to conduct original observations on geology towards developing a study on the geology of Hemphill County; 2) with the help of Spiller, give students practical experience in instrumental mapping; 3) collect relics and examine private collections from the Buried City site while soliciting donations for a museum to be established at the Canadian Academy, and; 4) study the remains from the Buried City to make accurate descriptions about the site and to contribute knowledge about the origins and antiquity of the ruins (Eyerly 1907c).

The expedition was outfitted with tents, camping equipment, a camera, hand tools, survey instruments and "everything necessary to render a pleasant trip" (Eyerly 1907c:14). Eyerly utilized a buggy and wagon equipped with bedding and a chuck box to carry the students, equipment, supplies, and food to Wolf Creek (Jamison 1907c:1). The duration of the Wolf Creek Expedition only lasted ten days.

During the first night of the expedition, they established two transient camps; the first was on Horse Creek in the sand hills region for the purpose of examining the geology, and a second was at Gibson Creek, a tributary of Wolf Creek located some 25 miles north of the Canadian Academy (Eyerly 1907c:14). By March 8, a more permanent camp was established in a timbered setting along the Wolf Creek portion of the Jim Fryer Ranch at the Buried City. The site is located near the headwaters of Wolf Creek and is bordered by an east-flowing sweet-water tributary of the Beaver or North Canadian River.

The geological reconnaissance of Horse Creek contributed information on the sand hills formation that was eventually incorporated into Eyerly's geological study of Hemphill County. During reconnaissance along Wolf Creek, he noticed concentrations of red and black scoria rock on a ridge, which he erroneously interpreted as remnants of a lava field in the northwestern part of the Texas Panhandle, instead of the residual Ogallala Formation outwash gravels that included igneous materials from an alluvial fan that developed from the up-lift of the Rocky Mountains (Eyerly 1907c:16). Other geological observations focused on the erosion and deposition of landforms and the rates of sediment deposition along Wolf Creek (Eyerly 1907c:15).

Eyerly (1907b:219) claimed that the series of mounds comprising the Buried City had been previously visited by a number of scientists, but none had published a report of investigations or described artifact collections made by these individuals or adjacent landowners. However, a brief description of the "old town built of stone on the breaks (sic. banks) of Wolf Creek" as observed ca. 1885, was published in the sworn deposition of Mr. W. B. Kiser, the Greer County Commissioner and Road Supervisor, who provided testimony to the U.S. Supreme Court about conditions of rivers and roads to determine whether Greer County should be assigned to Texas or Oklahoma Indian Territory (United States 1892:1096-1098). Despite the seven-year lapse between Mr. Kiser's visit to Buried City and his testimony, many of his observations about the size and layout of the site were accurate (Lintz and Shaller in press). Local belief was that the Buried City constituted a prehistoric town site. But no one could agree on whether the remains were left by Plains Indians, Spanish explorers, or buffalo hunters. An interview with Thomas Connell, a pioneer who established a homestead in 1877 a few miles from the ruins and who visited the site with Arapahoe Chief, Spotted Wolf, stated that the chief claimed the mounds at the Buried City were not the works by Indians at the site, but by buffalo hunters (Lintz and Shaller in press:220).

The main series of ruins consisted of 12 roughly rectangular mounds arranged in no particular order within a 70-acre triangular-shaped area south of Wolf Creek (Eyerly 1907b:221). Each mound was associated with unmodified stones varying from a few inches to a foot or more in size, and all but one mound was roughly rectangular with the long axis oriented east-west. The rock layout suggested that all structural remains had openings in the center of their east walls (ibid:222). Eyerly (1907b: 222-224) discussed each of the dozen mounds mapped by Hollis Spiller (Figure 2). Mound 9 was so indistinct that dimensions were not collected. Rectangular Mounds 4 and 8 were very small and measured but "a few feet" for a pair of features at Mound 4 to a mere 6 by 7 ft. (1.8 x 2.1 m) at Mound 8. Mound 12, the only circular mound, was also relatively small with a diameter of about 10 ft. (3.0 m). Six rectangular mounds (numbers 1, 2, 5, 6, 7 and 11) ranged from 23 by 30 ft. (7.0 x 9.1 m) to 32 by 47 ft. (9.8 x 14.3 m). These dimensions corroborated Eyerly's approximate claim that each mound's width was three-fourths their length (Eyerly 1907b:222). Two mounds, however, varied from the reported ratio and were considerably elongated. Mound 3 measured 25 by 50 ft. (7.6 x 15.2 m) and Mound 10, named "The Temple," measured a remarkable 20 by 60 ft. (6.1 x 18.3 m).

Excavations in several mounds found that stone slabs originally hypothesized as building foundation or wall remnants, were not laid as expected. Rather, the stones were set on-edge like a "walkway," and penetrated depths of 2 to 3 feet below surface (Eyerly 1907b:221). The stone alignment orientations clearly befuddled Eyerly, for although he initially referred to the alignments as "walls," he later claimed that these stone outlines could not be house foundations nor remnants of walls (Eyerly 1907b:222, 227). Despite his recovery of flint chips, chipped and ground stone tools (including arrowheads, scrapers, "mutat and crusher stones" [metates and manos], bone and shell debris and pottery), and the evidence proposed by the "walkway" alignments of stone, he denied that the mounds represented residential buildings. Instead, he claimed that all excavations yielded human remains, and mentioned that one bone fragment in particular had a broken arrow point

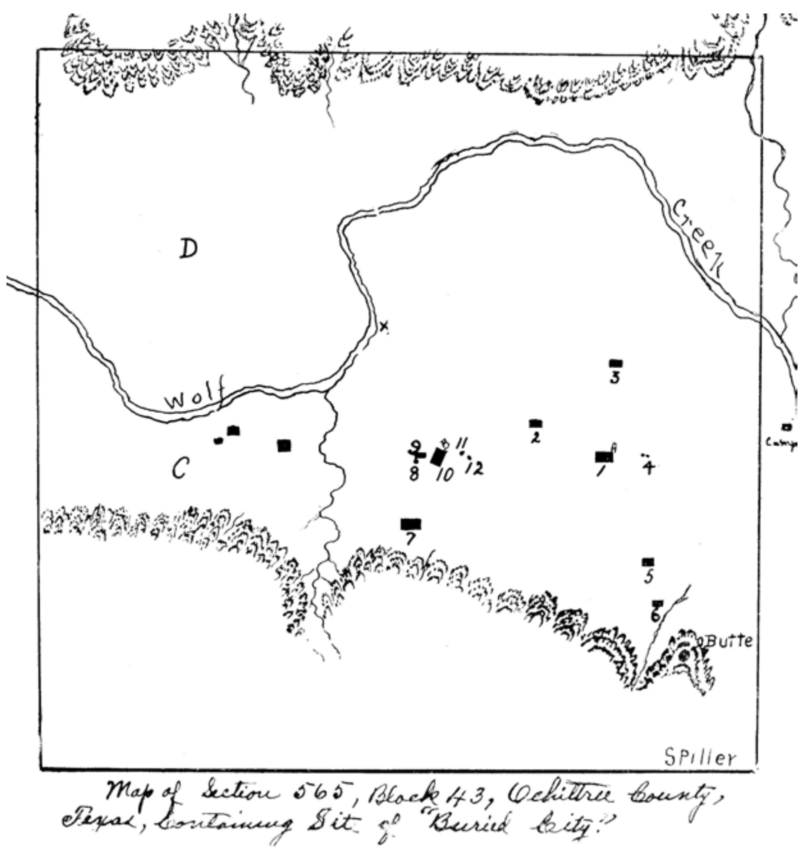

Figure 2. Map of Section 565, Block 43, Ochiltree County, Texas showing site of "Buried City" and field camp with scale added from Hollis Barclay Spiller's Map (Eyerly 1907b).

embedded in bone (Eyerly 1907b:224, 1907c:15). This statement, for the universal association of human remains with mounds, was not corroborated by Eyerly's individual mound descriptions (Eyerly 1907b:224), which stated that (human) skulls were only associated with "a small mound (No. 8), and the Temple Mound, (No. 10)". Perhaps one of these burials was shipped to the Smithsonian Institution by the original landowner of the Buried City, James Fryer. Accession records (247 and 358) at the museum indicate that a donation was made by Mr. Fryer in 1907 and consisted of cord marked potsherds, two pieces of possible plaster or caliche, and a broken human skull associated with three mastoid processes (perhaps indicative of two individuals) (Wedel 1973a, 1973b). Based on Eyerly's discussions of the recovery of an incised bone (perhaps scored bone tool manufacturing debris or a bison rib rasp [?]) as indicative of a probable human massacre, it is plausible that Eyerly may not have been able to accurately distinguish human from animal remains (Eyerly 1908:51, Eyerly 1910:79).

Eyerly (1907b:226) noted that other undescribed mounds occurred west of a small ravine on the south side of the Wolf Creek and up-stream some two miles to the west. An eroded gully through one of these mounds showed that it had the same characteristics as those previously excavated; they contained soil mixed with charcoal and extended to a depth of 4 ft. (1.25 m). Elsewhere, he mentioned the presence of scattered artifacts from an "Indian village" covering a 20-acre portion of a cultivated field on the north side of Wolf Creek, opposite the Buried City locale. The headwaters of Wolf Creek are thus characterized as having "abundant vestiges of Indian remains" (Eyerly 1907b:226).

Eyerly interpreted the mounds at the Buried City as a series of burials from a human massacre that occurred at some unknown time in the past. He noted the presence of numerous graves on prominences and buttes bordering Wolf Creek and he felt his argument was additionally supported following discussions he had with local landowners. Local ranchers informed Eyerly of a formal burial ground or cemetery (which included associated iron artifacts and glass beads) located some four miles from the Buried City, on property owned by a man named Jackson (Eyerly 1907b:225). His massacre theory may have also been influenced by the similarities he saw between the mounds at the Buried City and with burial mounds he was familiar with on an Iowa Indian Reservation in northeastern Kansas (Eyerly 1907b:227).

In contemplating the age and cultural affiliation of the Buried City mounds, Eyerly felt that the shallow depth of the artifacts (usually 1 or 2 ft. deep, but occasionally extending to depths of 4 ft.), and the state of bone and shell preservation indicated that the archeological remains were only a few centuries old. He rejected the local lore that the remains were evidence of early Spanish or "prehistoric Aztec" occupations and suggested that the kinds of pottery and flint tools were similar to remains found across the Plains; however, he felt that the mounds indicated a more advanced tribe than the nomadic Plains Indians whom recently inhabited the region (Eyerly 1907b:228).

Post Expedition Activities at the Canadian Academy

The Wolf Creek project wrapped up fieldwork on May 17, 1907. Immediately thereafter, Eyerly encouraged the compilation, publication and distribution of another 1,000-copy edition of a 92-page bulletin published by the Canadian Academy called, "The Student" (Jamison 1907c, 1907d). This Bulletin highlighted school accomplishments in all facets of the Academy, including research, to promote fundraising. The campaign was so successful that the Academy raised their student enrollment to almost 150 students, requiring the construction of separate male and female dormitories, and up-grading scientific laboratories designed for physics, botany, and geology (Jamison 1907f). These marked the peak years of support and enrollment for the Canadian Academy.

By June of 1907, Eyerly, Hollis Spiller, and four students conducted a civil engineering survey of the Evans Parcel, a land tract purchased in 1907 by the St. Louis Syndicate to establish the new community of Mendota along the rail line located ten miles (16 km) west of the Canadian Academy and south of the Canadian River. Eyerly, Spiller, and the students were charged with subdividing 38 sections of this parcel into quarter-section farm plots, and for laying out the revised town site of Mendota in the area surrounding the Santa Fe Railway spur station of the same name (Jamison 1907b, 1907e). The original Mendota town site was established along Red Deer Creek in 1887, but it was bypassed by the railroad (Anderson 1996:618). The survey team completed laying out the new Mendota locality, which eventually had a resident population of 100 people, and supported a post office, school, church, lumber yard, and general store. However, periodic Canadian River floods and sandy sediments made transportation to the new town difficult and most residents favored shopping in nearby Canadian. The Mendota post office closed in 1944 and the county-maintained Mendota Road is the last vestige of this abandoned community.

To promote further the Canadian Academy, Eyerly wrote several articles about the Buried City that were published in the Transactions of the Kansas Academy of Science (Eyerly 1907b) and reprinted in the Student (Eyerly 1907d). Other articles detailed the Wolf Creek expedition (Eyerly 1907c), the artifact assemblages found at the Buried City and private collections in the panhandle (Eyerly 1908), and a short monograph on the geology of Hemphill County (Eyerly 1907a). Notice of Eyerly's first published Buried City report were disseminated so far as to draw the attention of a religious scholar in England researching mythologies of ancient Mexico and Peru, who proclaimed that "the recent discovery of a buried city in the panhandle of Texas may throw some light upon the dark places of American archeology as a whole" (Spence 1907).

The archeology at the Buried City was not Eyerly's only field excavation while at the Canadian Academy. During 1907, one of the Canadian Academy students noticed fossil bones exposed 3.7 m (12 ft.) below surface in a 9.1 m (30 ft.) deep canyon located some 8 km west of Canadian, 3.2 km south of the river and west of its confluence within the Red Deer Creek (Young 1907:53). By January of 1908, Eyerly and two other chaperons took a four-horse wagon loaded with nearly a dozen students to the canyon to document the stratigraphic formations and collect fossil bones for the Academy museum (Jamison 1908a). The presence of fossil ivory among the remains suggested that the bones belonged to an extinct mammoth. A sample of these specimens were returned to the Canadian Academy.

Despite the tremendous work Professor Eyerly devoted to the Canadian Academy, the reason for his departure from the institution at the end of the spring semester of 1908 remains obscure. His departure approximately coincides with the resignation of J. F. McDonald, after the president's four-year stint at the helm of the academy. Whatever the reasons for their departures, the Canadian Academy rapidly declined into financial chaos (Anonymous 1908).

The academy had three other presidents (O. N. McBride, R. E. L. Farmer and J. P. Reynolds) over the subsequent five years (Farmer 1996:951). By September 1913, the Canadian Academy closed because the money raised from contributions, fees, and tuition, could not compete with income from tax-supported schools, which began offering broader educational opportunities. The Canadian Academy buildings were used until 1924 as an orphanage, but the structures were not maintained (Jamison 1927:1). In early April 1927, the abandoned and dilapidated main brick building of the Canadian Academy was gutted by fire and the unstable brickwork ruins were razed with dynamite for health and safety reasons (Jamison 1927). The boy's and girl's dormitories still exist in Canadian and are used as private residences.

Tema Eyerly's Later Years

Eyerly's departure from the Canadian Academy might have been motived by political turmoil or the progression of his tuberculosis. During the summer of 1908, Eyerly developed an interest in medicine and took courses at Rush Medical College at the University of Chicago (University of Chicago 1908). However, in the fall, he returned to the University of Kansas, Lawrence, and enrolled in graduate school in geology. He submitted a version of his 1907 study on the Geology of Hemphill County for his thesis requirement and was awarded his Masters of Arts degree in 1909 (Eyerly 1909; University of Kansas 1920:28). Following graduation, he worked for the Geology Department at the University of Kansas, Lawrence, on a reconnaissance of natural gas wells in Pawnee County, in southwestern Nebraska (Anonymous 1911). The results from this project constituted the last major report he prepared as a geologist (Eyerly 1911).

During this period, Eyerly was probably contacted by administrators from the financially floundering Canadian Academy who asked him to reprint articles of his Wolf Creek investigations as a means of bringing favorable publicity to the institution. He published a short article on the "Indian Remains from the Canadian River Valley" which was lifted from the last three pages of his

1908 article on the "Science Department" article (Eyerly 1910); two years later he republished full and condensed versions of his Kansas Academy of Science article on the Buried City (Eyerly 1912a, 1912b). It is an unlikely coincidence that he stopped publishing archeological articles after the Canadian Academy closed. In 1913, he published a physiography manual designed for use in high schools, although it is unclear whether he was involved with the teaching profession at the time (Eyerly 1913).

During the summer of 1912, Eyerly resumed his interest in medicine by enrolling in the Harvard University School of Medicine (Anonymous 1912:233). He subsequently enrolled in the Baylor University Medical School in Dallas, and was hired as a faculty member of the Pharmacy Department, as an instructor in chemistry, and lecturer in biology and embryology (Anonymous 1913). Baylor School of Medicine awarded him a Doctor of Medicine degree in 1914, whereupon he became the house physician with the Texas Baptist Memorial Sanitarium in Dallas. He met, courted and eventually married Estelle Sarah Webb (1891-1976), a nursing student working as an intern at the sanitarium. Upon his fiancé's graduation, Eyerly resigned his position at the sanitarium to join the Naval Medical Reserve Corps in 1917.

With America's entry into the Great War, Dr. Eyerly enlisted in the Student Medical Reserve Corp as an Assistant Surgeon for the Navy in 1918, and within a year he was promoted from seaman to lieutenant and served out his military career at the San Diego Naval Air Station in California (Baylor Bulletin 1918; Naval Directory 1918, 1919:100). On December 20, 1919, Eyerly was discharged from the Navy Medical Corps.

Upon release from the military, Tema and Estelle Eyerly moved to Tioga, Colorado, a coal mining company town developed by the Keebler Mining Company located 10 miles northwest of Walsenburg, Colorado (Borglum 1972). Dr. Eyerly secured his Colorado Medical Certificate and practiced as the company physician in Tioga for four years (December 1919-1923). In Tioga, Estelle gave birth to their two daughters: Carmen Z. (born 1920) and Loma Linda (born 1923). The Eyerlys left Tioga in 1923 and settled in Denver where he secured a position with the Veterans Administration (VA) as a Medical Examiner. Eyerly published one observation on a bladder condition in the prestigious Journal of American Medical Association (Eyerly 1923). Otherwise, he lived a relatively quiet life for the next 15 years while on staff at the Veterans Administration where he variously served as an Associate Medical Officer, a Rating Specialist, and Permanent Medical Officer at VA offices in Denver, Colorado, and Cheyenne, Wyoming (Borglum 1972; Eyerly 1935, Van Zante 1973). In 1937, nearing the end of this career, Eyerly drew an assignment to work at the VA Hospital in Honolulu, Hawaii. Following this appointment, he retired before the beginning of World War II and moved to southern California. He died on February 7, 1957, and is buried at the Golden Gate National Cemetery, in San Bruno, California. Interestingly, his original report on the Buried City of the Panhandle as published in the Kansas Academy of Science is still available as a reprint-on-demand from two publishers in Delhi, India (Eyerly 2018a, 2018b).

Retrospective Contributions

The biographical sketch of T. L. Eyerly shows that he was a renaissance man of many diverse interests, brimming with passion and boundless energies. He was skilled in geology, mathematics and education before turning his interests to medicine after his departure from the Canadian Academy. He lacked formal training in archeology beyond what he read and what he encountered with archeological sites during his youth, and on his field trips with the Kansas Geological Survey.

The Buried City ruins along Wolf Creek were recognized and well known by local ranchers of the region before 1885 (United States 1892; Lintz and Shaller in press). Several people had artifact collections from the site, and some may have even begun excavations within the ruins. Stories about the existence of the stone town reached Eyerly in Canadian, and there is little doubt that freshmen student Floyd Studer convinced Professor Eyerly to undertake the Wolf Creek project to gain notoriety for the Canadian Academy and provide training for students in the principles of survey mapping, excavation, and geological studies. Artifacts and records from the project added to the Academy's fledgling museum, and published reports from the project were used to raise funds for the school.

Eyerly approached the Wolf Creek expedition fieldwork using his geological and surveying skills. He correctly noted that the stonewalls in the dozen mounds at the site employed a rather unusual construction method of setting the stones on edge, sometimes in parallel rows like walkways. Indeed, the use of vertical-set, parallel rows of stacked foundation stones several tiers high seemed so strange to him that he incorrectly concluded that these mounds were not the remains of residential structures, despite their association with a diverse, domestic artifact assemblage. In addition, the recovery of at least two human crania led Eyerly to suggest incorrectly that the site consisted of a series of burial mounds from some ancient massacre. However, because of his familiarity with sedimentary depositional processes, he keenly observed charcoal-flecked soil at depths of several feet. This led him to correctly hypothesize that the Buried City mounds must be several hundred years old, and predate the recent equestrian Plains Indian cultures.

Unfortunately, no detailed maps of the individual mound excavations were made and only a few photographs exist to document Eyerly's 1907 fieldwork. Today, the whereabouts of the artifacts obtained from the 1907 expedition to the Buried City are unknown (Wedel 1973b).

Although Eyerly's later publications of the Wolf Creek expedition were primarily intended to drum up support for the Canadian Academy, he was also able to reach the scientific archeological community through his papers. This was especially so for publications placed in the Kansas Academy of Science journal (Eyerly 1907b), the two articles printed in the Archeological Journal from Hico, Texas (Eyerly 1910, 1912a), and especially, his brief note that appeared in the Records of the Past, a journal of the Exploration Society of Washington D. C. (Eyerly 1912b).

Eyerly's documentation of the Buried City forced lay people residing in the area and archaeologists from East Coast Institutions and even in England, to take note of his discoveries. Undoubtedly, his reports were discussed among archaeologists from the East Coast, and a series of visits to the Buried City site were conducted within a few years of Eyerly's publications. For example, Jesse Walter Fewkes from the Bureau of American Ethnology, Smithsonian Institution, was the first professional archeologist to try to visit the Buried City site in 1915 to investigate local claims that the site represented the eastern-most extent of the Southwestern Puebloan culture (Hodge 1923; Anonymous 1917).

Although Warren Moorehead (1931:94) insisted that Fewkes excavated a burial from the site, the Smithsonian Institution records suggest that the only human remains submitted from the Buried City were those dug up in 1907 and submitted by the landowner, James Fryer. Thus, Fewkes conducted no excavations at the Buried City. Fewkes did indeed attempted to visit the Buried City based on his understanding of Eyerly's reports, and claims to have visited "certain Indian remains along Wolf Creek (a tributary of the Canadian River [sic, North Canadian]), said to be the location of the 'city'" (Hodge 1923). Fewkes was unimpressed with the site he found and dismissively proclaimed that "the remains hardly justify the name given the site, which in former days was used as an encampment by wandering Indians, rather than by sedentary peoples" (Hodge 1923:6). Elsewhere, Fewkes states that "sites of aboriginal camping places, probably nomadic Indians, were found in this location, but no remains of walls or pottery suggestive of Pueblo occupancy. There were no signs of a 'Buried City of the Panhandle' in the region visited," (Anonymous 1917:97). Based on these comments and subsequent excavations of several houses at the Buried City during the 1980s (Hughes and Hughes-Jones 1986; Hughes 1989), one wonders if Fewkes was erroneously looking for a village along a northern tributary of the Canadian River, rather than along a portion of the Wolf Creek drainage.

Other archeological field expeditions and extensive excavations at the Buried City occurred over four summers between 1917 and 1921 under the auspices of Warren King Moorehead of the Phillips Academy, Andover, Massachusetts (Moorehead 1920, 1931; Lintz and Hughes 2006). Moorehead felt that the Buried City had an intermediate location on the high plains and had the potential to unravel the cultural relationship among the "advanced cultures" of the Southeastern Mound Builders, the Southwestern Puebloans, and the Meso-American cultures (Moorehead 1920, 1931). He designed a regional survey and sent his agents Dr. Fred Sterns, and Joseph Thoburn (1917) and later, C. B. Franklin (1919) on large-scale surveys from eastern Oklahoma to central and western New Mexico; invariably these trips ended up conducting excavations on various structures at the Buried City. Moorehead personally conducted additional expeditions during 1920 and 1921 centering on the Buried City but also focused on the upper Canadian River drainage (Lintz and Hughes 2006). The various excavations by Moorehead and his agents along the Canadian demonstrated that the paired rows of vertically set stones were common forms of Late Prehistoric house wall foundations and that mounds were buildings representing Late Prehistoric residential communities. Moorehead (1921) wrote a preliminary article on his various projects, but his final report discussing details of his Buried City studies and his regional conclusions were not printed until a decade later.

The last of the early excavations to occur at Buried City took place during Easter break in 1929. Instructor William Currie Holden took Professor Leroy Glass and four or five students from McMurry College in Abilene to the Buried City and dug out a two-room, stone slab structure in two days using picks and spades but without screening the fill. They then attacked three more houses and left the site with very little new information or artifacts to show for their efforts (Holden 1929; Tunnell 2000:12-13). The five houses investigated may have been some of the same as those excavated by Moorehead. The McMurry College crew then moved to the Cottonwood-Tarbox vicinity on the north side of the Canadian River, where they mapped and dug a series of room blocks (Holden 1929:16). The 1929 work at the Buried City was the first of six large sites excavated by Holden between 1929 and 1932 to investigate cultural transitions between masonry sites in the Texas Panhandle and those of the New Mexican Pueblos (Lintz 1986:10). The publications of Holden's research results (1929, 1930, 1931, 1932a, 1932b, 1933) coupled with Moorehead's (1931, 1933) final report and summary demonstrated that the Texas Panhandle sites were not involved with the interactions among the high cultural centers of Meso-America, the Southwest, or the Southeast. Southwestern trade ceramic types from the Texas Panhandle sites also demonstrated that they had relatively little time depth (Holden 1934). With the resolution of these regional influence and interaction issues, professional excavations at the Buried City lapsed for five decades.

Renewed excavations since 1966 focused on understanding the diversity of house forms and material remains at the Buried City locality and examining the cultural relationships of the Buried City to adjacent Late Prehistoric period manifestations. Recent initial work focused on investigating midden deposits and examining one masonry structure called Eyerly Ruin by W. K. Moorehead (Ellzey 1966). An intensive sustained program at the Buried City locale was conducted by the Courson Archeological Projects with private funds to explore masonry house ruins designated Courson A and B during 1985 and 1986 (Hughes and Hughes-Jones 1986). Further intensive excavations at six other masonry houses (41OC26 through 41OC-1 [Temple Ruin], 41OC29, 41OC43 and 4OC51) resumed with the help of the Texas Archeological Society during 1987 and 1988. Large pits of 2 or more meters were found near 41OC26, and a series of pits 1-2 m in size filled with daub were found under the masonry structure at 41OC27 (Hughes 1989:120). Subsequently, geophysical surveys were conducted during 2000 in the locale resulting in the discovery of 26 anomalies (Brosowske and Maki 2002). The 2003 University of Oklahoma field school conducted ground-truthing of these anomalies, which resulted in the affirmation that 18 of the 26 anomalies were cultural features and two pit house structures were delineated near areas with masonry buildings (Archaeo-physics 2012). Although the significance and association of masonry surface structures and subsurface pit house forms remain to be resolved (Brosowske and Bevitt 2006:186), Tema Eyerly's pioneering investigations at the Buried City provided the first insights into, and prompted a century of archeological explorations of the prehistoric remains along Wolf Creek and in the greater Texas Panhandle.

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A Preliminary Study of Smithport Plain Bottle Morphology in the Southern Caddo Area

Robert Z. Selden, Jr.

This study expands upon a previous analysis of the Clarence H. Webb collection, which resulted in the identification of two discrete shapes used in the manufacture of the base and body of Smithport Plain bottles. The sample includes the Smithport Plain bottles from the Webb collection, and four new bottles: two previously repatriated specimens in the Pohler Collection, and two from the Mitchell site (41BW4) to test whether those specimens align morphologically with the Belcher Mound or Smithport Landing specimens. Results indicate significant allometry and a significant difference in Smithport Plain body and base shapes for bottles produced at the Smithport Landing and Belcher Mound sites in northwest Louisiana. The Pohler and Mitchell specimens do not differ significantly from those found at Smithport Landing or Belcher Mound. Analysis of the aggregated sample indicates some significant relationships between bottle shape and size, bottle shape and type, and bottle shape and site, highlighting assemblage-level and type-specific variability. The test of morphological disparity by period indicates a gradual trend toward standardization, and the test of morphological integration indicates that Caddo bottles are significantly integrated, meaning that those discrete traits used to characterize their shape (rim, neck, body, and base) vary in a coordinated manner. The iterative development of this research design can lead to substantive theoretical gains that augment discussions of decorative components and motifs as well as ceramic technological attributes.

Defined as "a vessel with a spheroid or oval body, surmounted by a slender, cylindrical neck," Caddo bottles were initially seen as a somewhat homogenous ceramic form (Harrington 1920:187); some with shapes and motifs so similar to be deemed the work of a single maker (Harrington 1920:188). In a more recent study, Caddo bottles were found to be more symmetrical than bowls and ollas (Selden, Jr. 2017); however, additional work is needed to identify whether—and to what extent—this holds true across a broader range of vessel shapes and types. Caddo vessel shapes are variable among groups and through time, reflecting stylistic, functional, and social change (Perttula 2010). Caddo potters elevated local ceramic production to high art, and "had no superiors short of the Pueblo country" (Swanton 1942:239), leading some analysts to posit that Caddo bottles rest at the apex of Native American ceramic technology (Gadus 2013). A division of the Caddo bottle category has been proposed for northeast Texas that segregates bottle forms into 27 shapes, each with distinct temporal and spatial distributions (Perttula 2015:Figure 2), and novel deployments of geographic information systems are aiding in the refinement of their probable geographic extents (McKinnon 2011).

This effort capitalizes on the quiddity of Caddo bottle shape for a small sample (n = 8) of Smithport Plain bottles previously posited to exhibit morphological differences (Selden Jr. 2018a; Suhm and Jelks 1962; Webb 1959). Three-dimensional (3D) meshes for the Webb Collection and four new samples from one site and one collection were used to test whether a significant difference in shape exists for Smithport Plain bottles by site, followed by a test for allometry. The Smithport Plain bottles were subsequently examined as part of the aggregated sample of Caddo bottles to demonstrate morphological variability, allometry, morphological disparity, and morphological integration among the types (Table 1 and Figure 1).

Taxonomic definitions for Caddo ceramics integrate semiotic and morphological attributes, and each type is characterized by a broad range of vessel shapes that often include bottles, bowls, carinated bowls, ollas, as well as other shapes (Suhm and Jelks 1962; Suhm et al. 1954). The Smithport Plain type was defined by Webb (1959) at the Smithport Landing site (16DS4) in northwest Louisiana and is believed to range in age from the Formative to Early Caddo periods (ca. AD 800–1200) (Webb 1963). All Caddo bottles used in this analysis fall

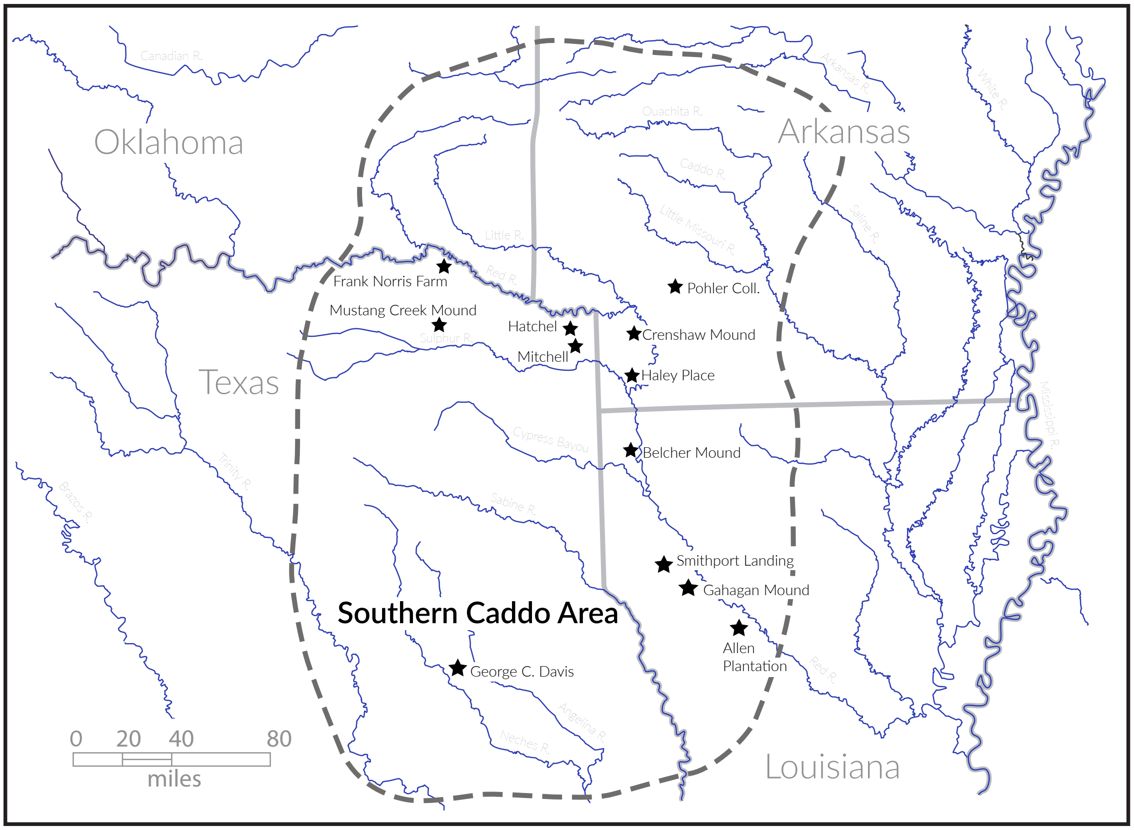


Figure 1. Locations of Allen Plantation, Hatchel, Belcher Mound, Crenshaw Mound, Frank Norris Farm, Gahagan Mound, George C. Davis, Haley Place, Mustang Creek Mound (also known as T. N. Cole), Paul Mitchell (Mitchell), specimens from the Pohler Collection (Clark County, Arkansas), and Smithport Landing.

Table 1. Caddo bottles used in this analysis.

Specimen	Site Name	Trinomial	Context	Museum	Type
256	Belcher Mound	16CD13	Burial 5	LSUMNH	Taylor Engraved
267	Belcher Mound	16CD13	Burial 5	LSEM	Belcher Engraved
269	Belcher Mound	16CD13	Burial 5	NSU	Belcher Engraved
271	Belcher Mound	16CD13	Burial 5	LSUMNH	Taylor Engraved
361	Belcher Mound	16CD13	Burial 9	NSU	Belcher Engraved
363	Belcher Mound	16CD13	Burial 10	NSU	Belcher Engraved
404	Belcher Mound	16CD13	Burial 11	NSU	Hickory Engraved
405	Belcher Mound	16CD13	Burial 11	NSU	Smithport Plain
430	Belcher Mound	16CD13	Burial 12	NSU	Smithport Plain
775	Belcher Mound	16CD13	Burial 15	NSU	Belcher Engraved
784	Belcher Mound	16CD13	Burial 15	LSUMNH	Keno Trailed
787	Belcher Mound	16CD13	Burial 15	LSUMNH	Taylor Engraved
788	Belcher Mound	16CD13	Burial 15	NSU	Belcher Engraved
803	Belcher Mound	16CD13	Burial 15	LSUMNH	Belcher Engraved
805	Belcher Mound	16CD13	Burial 15	NSU	Belcher Engraved
845	Belcher Mound	16CD13	Burial 17	NSU	Belcher Engraved
852	Belcher Mound	16CD13	Burial 17	NSU	Keno Trailed
897	Belcher Mound	16CD13	House 6	NSU	Belcher Engraved
997	Belcher Mound	16CD13	Burial 24	NSU	Belcher Engraved
1054	Belcher Mound	16CD13	Burial 26	LSEM	Taylor Engraved

Table 1. Caddo bottles used in this analysis. *(Continued)*

Specimen	Site Name	Trinomial	Context	Museum	Type
1073	Belcher Mound	16CD13	House 6	NSU	Belcher Engraved
95	Smithport Landing	16DS4	Burial 1	NSU	Smithport Plain
96	Smithport Landing	16DS4	Burial 1	NSU	Hickory Engraved
152	Smithport Landing	16DS4	Burial 10	NSU	Smithport Plain
No #	Smithport Landing	16DS4	Unknown	NSU	Hickory Engraved
142	Allen Plantation	16NA6	Unknown	NSU	Hickory Engraved
955	Gahagan Mound	16RR1	Mound A	NSU	Hickory Engraved
956	Gahagan Mound	16RR1	Mound A	LSUMNH	Hickory Engraved
HFE1	Haley Place	3MI1	Unknown	LSEM	Hickory Engraved
HFE2	Haley Place	3MI1	Unknown	LSEM	Hickory Engraved
HFE3	Haley Place	3MI1	Unknown	LSEM	Hickory Engraved
HFE4	Haley Place	3MI1	Unknown	LSEM	Hickory Engraved
HFE5	Haley Place	3MI1	Unknown	LSEM	Hickory Engraved
55-1-8*	Crenshaw Mound	3MI6	Unknown	CNO	Hickory Engraved
2002-01-18*	Unknown (Clark County, AR)	Pohler Coll	Unknown	CNO	Smithport Plain
2002-01-20*	Unknown (Clark County, AR)	Pohler Coll	Unknown	CNO	Hickory Engraved
2002-01-23*	Unknown (Clark County, AR)	Pohler Coll	Unknown	CNO	Hickory Engraved
2002-01-27*	Unknown (Clark County, AR)	Pohler Coll	Unknown	CNO	Smithport Plain
FS7	Hatchel	41BW3	Unknown	TARL	Hickory Engraved
6-2-67	Paul Mitchell	41BW4		TARL	Smithport Plain
6-2-78	Paul Mitchell	41BW4		TARL	Smithport Plain
6-2-132	Paul Mitchell	41BW4	Unknown	TARL	Hickory Engraved
341-427	Paul Mitchell	41BW4	Burial 9	TARL	Hickory Engraved
341-464	Paul Mitchell	41BW4	Burial 21	TARL	Hickory Engraved
2015-1	George C. Davis	41CE19	Burial F-154	TARL	Hickory Engraved
7	Frank Norris Farm	41RR2	Unknown	TARL	Hickory Engraved
2	Mustang Creek Mound	41RR3	H. O. #568	TARL	Hickory Engraved

The bottle without a number (Webb Collection) is assumed to have come from the Smithport Landing site in fragments. The bottle was later reassembled, but a number was never assigned. * = repatriated to the Caddo Nation of Oklahoma. NSU = Northwestern State University (Williamson Museum); LSUMNS = Louisiana State University Museum of Natural Science; CNO = Caddo Nation of Oklahoma; TARL = Texas Archeological Research Laboratory; LSEM = Louisiana State Exhibit Museum.

under the Native American Graves Protection and Repatriation Act (NAGPRA), excepting those found in House 6 at the Belcher Mound site (see Table 1). The Caddo Nation of Oklahoma granted permission to scan the collections with the provision that any scan data used in the analysis must not include the texture (color) file. Full-resolution scan data were forwarded to the Caddo Nation of Oklahoma with the texture applied. This provides them with an accurate 3D record of each vessel, and a means of viewing a collection of bottles that is curated across numerous repositories.

Geometric Morphometrics in Archeology

Analyses of artifact shape are neither new or novel (Okumura and Araujo 2018), and it is not surprising that geometric morphometrics (GM) (sensu Corti (1993)) has captivated analysts of material culture due to the substantive contribution of morphology to lithic (Fox 2015; Thulman 2012; Wilczek et al. 2015) and ceramic typologies (Girrulat 2006; Topi et al. 2017; Wilczek et al. 2014), additional categories of material culture (Chitwood 2014; Ros et al. 2014; Windhager et al. 2012), and novel applications (Barceló 2010; Lenardi and Merwin 2010). The earliest study of artifacts was an analysis of irregular shapes by elliptic Fourier analysis (EFA) (Gero and Mazzullo 1984), and the adoption of the method by the archaeological community has grown to include an impressive array of applications (Figure 2).

EFA has been employed at an increasing rate in lithic and ceramic analyses (Cardillo et al. 2010; Costa 2010; Fox 2015; Ioviţă 2009, 2010, 2011; Ioviţă and McPherron 2011; Smith et al. 2014; Wilczek et al. 2014), where new approaches advance archeological applications. Creative research designs are also being developed to address challenges with incomplete specimens in the archeological record (Byrne et al. 2016; Rezek et al. 2011; Smith 2010; Smith and DeWitt 2016; Smith and Goebel 2018). These advancements have aided in the development of a useful suite of protocols applicable to wide-ranging research questions.

The recent fluorescence of landmark-based applications has been driven by advances in anthropology (Bookstein et al. 2004; Elewa 2010; Richtsmeier et al. 1992; Slice 2007) and a variety of other research domains (Adams et al. 2004, 2013; Bookstein 1982, 1991, 2016; Jensen 2003; MacLeod 2017; Marcus et al. 1996; Rohlf 1990, 1999; Rohlf and Marcus 1993; Rohlf and Slice 1990; Zelditch et al. 2004) that articulate with the rise of the Procrustes paradigm (Adams et al. 2013:8). Archaeological applications have included two-dimensional (2D) analyses of Clovis technology in North America (Buchanan and Collard 2010; Buchanan et al. 2011; Buchanan et al. 2015; Buchanan et al. 2013; Eren et al. 2015), Fishtail or Fell projectile points in South America (Castiñeira et al. 2011; Loponte et al. 2015), bifacial points from the Umbu Tradition in Brazil (Okumura and Araujo 2013, 2014, 2017), lanceolate points—*ayampitin*—from Argentina (Rivero and Heider 2017), the size and shape of projectile points from southern Patagonia (Charlin et al. 2014; Charlin and González-José 2012), bifacial tools from southern Poland (Serwatka 2015), Final Palaeolithic large tanged points (Serwatka and Riede 2016), Paleoindian point types from Florida (Thulman 2012) and the Southern High Plains (Buchanan et al. 2007), ceramics from Casas Grandes (Topi et al. 2017), flake morphology (Picin et al. 2014), and reduction effects (de Azevedo et al. 2014). All of these studies capitalize on the morphological variation that occurs in a single plane (Buchanan and Collard 2010; Velhagen and Roth 1997).

For research designs that incorporate questions associated with more complex geometry, 3D landmark-based approaches may be more appropriate. Examples from the literature include the development of novel tools and applications (Lycett et al. 2006) that cover a broad range of artifact categories including projectile points (Shott 2011; Shott and Trail 2010), bifaces (Archer and Braun 2010; Archer et al. 2015; Archer et al. 2016), percussive tools (Caruana et al. 2014), flake scars (Sholts et al. 2012), flake tools (Archer et al. 2017), handaxes (Lycett 2009; Lycett et al. 2010; Lycett and von Cramon-Taubadel 2013; Lycett et al. 2016; Wang et al. 2012), and Caddo ceramics (Selden Jr. 2017, 2018a; Selden Jr. et al. 2014). This study adduces the variation that occurs within a single plane (widest vessel profile) for a sample of Caddo bottles; however, 3D data were required to identify the widest profile. Additionally, a variety of landmark and semilandmark configurations are in development that provide for a more robust analysis of 3D morphology associated with specific elements of vessel morphology.

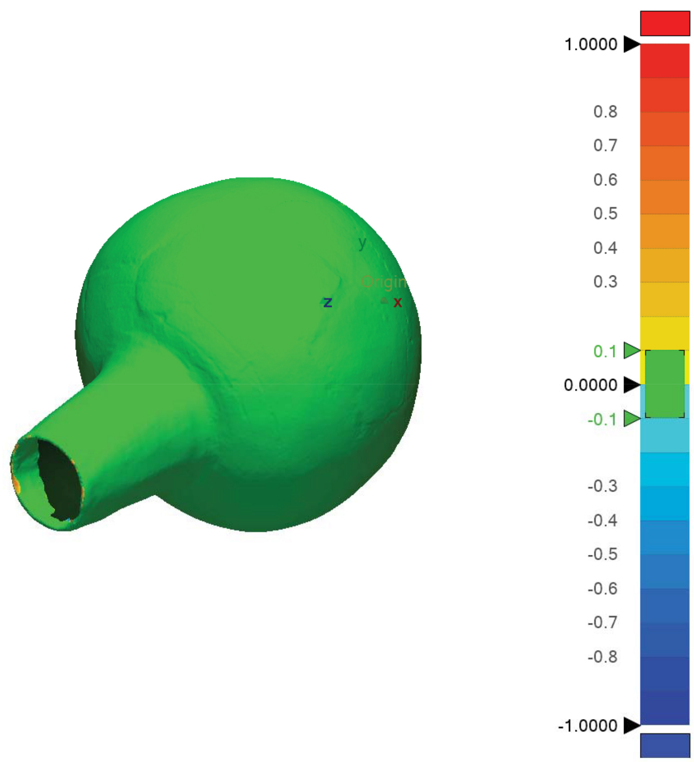
Methods

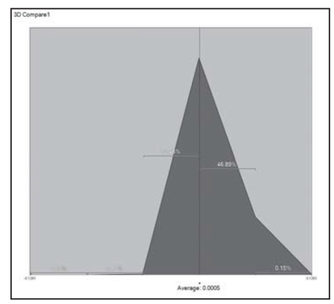
Bottles were scanned with a Creaform GoSCAN 50 at a 0.8 mm resolution or a Creaform GoSCAN20 at 0.5 mm resolution depending on their size. Scanner calibration was optimized prior to each scan, with positioning targets required for increased accuracy. Shutter speed was reconfigured in each instance; clipping planes were established to reduce the amount of superfluous data collected during each scan. Following data collection, resolution for the GoSCAN 50 meshes was increased to 0.5 mm, and meshes from both scanners were transferred to VXmodel where the final mesh was rendered following application of the *clean mesh* function. This was used to remove isolated patches, self-intersections, spikes, small holes, singular vertices, creased edges, narrow triangles, outcropping triangles, narrow bridges, and non-manifold triangles prior to export as an ASCII stl file. The stl functions as a backup, and the ply was subsequently imported to Geomagic Design X (Dx).

Prior to pursuing the mixed-method analysis employing data from two different scanners, two meshes of the same object—produced with the Creaform GoSCAN 50 and GoSCAN 20—were imported to a computer-aided inspection program (Geomagic Control X) in an effort to identify any significant deviations that may exist between the meshes prior to the GM analysis (Figure 2). The tolerance level for the inspection was selected using the highest resolution of the GoSCAN 20 (0.1 mm). Small areas of the rim exhibited minor differences while the remainder of the vessel was at or below the arbitrary 0.1 mm tolerance; thus, results fell within an acceptable error range.

The histogram shown in Figure 2 illustrates the Gaussian distribution for the number of errors over the whole deviation. The graph is split into six segments: 1-Sigma at 31 percent from the average to the maximum deviation in each direction, 2-Sigma at 69 percent from the average to the maximum deviation in each direction, and 3-Sigma at 93.3 percent from the average to the maximum deviation in each direction. The average (AVG) is the sum of all deviations divided by the number of all deviations, and the RMS is the square root of all squared deviations divided by the number of all deviations (sometimes referred to as the effective deviation). In tolerance (In Tol) and out tolerance (Out Tol) percentages indicate the percentage of deviations in or out of a given tolerance, and over tolerance (Over Tol) and under tolerance (Under Tol) percentages indicate the percentage of deviations over (positive direction) or under (negative direction) the tolerance range by the mesh normal of the reference mesh.

Result Data - 1 : 3D Compare1





Min.	-5.5929
Max.	4.3588
Avg.	0.0005
RMS	0.0426
Std. Dev.	0.0426
Var.	0.0018
+Avg.	0.0071
-Avg.	-0.0063
In Tol.(%)	99.6905
Out Tol.(%)	0.3095
Over Tol.(%)	0.2423
Under Tol.(%)	0.0672

Product Name	41BW4-341-464	Department	CRHR	Date	Mar 11, 2018
Part Name	41BW4_341-464	Inspector	Selden	Unit	mm

Figure 2. Results of 3D compare for the GoSCAN 50 and GoSCAN 20 meshes of bottle 41BW4 341-464 indicating that 99.6905 percent of the vessel falls within the arbitrary 0.1 mm tolerance.

Alignment and Reference Geometry

Following transfer to Dx, each mesh was subjected to an additional quality check to eliminate non-manifold poly-vertices, folded poly-faces, dangling poly-faces, small clusters, small poly-faces, non-manifold poly-faces, crossing poly-faces, and small tunnels. Due to the paucity of homologous landmarks on cultural artifacts (Lycett 2009), reference geometry was constructed around each vessel in a manner that yielded a replicable configuration of nine landmarks, and 46 equidistant semilandmarks along the widest vessel profile, with notable similarities to previous landmark configurations used by Girrulat (2006:Figure 4), Selden Jr. et al. (2014:Figure 5), Selden, Jr. (2018a:Figure 3), and Topi et al. (2017:Figure 4), all of which largely follow Birkhoff (1933).

The first component of reference geometry added, and the principal assumption, was a reference vector. A sampling ratio of 100 percent was used to apply the reference vector on a revolving axis, after which a reference point was added by projecting it atop the mesh surface at the location where the reference vector exits the base of the vessel. A reference plane was inserted using the *pick multiple points* function, by adding a series of 10 points around the circumference of the bottle's base. Each element of reference geometry (vector, point, and plane) was then used in an interactive 3-2-1 alignment where the vessel was aligned to a global origin, orienting it in 3D space where it sat upright atop a planar surface (assumed to be the intent of the maker). Following alignment, the reference plane and point were deleted.

The widest profile is defined as the location on a mesh that lies farthest from that point where the reference vector exits the vessel base while oriented atop the planar surface. To identify that location, a mesh sketch was generated with the planar method using the plane at the base of the vessel to identify and sketch the widest vessel circumference. By using the plane located at the base of the vessel for the sketch, the point at which the reference vector exits the mesh remains linked to the remainder of the reference geometry. A circle was then sketched using the vector as the center, extending outward until the whole of the vessel fit within. Using the mesh sketch, a cylinder (surface) was extruded around the vessel. The accuracy analyzer in Dx was then used to identify the point on the vessel with the lowest deviation from the extruded surface, and a plane (MPlane) was inserted coplanar to the vector and oriented to the widest point, bisecting the vessel along the widest profile.

Using the MPlane as the basis for a second mesh sketch, a spline with 15 interpolation points was sketched on one rim. Above that sketch, a horizontal line was added where both the spline and horizontal line determine the horizontal tangent of the rim. A vertical line was subsequently added that bisected the rim at the location of the tangent. This operation was repeated for the opposing rim. The addition of this added step was necessary because surface scanners are unable to collect data from the interior of the bottles, so the spline needed to be cut in a replicable location. Since the Smithport Plain bottles exhibit slightly inverted-to-vertical rims, the preceding step was extended to include an additional measure. A line was drawn between each rim tangent, then a second from the intersection of the line and reference vector to a point 10 mm down the vector, where a horizontal line (parallel with the rim peaks) was inserted to intersect with both external walls of the bottle (Selden, Jr. 2018a:Figure 3). It is at this intersection that the final mesh sketch was cut to discriminate between the neck and rim. While this step admittedly appears odd in the context of a comparison of bottle shapes that all exhibit direct rims, it is of considerable import for inter-type comparisons where other bottle types exhibit differing rim morphologies (i.e., everted, etc.) (Selden, Jr. 2018b).

Using the MPlane as the basis for a third sketch, a spline was populated for the entirety of the silhouetted profile. That spline was split at the location of the horizontal tangent on each rim, and the remaining sections that continued into the bottle interior were deleted. The second split was added at the intersection of the spline and reference vector (center of base). Four additional splits were subsequently added at the juncture of the base/body and body/neck on each side of the vessel at the points of highest curvature. The point of highest curvature used to split the spline was identified using the *curvature* function in Dx, and does not represent an arbitrary location.

Landmarks and Semilandmarks

A total of nine landmarks and 46 semilandmarks segregated each bottle into four discrete components corresponding with the rim, neck, body, and base (Table 2 and Figure 3). Landmarks and semilandmarks were populated along the spline, and numbering always began on that side of the profile determined to include the widest point. Divisions between each component articulate with those of the spline splits, where landmarks were placed at each point in Table 2, with a series of equidistant semilandmarks between them.

While sliding semilandmarks were an early consideration of this research design, the decision to use equidistant semilandmarks rather than sliding semilandmarks was based upon results from an earlier iteration of the Webb collection analysis (Selden, Jr. 2018a:Figure 3). In the study of the Webb collection, the first landmark and sliding semilandmark configuration did not split the spline between the neck and rim, and when mean shapes were generated for each type, an anomaly, from the everted rims of Belcher Engraved bottles in that case, was added to the otherwise direct or tapered necks of the Hickory

Table 2. Landmarks used in this analysis.

Landmark	Location	Definition
Point01	Rim peak	Horizontal tangent of rim curvature on widest side of vessel
Point06	Rim/Neck	Point of highest curvature (everted rim) or intersection of horizontal line 10 mm below rim tangents (direct rim)
Point15	Neck/Body	Point of highest curvature
Point24	Body/Base	Point of highest curvature
Point28	CenterBase	Intersection of vector and external surface of the 3D mesh
Point32	Body/Base	Point of highest curvature
Point41	Neck/Body	Point of highest curvature
Point50	Rim/Neck	Point of highest curvature (everted rim) or intersection of horizontal line 10 mm below rim tangents (direct rim)
Point55	Rim peak	Horizontal tangent of rim curvature

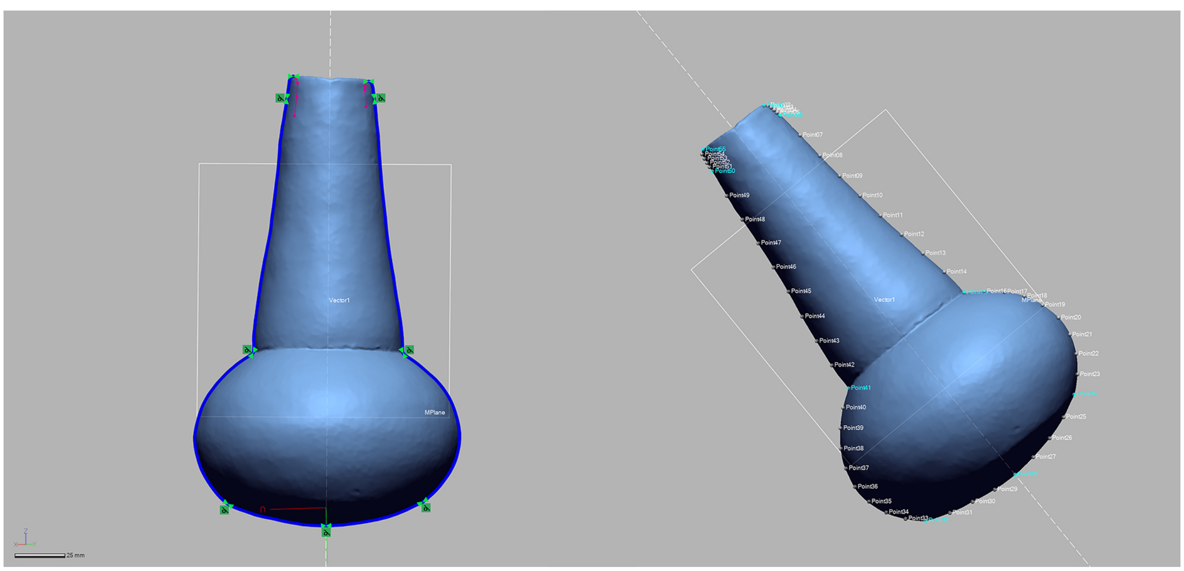


Figure 3. Spline splits for discrete components (rim, neck, body, and base) used in the GM analysis (left) segregated by landmarks (blue), with equidistant semilandmarks (white) populated between (right).

Engraved and Smithport Plain bottles. Given that the use of sliding semilandmarks could potentially influence the results of this analysis by introducing a morphological attribute to specimens where one does not exist, they were abandoned.

Analysis

Landmarks and equidistant semilandmarks were exported as x, y, and z coordinate data from Dx. Those data were aligned to a global coordinate system (Kendall 1981, 1984; Slice 2001), achieved through generalized Procrustes superimposition (Rohlf and Slice 1990) performed in R 3.5.0 (R Development Core Team 2018) using the *geomorph* library v.3.0.6 (Adams et al. 2017; Adams and Otárola-Castillo 2013). Procrustes superimposition translates, scales, and rotates the coordinate data to allow for comparisons among objects (Gower 1975; Rohlf and Slice 1990). The *geomorph* package uses a partial Procrustes superimposition that projects the aligned specimens into tangent space subsequent to alignment in preparation for the use of multivariate methods that assume linear space (Rohlf 1999; Slice 2001).

Principal components analysis (Jolliffee 2002) was used as an exploratory means of visualizing shape variation among the bottles. The shape changes described by each principal axis are commonly visualized using thin-plate spline warping of a reference 3D mesh (Klingenberg 2013; Sherratt et al. 2014). A residual randomization permutation procedure (RRPP; n=1000 permutations) was used for all Procrustes ANOVAs (Adams and Collyer 2015; Collyer and Adams 2018), which has higher statistical power and a greater ability to identify patterns in the data should they be present (Anderson and Ter Braak 2003). To assess whether shape differs by size (allometry) and site, Procrustes ANOVAs (Goodall 1991) were run that also enlist effect-sizes (z-scores) computed as standard deviates of the generated sampling distributions (Collyer et al. 2015). For the aggregated sample, a Procrustes ANOVA was run to assess whether shape changes with size, and the assumption of allometric slope homogeneity was tested with the *procD.allometry* function using the PredLine option (Adams and Nistri 2010). Should this test not be significant, then allometric slopes are similar—if not identical—across time and types.

A Procrustes ANOVA and pairwise test was used to identify sites where bottle shapes and types differ. The pairwise test is conceptually similar to trajectory analysis (Adams and Collyer 2007, 2009; Collyer and Adams 2007, 2013) in that pairwise statistics are vector lengths between vectors, but differs in that a factorial model is not explicitly needed to contrast vectors between point factor levels nested within group factor levels (Adams et al. 2017). Procrustes variance was used to discriminate between groups and to compare the amount of shape variation (morphological disparity) across communities (Zelditch et al. 2004), which is estimated as the Procrustes variance using residuals of linear model fit (Adams et al. 2017).

Morphological integration was assessed for the aggregated sample of whole vessels. Integration between pairs of traits was tested using a two-block partial least-squares (2B-PLS) analysis to evaluate relationships for two blocks of variables collected from the same specimens (Bookstein et al. 2003; Rohlf and Corti 2000; Wold 1966), using shape coordinates in all blocks of variables (Bastir and Rosas 2006; Bookstein et al. 2003; Gunz and Harvati 2007). To assess whether the different modules (RIM_{neck}, $NECK_{body}$, and $BODY_{base}$ in particular) are integrated, a two-sample test using effect sizes calculated as standard deviates in sampling distributions from the 2B-PLS analyses were used to determine the significance and strength of integration between the modules (Adams and Collyer 2016).

Results

The mean consensus configuration and Procrustes residuals were calculated using a generalized Procrustes analysis (GPA) (Figure 4). This initial view of the data demonstrates the degree of variability in Caddo bottles that occurs across the sample. As an exploratory measure, GM methods—to include GPA—aid in clarifying shape differences, and in the production of novel *a posteriori* hypotheses (Mitteroecker and Gunz 2009).

Principal components analysis (PCA) was conducted on scaled, translated, and rotated landmarks and semilandmarks, and demonstrates that the first two PC's account for 68 (PC1) and 27 (PC2) percent of the variation in bottle shape (Table 3 and Figure 6). Together, PC1 and PC2 account for 95 percent of shape variation, with all remaining PCs representing three or fewer percent of the variation (see Table 3). The first two PCs are plotted in Figure 5, where warp grids represent the shape changes along PC1 and PC2. This plot indicates that shape

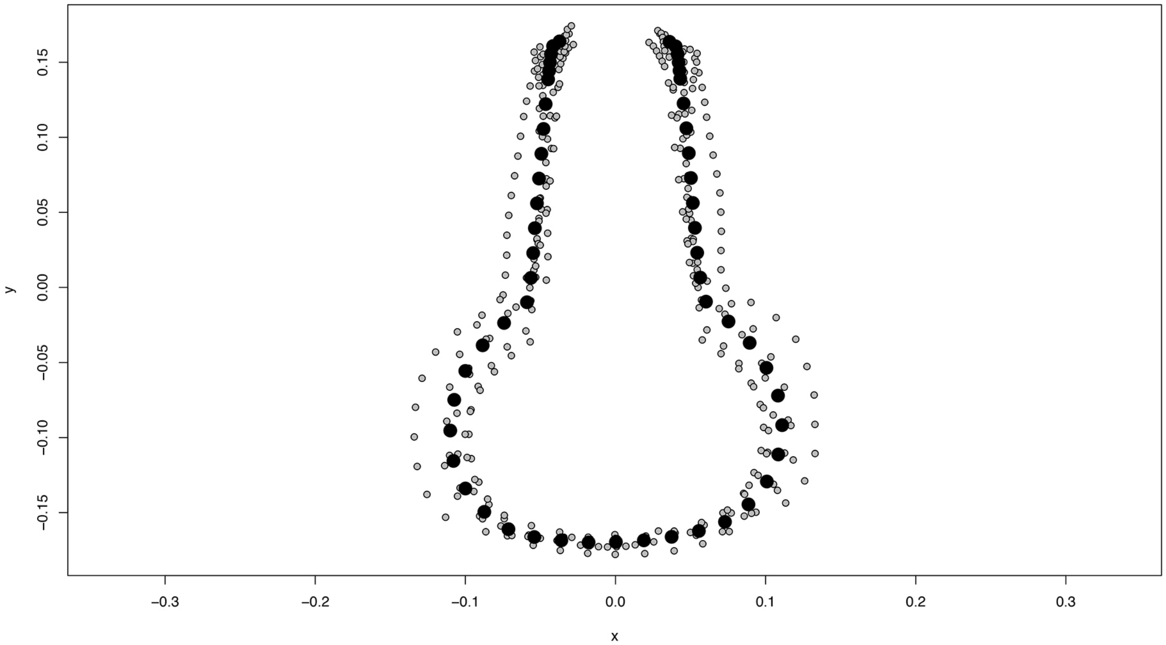


Figure 4. Results of generalized Procrustes analysis for Smithport Plain whole bottles. Mean consensus configuration shown in black; samples in gray.

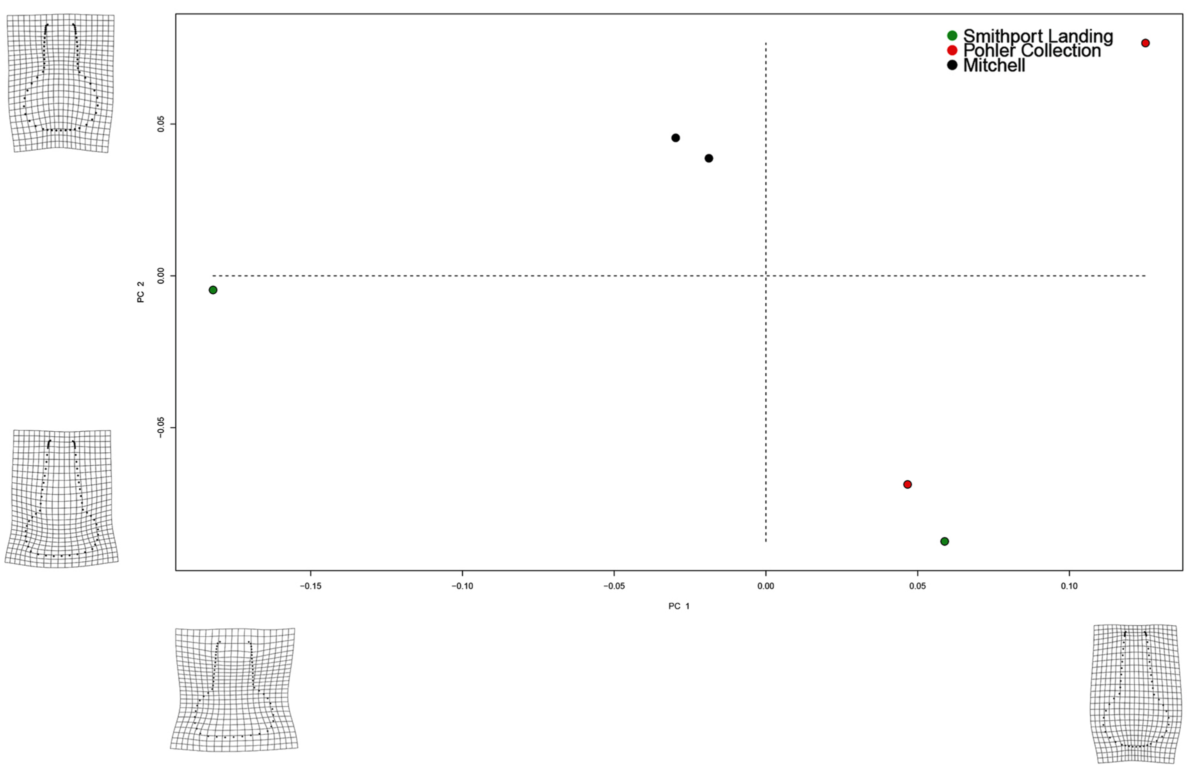


Figure 5. Results of PCA summarizing shape variation in the whole bottle sample.

Table 3. Results of PCA.

	SD	PV	CP
PC1	0.106	0.683	0.683
PC2	0.066	0.268	0.951
PC3	0.023	0.033	0.985
PC4	0.014	0.013	0.997
PC5	0.007	0.003	1.000

SD = standard deviation; PV = proportion of variance; CVE = cumulative proportion.

changes associated with PC1 articulate most readily with base and body shape, and shape changes associated with PC2 articulate with base, body, and neck shape.

A Procrustes ANOVA was used to test for significant allometry. Results of the ANOVA indicate significant allometry in the sample (RRPP = 1000, Rsq = 0.59427, Pr(>F) = 0.0075), indicating that Smithport Plain bottle shapes change with size. A Procrustes ANOVA was used to test for a significant difference in bottle shape by site, and results indicate that there is not a significant difference in bottle shape by site (RRPP = 1000, Rsq = 0.40907, Pr(>F) = 0.537).

Bottle base and body morphology

Two Smithport Plain bottles, specimen numbers 405 and 430, from Burials 11 and 12 at the Belcher Mound site are missing the upper portions of the neck and rim, and therefore could not be included in the analysis of whole vessels. Using a subset of the same constellation of landmarks and equidistant semilandmarks from the analysis of whole vessels (landmarks/semilandmarks 15-41), these two samples were added for an analysis of bottle base and body morphology. The mean consensus configuration and Procrustes residuals were calculated using a GPA for the base and body sample (Figure 6).

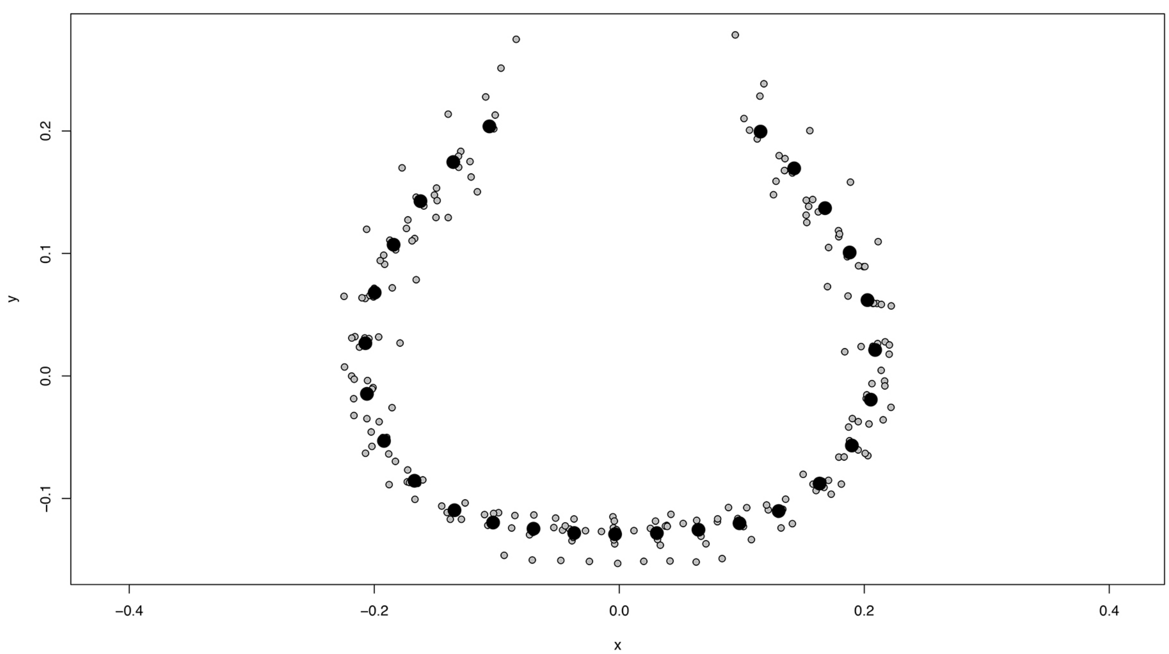


Figure 6. Results of generalized Procrustes analysis for Smithport Plain base and body sample. Mean consensus configuration shown in black; samples in gray.

PCA was conducted on scaled, translated, and rotated landmarks and semilandmarks, and demonstrates that the first two PCs account for 83 (PC1) and 15 (PC2) percent of the variation in bottle base and body shape (Table 4 and Figure 8). Together, PC1 and PC2 account for 98 percent of the variation for base and body shape, with each remaining PC representing less than two percent of the variation (see Table 4). The first two PCs are plotted in Figure 7, where warp grids represent the shape changes along PC1 and PC2. The plot indicates that shape changes associated with PC1 articulate most readily with a tall, pear-shaped body and narrow base at the maximum, and a shorter, globular body and wide base at the minimum. For PC2, the maximum values articulate with a pear-shaped body that is widest near a broad base, and a shorter, globular body with a narrow and rounded base at the minimum.

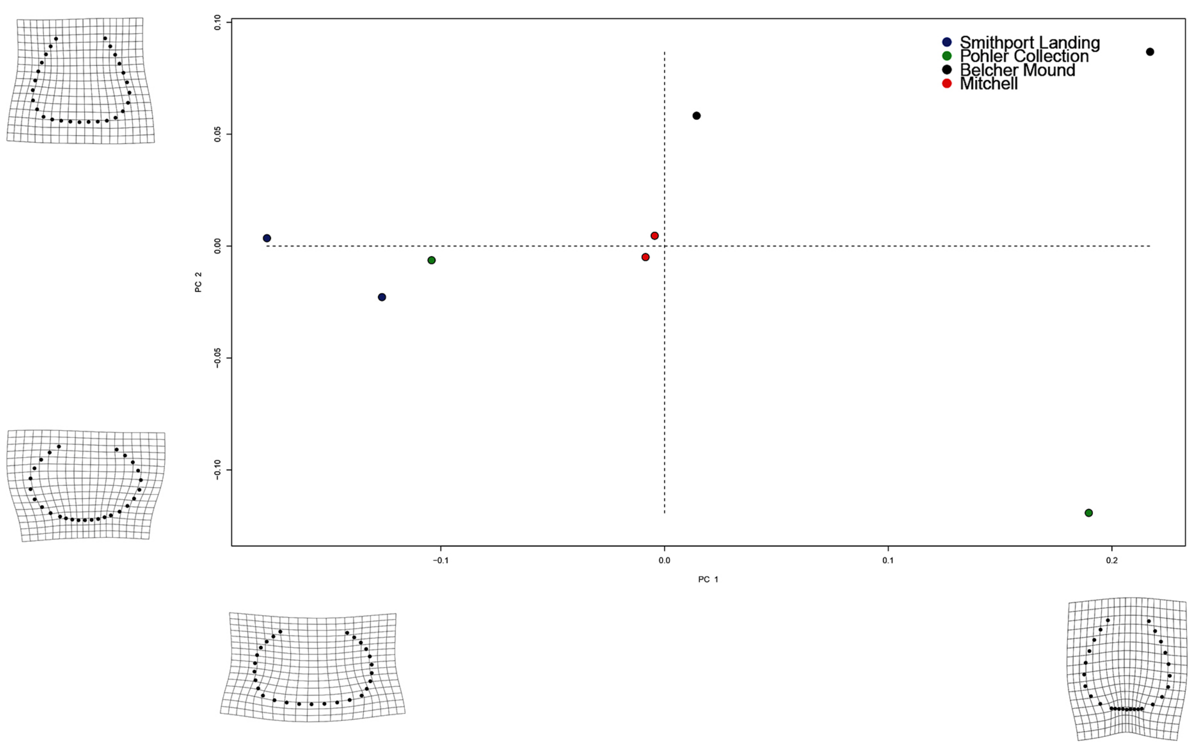


Figure 7. Results of PCA summarizing shape variation in the base and body sample.

Table 4. Results of PCA.

	SD	PV	CP
PC1	0.142	0.826	0.826
PC2	0.061	0.150	0.976
PC3	0.020	0.017	0.993
PC4	0.009	0.003	0.996
PC5	0.006	0.002	0.998
PC6	0.005	0.001	0.999
PC7	0.004	0.001	1.000

SD = standard deviation; PV = proportion of variance; CVE = cumulative proportion.

A Procrustes ANOVA was used to test for significant allometry. Results of the ANOVA indicate that allometry is not significant in the base and body sample (RRPP = 1000, Rsq = 0.17667, Pr(>F) = 0.275). A second Procrustes ANOVA was used to test for a significant difference in bottle shape by site. The advanced Procrustes ANOVA and pairwise test demonstrates a significant difference between Smithport Plain bottles from the Smithport Landing and Belcher Mound sites (Table 5).

Synthesis with aggregated sample

The Smithport Plain bottles were then added to the aggregated sample (see Table 1), omitting the two previously mentioned incomplete specimens (405 and 430). The aggregated sample of whole vessels (n=45) consists of five Caddo bottle types from 12 sites curated across five repositories in three states, with iterative analytical improvements achieved as new samples are added. The mean consensus configuration and Procrustes residuals were calculated using a GPA for the aggregated sample (Figure 8).

PCA was conducted on scaled, translated, and rotated landmarks and semilandmarks, and demonstrates that the first two PCs account for 59 (PC1) and 20 (PC2) percent of the variation in bottle shape (Table 6 and Figure 9). Together, PC1 and PC2 account for 79 percent of the variation in bottle shape, with each remaining PC representing ≤10 percent of the variation. The first two PCs are plotted in Figure 9, where warp grids represent the shape changes along PC1 and PC2. The plot indicates that shape changes associated with PC1 articulate with relative differences in base, body, neck, and rim shapes. Differences include a sharp or diffuse angle at the base and body juncture, flat versus slightly convex geometry, and a difference in relative width. Body differences range from globular to sub-globular, necks from everted to tapering, and rims from everted to slightly inverted. Shape changes associated with PC2 articulate with differences in relative base width, and a slightly carinated to globular body shape. In addition to a difference in relative width, the bottle necks also range from direct to slightly tapering, with rims that are vertical to slightly everted.

A Procrustes ANOVA was used to test for allometry, and significant allometry was identified in this sample (RRPP = 1000, Rsq = 0.18337, Pr(>F) = 0.001). Plots of predicted allometric trajectories for period (Formative-Early and Late-Historic Caddo) and type factors are presented in Figure 10. The null hypothesis of parallel slopes is rejected by the homogeneity of slopes test for group allometries, as the allometric trajectories differ significantly by period (RRPP = 1000, Rsq = 0.03711, Pr(>F) = 0.010). Allometric trajectories also differ significantly by type (RRPP = 1000, Rsq = 0.10182,

Table 5. Results of advanced Procrustes ANOVA and pairwise test (RRPP = 1000) of Smithport Plain bottle shape by site.

	Belcher Mound	Mitchell	Pohler Coll	Smithport Landing
Belcher Mound	0			
	0			
	1.000			
Mitchell	0.143	0		
	0.040	0		
	0.431	1.000		
Pohler Coll	0.155	0.086	0	
	0.172	-0.816	0	
	0.362	0.785	1.000	
Smithport Landing	0.280	0.147	0.203	0
	2.010	0.105	0.945	0
	0.032	0.393	0.183	1.000

Least-squares means distance matrix (top), effect sizes (middle), and P-values (bottom--significant results in bold).

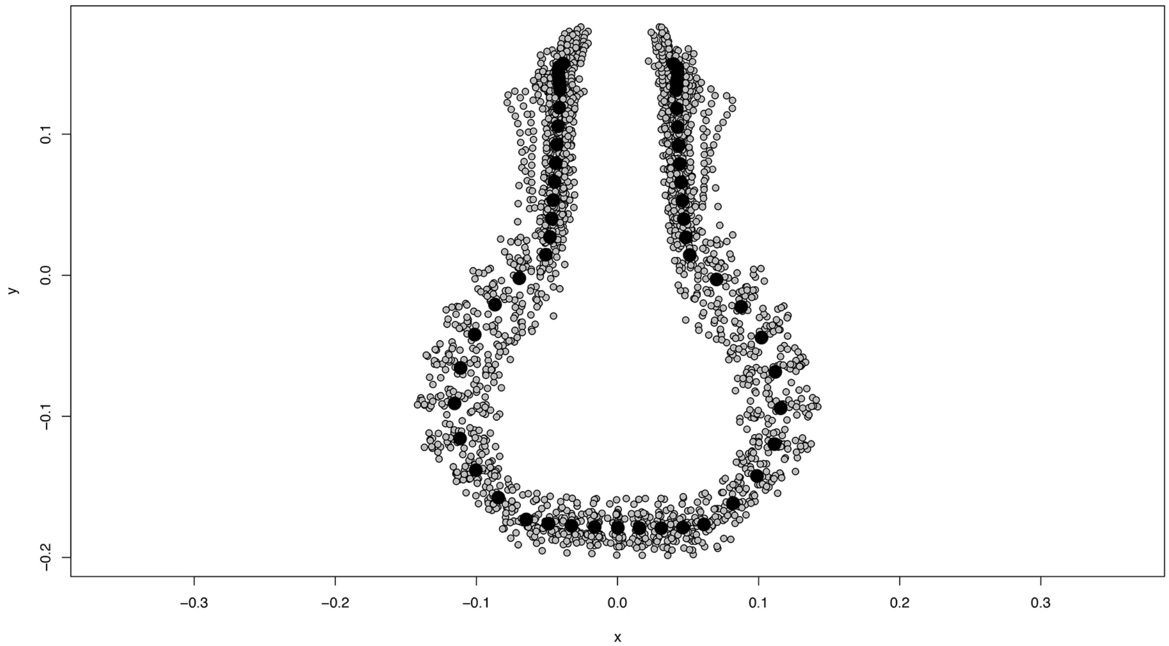


Figure 8. Results of generalized Procrustes analysis for the aggregated sample. Mean consensus configuration shown in black; samples in gray.

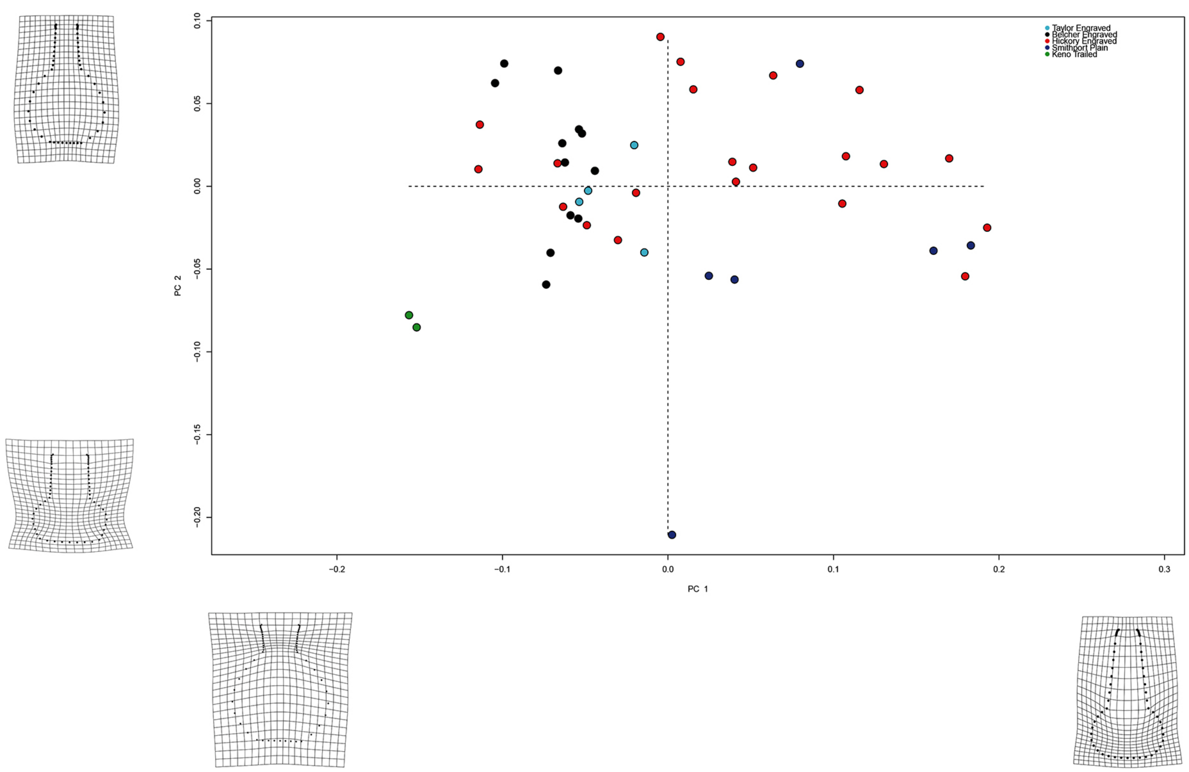


Figure 9. Results of PCA summarizing shape variation in the aggregated sample.

Table 6. Results of PCA.

	SD	PV	CP
PC1	0.093	0.592	0.592
PC2	0.055	0.205	0.797
PC3	0.038	0.100	0.897
PC4	0.026	0.045	0.942
PC5	0.018	0.022	0.964
PC6	0.013	0.011	0.975
PC7	0.010	0.007	0.982
PC8	0.008	0.004	0.986
PC9	0.007	0.004	0.990
PC10	0.006	0.003	0.993

SD = standard deviation; PV = proportion of variance; CVE = cumulative proportion.

Pr(>F) = 0.001) (see Figure 10), and the size of Formative-Early bottles, specifically those of the Hickory Engraved type, extends beyond the range of the Late-Historic and Smithport Plain types.

A second Procrustes ANOVA was used to test for a difference in bottle shape by site, which is (RRPP = 1000, Rsq = 0.52213, Pr(>F) = 0.001). An advanced Procrustes ANOVA and pairwise comparison was used to identify those sites where bottle assemblages differ, and whether that difference is in magnitude, direction, or both (Table 7). Those sites with bottle samples found to differ significantly include Belcher Mound compared to Gahagan Mound, Smithport Landing, Haley Place, Mitchell, and the Pohler Collection. In addition, Smithport Landing also differs significantly compared to Haley Place, and Mitchell.

A third Procrustes ANOVA was used to test for a difference in bottle shape by type, which is significant (RRPP = 1000, Rsq = 0.3907, Pr(>F) = 0.001). An advanced Procrustes ANOVA and pairwise comparison was used to identify which bottle types differ and whether that difference is in magnitude, direction, or both (Table 8). Those bottle types found to differ significantly include Keno Trailed compared to Belcher Engraved, Hickory Engraved, Smithport Plain, and Taylor Engraved; also Belcher Engraved compared to Hickory Engraved, and Smithport Plain; and finally, Smithport Plain compared to Taylor Engraved.

A test of morphological disparity indicates that Hickory Engraved and Smithport Plain bottles display a greater range of shape variation among individual bottles relative to other groups, and differ significantly from the Belcher Engraved, Keno Trailed, and Taylor Engraved bottles (Table 9). This indicates that the Formative-Early Caddo bottles may encompass a greater range of morphological variability than the Late-Historic Caddo bottles in the sample; an assertion that was later confirmed in a subsequent test of morphological disparity by period (Table 10).

The 2B-PLS analyses, each enlisting 1000 random permutations, was used to test for morphological integration between combinations of bottle components (rim, neck, body, and base). The results indicate significant integration between the rim and neck (r_{PLS} = 0.969, P-value = 0.001), rim and body (r_{PLS} = 0.942, P-value = 0.001), rim and base (r_{PLS} = 0.663, P-value = 0.001), neck and body (r_{PLS} = 0.962, P-value = 0.001), neck and base (r_{PLS} = 0.869, P-value = 0.001), and the body and base (r_{PLS} = 0.859, P-value = 0.001) for bottles in the sample (Figure 11). A pairwise test of morphological integration was used to identify combinations of traits that covary. Results indicate that for this sample of Caddo bottles, the RIM_{neck} and RIM_{base}, RIM_{body} and RIM_{base}, and RIM_{base} and $NECK_{body}$ are significantly integrated (Table 11).

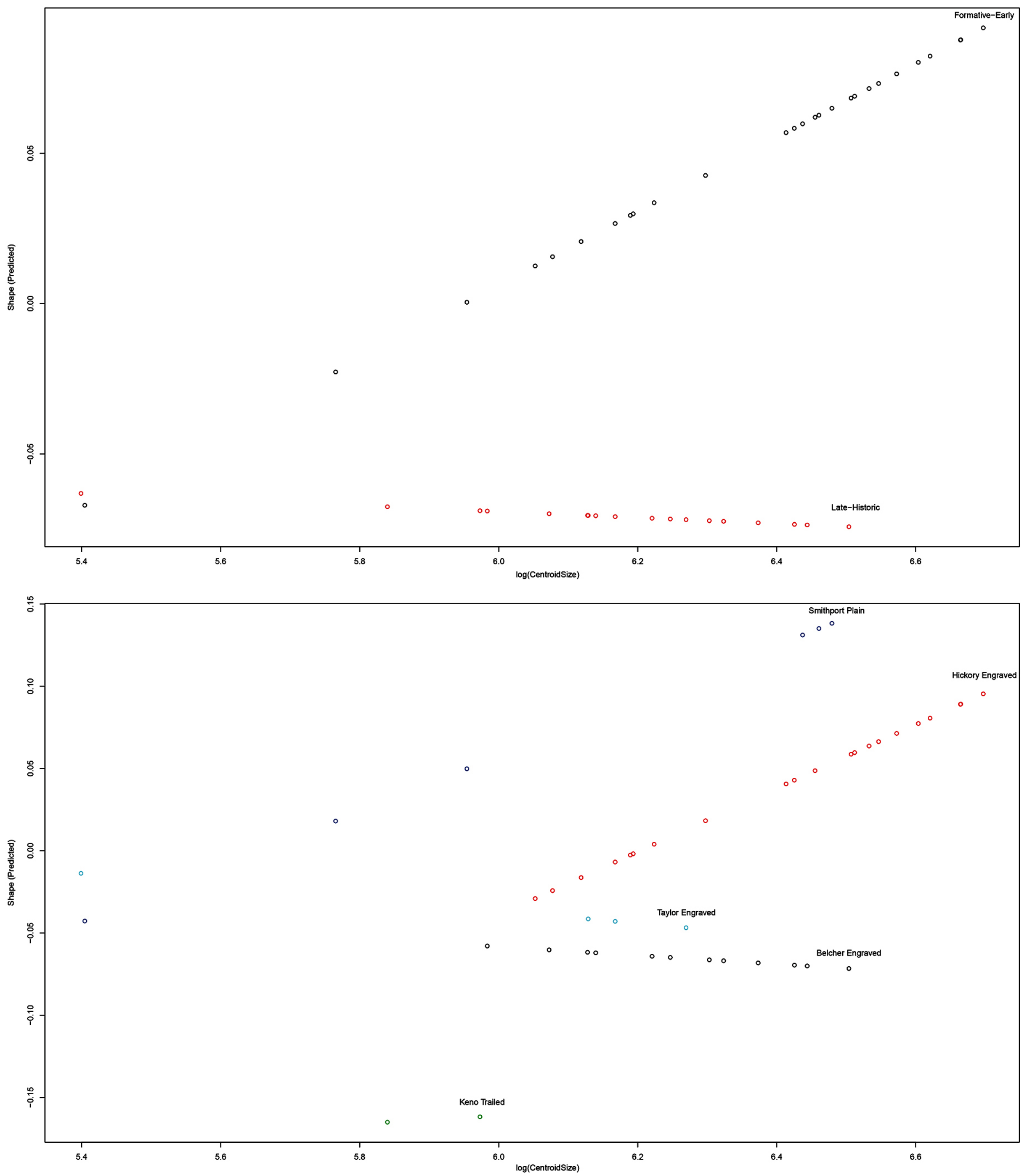


Figure 10. Predicted values of Caddo bottle shape from temporal (top) and type (bottom) regressions versus log(CentroidSize).

Table 7. Least-squares mean distance matrix (top), effect sizes (middle), and P-values (bottom) for advanced Procrustes ANOVA and pairwise test (RRPP = 1000) of bottle shape by site.

	Allen	Belcher	Crenshaw	FNF	Gahagan	GCD	Haley	Hatchel	MCM	Mitchell	Pohler	Smithport
Allen	0 0 1.000											
Belcher	0.181 1.478 0.118	0 0 1.000										
Crenshaw	0.161 0.059 0.433	0.132 0.333 0.319	0 0 1.000									
FNF	0.070 -1.289 0.930	0.204 1.870 0.075	0.147 -0.117 0.488	0 0 1.000								
Gahagan	0.096 -0.672 0.706	0.251 4.902 **0.001**	0.218 1.382 0.101	0.092 -0.754 0.756	0 0 1.000							
GCD	0.150 -0.060 0.455	0.127 0.278 0.328	0.057 -1.470 0.954	0.143 -0.197 0.513	0.203 1.211 0.138	0 0 1.000						
Haley	0.134 0.313 0.303	0.092 1.598 0.078	0.066 -1.095 0.894	0.134 0.190 0.337	0.202 2.739 **0.013**	0.068 -1.072 0.899	0 0 1.000					
Hatchel	0.117 -0.531 0.652	0.202 1.830 0.069	0.121 -0.507 0.648	0.067 -1.307 0.915	0.129 -0.081 0.457	0.121 -0.496 0.632	0.127 0.106 0.378	0 0 1.000				
MCM	0.116 -0.593 0.693	0.139 0.509 0.279	0.151 -0.124 0.511	0.135 -0.321 0.559	0.142 0.110 0.400	0.122 -0.521 0.665	0.124 0.033 0.382	0.140 -0.246 0.546	0 0 1.000			
Mitchell	0.131 0.188 0.368	0.064 0.376 0.308	0.096 -0.503 0.624	0.146 0.473 0.268	0.201 2.942 **0.007**	0.087 -0.630 0.697	0.040 -1.029 0.849	0.148 0.527 0.264	0.107 -0.273 0.531	0 0 1.000		
Pohler	0.115 -0.196 0.493	0.092 1.178 0.124	0.088 -0.722 0.742	0.124 -0.034 0.433	0.175 1.969 **0.046**	0.070 -1.020 0.869	0.048 -0.874 0.813	0.124 -0.034 0.440	0.079 -0.866 0.809	0.040 -1.186 0.924	0 0 1.000	
Smithport	0.075 -0.942 0.849	0.200 5.374 **0.001**	0.195 1.298 0.138	0.094 -0.634 0.683	0.105 0.241 0.354	0.177 1.000 0.163	0.153 2.435 **0.026**	0.144 0.348 0.309	0.133 0.160 0.370	0.147 2.315 **0.027**	0.136 1.668 0.072	0 0 1.000

Significant results in bold; FNF = Frank Norris Farm, GCD = George C. Davis, MCM = Mustang Creek Mound.

Table 8. Least-squares mean distance matrix (top), effect sizes (middle), and P-values (bottom) for advanced Procrustes ANOVA and pairwise test (RRPP = 1000) of bottle shape by type

	Belcher Eng	HE	Keno Tr	Smithport Pl	Taylor Eng
Belcher Engraved	0				
	0				
	1.000				
Hickory Engraved	0.114	0			
	4.499	0			
	0.002	1.000			
Keno Trailed	0.171	0.226	0		
	2.449	4.131	0		
	0.023	**0.001**	1.000		
Smithport Plain	0.168	0.085	0.251	0	
	4.812	1.589	4.133	0	
	0.002	0.071	**0.001**	1.000	
Taylor Engraved	0.046	0.085	0.176	0.130	0
	-0.738	0.932	1.931	2.021	0
	0.745	0.184	**0.049**	**0.034**	1.000

Significant results in bold.

Table 9. Pairwise absolute differences between variances (top) and P-values (bottom) for the test of morphological disparity by type.

	Belcher Eng	HE	Keno Tr	Smithport Pl	Taylor Eng
Belcher Engraved	0				
	1.000				
Hickory Engraved	0.009	0			
	0.004	1.000			
Keno Trailed	0.001	0.010	0		
	0.906	0.082	1.000		
Smithport Plain	0.011	0.002	0.012	0	
	0.015	0.698	0.093	1.000	
Taylor Engraved	0.001	0.008	0.002	0.009	0
	0.827	0.088	0.760	0.080	1.000

Significant results in bold, RRPP = 1000.

Table 10. Pairwise absolute differences between variances (top) and P-values (bottom) for the test of morphological disparity by time period.

	Formative-Early	Late-Historic
Formative-Early	0	
	1.000	
Late-Historic	0.007	0
	0.007	1.000

Significant results in bold, RRPP = 1000.

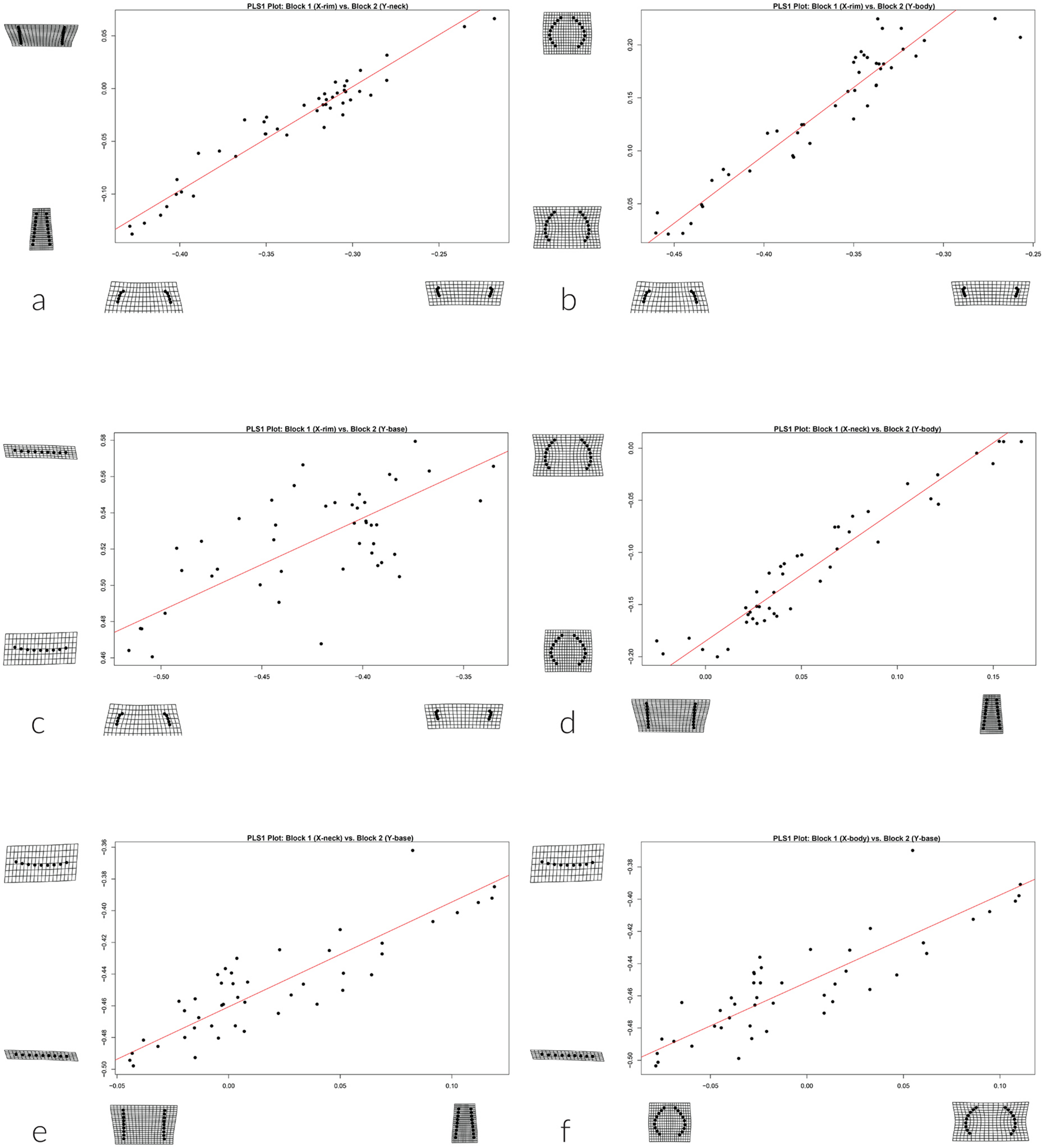


Figure 11. Results of 2B-PLS analyses for pairs of morphological components; (a) rim and neck, (b) rim and body, (c) rim and base, (d) neck and body, (e) neck and base, and (f) body and base.

Table 11. Comparison of morphological integration between modules.

Z	RIM_{neck}	RIM_{body}	RIM_{base}	$NECK_{body}$	$NECK_{base}$	$BODY_{base}$	P	RIM_{neck}	RIM_{body}	RIM_{base}	$NECK_{body}$	$NECK_{base}$	$BODY_{base}$
RIM_{neck}	0						RIM_{neck}	1.000					
RIM_{body}	0.451	0					RIM_{body}	0.326	1.000				
RIM_{base}	2.727	2.401	0				RIM_{base}	**0.003**	**0.008**	1.000			
$NECK_{body}$	0.493	0.048	2.331	0			$NECK_{body}$	0.311	0.481	**0.010**	1.000		
$NECK_{base}$	1.120	0.726	1.566	0.674	0		$NECK_{base}$	0.131	0.234	0.059	0.250	1.000	
$BODY_{base}$	1.424	1.030	1.362	0.972	0.258	0	$BODY_{base}$	0.077	0.152	0.087	0.165	0.398	1.000

Matrix of pairwise differences in PLS effect sizes (left), and their associated significance levels (right).

Discussion and Conclusion

This repository-based analysis of a curated and majority-NAGPRA collection of intact or reconstructed Caddo bottles resulted in an improved characterization of Caddo bottle shapes, while highlighting similarities, differences, and a general trend toward standardization for the aggregated sample. Specifically, it resulted in a test of Smithport Plain bottle shapes confirming that discrete morphological characteristics (body and base) differ significantly between the Belcher Mound and Smithport Landing sites, supporting the morphological assertion initially posited by Webb (1959). The test included an analysis of Smithport Plain bottles from the Pohler Collection and Mitchell site, which do not differ significantly in shape from those recovered at the Smithport Landing or Belcher Mound sites. Analysis of the aggregate sample indicates allometric trajectories that are not homogenous for Formative-Early and Late-Historic Caddo types, a significant difference in bottle shape by site and type, significant morphological disparity between the Formative-Early and Late-Historic Caddo types, and significant morphological integration of pairs and suites of bottle components.

In the aggregated sample, significant assemblage-level differences in bottle shape exist between Belcher Mound compared with Gahagan Mound and Smithport Landing, Gahagan Mound compared with Haley Place, Mitchell, Pohler Collection, Haley Place and Smithport Landing, and Mitchell compared with those from Smithport Landing (see Table 7 and Figure 12). The results imply that bottle shapes employed by Formative-Early Caddo potters differ from those produced by Late-Caddo potters; an assertion echoed by the analyses of allometric trajectories (see Figure 10) and morphological disparity (see Table 10). While only a small sample has been examined thus far, the results of morphological disparity by period highlight a gradual trend toward standardization, where bottles produced in the Late-Historic Caddo periods occupy a more restricted range of morphospace than those manufactured in the Formative-Early Caddo periods. This dynamic assertion is subject to change as more bottles are added to the analysis.

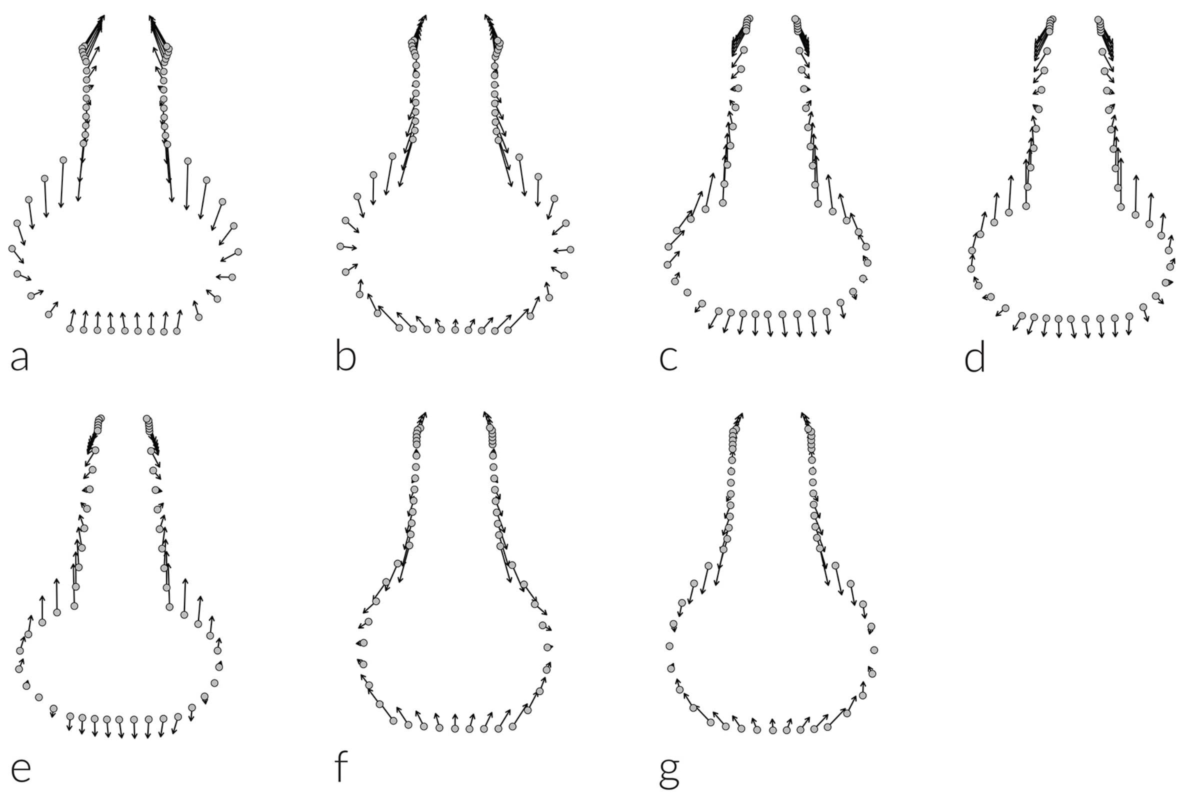


Figure 12. Comparison of mean bottle shapes by site for those sites found to differ significantly; (a) Belcher Mound (gray) and Gahagan Mound, (b) Belcher Mound (gray) and Smithport Landing, (c) Gahagan Mound (gray) and Haley Place, (d) Gahagan Mound (gray) and Mitchell, (e) Gahagan Mound (gray) and Pohler, (f) Haley Place (gray) and Smithport Landing, and (g) Mitchell (gray) and Smithport Landing.

Significant type-specific differences in bottle shape occur between Belcher Engraved compared with Hickory Engraved, Keno Trailed, and Smithport Plain; Keno Trailed compared with Smithport Plain and Taylor Engraved; Hickory Engraved compared with Keno Trailed; and Smithport Plain compared with Taylor Engraved (see Table 8 and Figure 13). The test of morphological disparity indicated that Hickory Engraved and Smithport Plain bottles occupy a significantly greater range of morphospace than the Belcher Engraved bottles (see Table 9). Elsewhere it may be the case that dimensional attributes are inappropriate for use in studies of standardization and diversity (Rice 1991); however, the morphological disparity results suggest a high degree of utility in clarifying questions of standardization and diversity through the employment of morphological traits associated with Caddo bottles. This can, in turn, provide evidence for varying degrees of tolerance in production, where a higher tolerance yields a greater range of variation in shape that decreases as shapes become more standardized (Eerkins and Bettinger 2001). In this sample, the tolerance for diversity in Caddo bottle shape is higher in the Formative-Early Caddo period, and becomes more restricted through time. Results specify that the tolerance for variation in Caddo bottle shapes is greater in the case of Smithport Plain and Hickory Engraved than it is for Belcher Engraved.

Results from the test of morphological integration indicate that Caddo bottles are significantly integrated (see Figure 11), lending some support to the hypothesis that Caddo potters were adhering to a template of vessel shape associated with specific decorative motifs (Early 2012). However, the suites of attributes were not found to covary in a predicted manner, as it is the RIM_{neck} and RIM_{base}, RIM_{body} and RIM_{base}, and RIM_{base} and $NECK_{body}$ that exhibit significant integration (see Table 11). An important component of the expanded research program will be type-specific tests of morphological integration following an increase in sample size.

The significant difference in the production of Smithport Plain body and base shapes at the

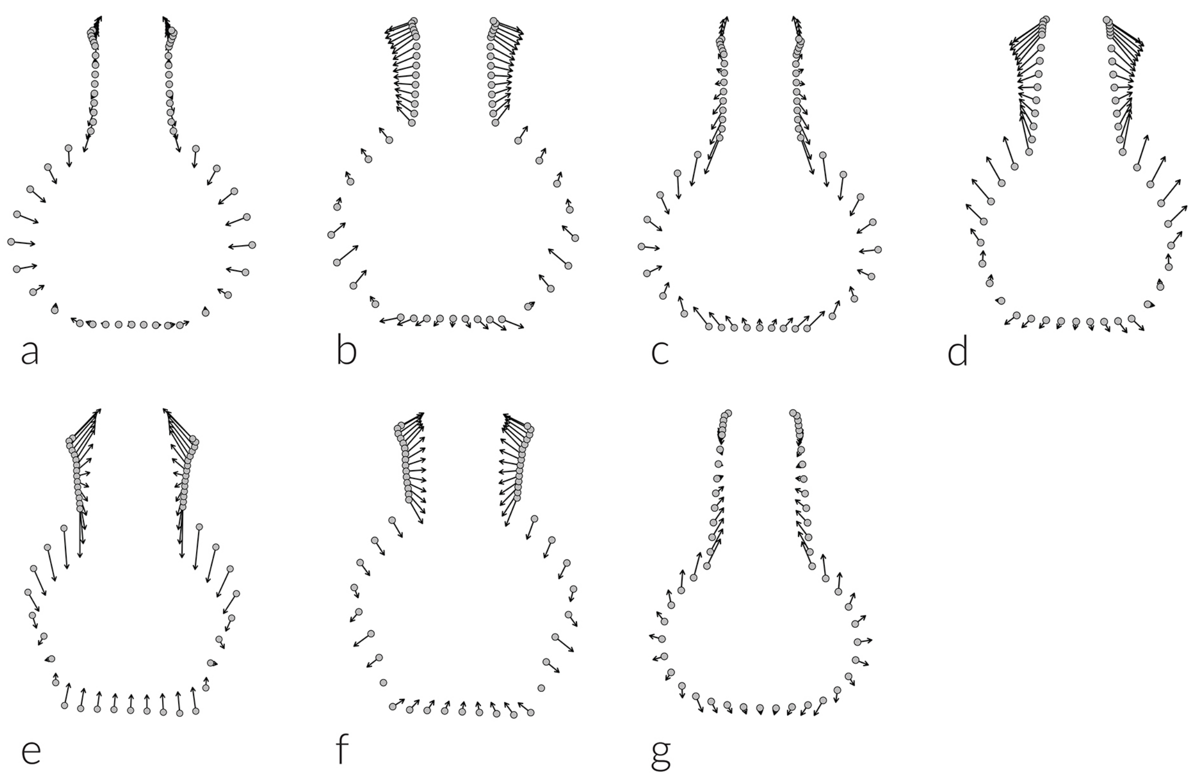


Figure 13. Comparison of mean bottle shapes by type for those types found to differ significantly; (a) Belcher Engraved (gray) and Hickory Engraved, (b) Belcher Engraved (gray) and Keno Trailed, (c) Belcher Engraved (gray) and Smithport Plain, (d) Hickory Engraved (gray) and Keno Trailed, (e) Keno Trailed (gray) and Smithport Plain, (f) Keno Trailed (gray) and Taylor Engraved, and (g) Smithport Plain (gray) and Taylor Engraved.

Smithport Landing and Belcher Mound sites was posited in the initial analysis (Selden, Jr. 2018a) where the differences in shape were seen as a possible north-south transition for the combined sample of Hickory Engraved and Smithport Plain types. In comparing these results with a recent analysis of the Hickory Engraved sample (Selden, Jr. 2018b), it is evident that while these two Formative-Early Caddo types exhibit similar morphological differences over geographic space, the differences are dynamic and will be further clarified by the continued and iterative expansion of type-specific analyses.

The contribution of GM methods to questions of Caddo ceramic morphology holds substantial promise. Those results presented here provide a succinct preview of a rigorous and systematic research design that capitalizes on the variability of Caddo ceramic shapes through an analysis of type-specific (Smithport Plain) morphology that is followed by an analysis of the aggregated sample of Caddo bottles. Iterative improvements to this research program will continue as new specimens are made available and incorporated. That progression will include the addition of Caddo bottles from the Bison B site in northwest Louisiana (Woodall 1969) curated at Southern Methodist University, and an expansion of the Belcher and Taylor Engraved samples. This will test whether similarity in Late-Historic Caddo bottle shape is a local, regional, or area-wide trend. Also considered will be the continued analyses of morphological disparity between different temporal periods to test whether significant morphological disparity and allometry between the temporal periods varies elsewhere; and the continued use of morphological integration to identify which of those morphological traits associated with Caddo bottle production might be said to covary.

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An Example of Trepanation and Survival from the Wood Springs Site (41LB15), Liberty County, Texas

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In early 2017, the lead author was asked to assist the Sam Houston Regional Library and Research Center in Liberty, Texas in creating a new interactive exhibit on the prehistory of southeast Texas. This effort required analyzing the extensive Andy Kyle Archeological Collection that had been donated previously to the Center by the late Mr. Andy Kyle. In assessing material from the Wood Springs site (41LB15), a piece of human skull was found with a circular perforation drilled through its center. The cranial fragment appears to have come from the lower part of the parietal bone and measures 62.5 by 44.9 mm in terms of maximum dimensions. Thickness across the fragment averages about 5.0 mm (range 4.5-6.0). The perforation is almost perfectly circular and is 5.5 by 6.0 mm in diameter. Examination of the perforation under a high-powered binocular microscope shows the perforation to have been drilled using a rotary motion. Moreover, on one side of the perforation, a small amount of osteoclastic activity (remodeling) was present indicating that the perforation was made ante mortem and that the patient survived the surgery. The Wood Springs artifact suggests the first known successful attempt at prehistoric trepanation in Texas and one of a few such cases known in prehistoric North America.

Introduction

The Sam Houston Regional Library and Research Center in Liberty, Texas is currently in the process of renovating its entire museum display. A major component of their future exhibits will be the prehistory of Southeast Texas utilizing the extensive Andy Kyle Archeological Collection. The collection of prehistoric artifacts was a gift to the museum by the late Mr. Andy Kyle, long-time resident of Liberty County and avid avocational archeologist. The collection comprises well over 30,000 artifacts from 95 archeological sites in nine counties within Southeast Texas. These include sites in Liberty, Polk, Jasper, Sabine, Tyler, Hardin, Angelina, San Augustine, and Newton Counties. The sites present in the collection represent an area between the Trinity and Sabine Rivers (Figure 1).

In early 2017, members of the Houston Archeological Society (HAS) were asked to assist the Sam Houston Regional Library's project by going through the entire Andy Kyle Archeological Collection and identifying distinctive artifacts from each chronological period for the new display. A number of hitherto unrecorded discoveries were made during this process which will be the subjects of several future publications from the HAS (Crook et al. 2017). One of the more interesting finds was the discovery of an apparent example of trepanation from the Wood Springs (41LB15) site. The human skeletal specimen marks the first reported occurrence of successful prehistoric trepanation from the State of Texas (Timothy K. Perttula, personal communication, 2017).

Trepanation – A Global Phenomenon

Trepanation, also known as trephining, trepanning or "bore holing" is derived from the Greek word, *trypanon*, meaning to auger or to bore (Irving 2013). In archeological terms, a perforation is cut or drilled into the skull using simple stone tools in a surgical technique. The dura matter is exposed without damage to the underlying blood vessels, meninges or brain. Trepanation is the earliest neurosurgical technique known to man; in fact, it is the oldest surgical procedure for which we have archeological evidence (Lisowski 1967; Constandi 2007; Irving 2013).

The practice of trepanation was largely used for therapeutic purposes to relieve depressed fractures, trauma-induced intracranial swelling, epilepsy, vascular headaches (migraines), mastoiditis, ear infections, meningiomas and mental disorders by relieving pressure on the brain (England 1962;

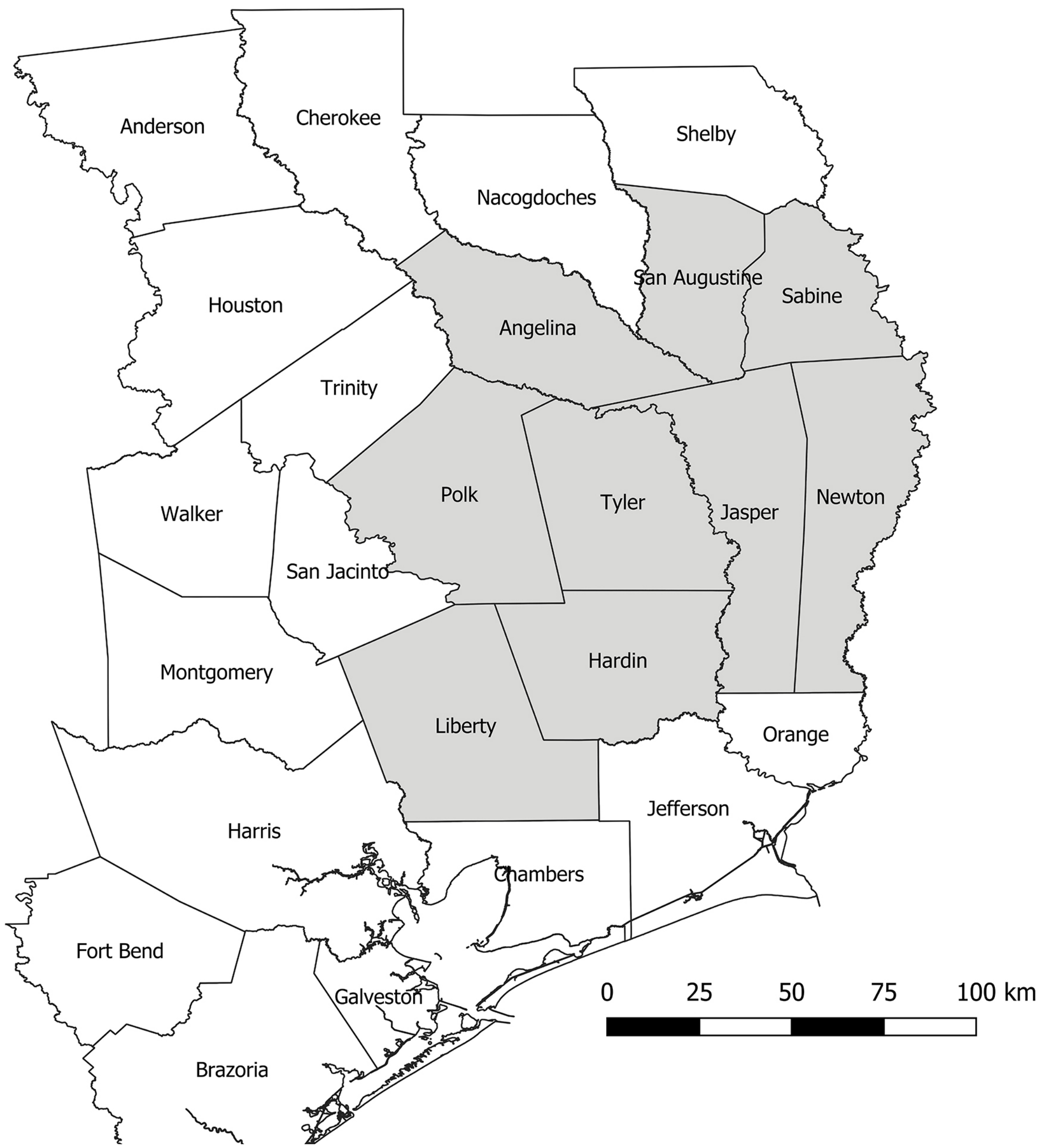

Figure 1. Map of Southeast Texas showing the nine counties (gray) represented in the Andy Kyle Archeological Collection.

Campillo 1984; Aufderheide 1998; Constandi 2007). In today's medical terminology, we would call the procedure a craniotomy (Moskalenko et al. 2008). Apart from medical conditions, trepanation was also apparently used for relieving people of demonic spirits by providing a hole for the spirit to escape (Frame 2010). Prehistoric trepanation was conducted while the patient was fully conscious and often, un-anaesthetized and with no antibiotics (Oakley et al. 1959; Lisowski 1967).

The earliest example of the practice of trepanation is from the Neolithic at Ensisheim, France, and dates to around 6,500 B.C. (Oakley et al. 1959; Lisowski 1967; Andrushko and Verano 2008). From the Neolithic Period onwards to historic times, more than 1,500 examples of trepanation have been found on every continent and including Oceania. Trepanned skulls are known from across Europe (U.K., Ireland, Denmark, Sweden, France, Germany, Austria, Spain, Portugal, Italy, Greece, Hungary, Czech Republic, Latvia, Ukraine and Russia), Asia (China, Japan, India), Australia and Melanesia, the Middle East (Iran, Jordan and Israel), Africa (Egypt, Guinea and South Africa), Mesoamerica and South America (especially Peru and Bolivia) (Stewart 1958; Oakley et al. 1959; England 1962; Zias 1982; Jorgensen 1988; Zias and Pomeranz 1992; Finger and Fernando 2001; Verano 2003; Weber and Wahl 2006; Andrushko and Verano 2008; Frame 2010; Faria 2015).

The Edwin Smith Papyrus, which dates to the 17th century B.C., is the oldest known medical document. The writing is credited to Imhotep but is likely the collective work of a number of Egyptian physicians. The papyrus mentions 48 different battlefield cases including several injuries to the skull. Therein, the cranial sutures, meninges and cerebrospinal fluid are described with great accuracy, but there is no mention of surgical intervention into the skull (Missios 2007). It is not until Hippocrates in the 5th century B.C. that documentation and description of various skull fractures, indications for trepanation, and dangers associated with the use of trepanation are noted (Hippocrates – *On Injuries of the Head*). The great Roman physician, Galen, expanded upon this by detailing anatomy, operation success rates and surgical procedures for trepanation that served as a guide for all such medical procedures up until the Renaissance period (Missios 2007).

In North America, there are 18 reported cases of trepanation from prehistoric contexts in Canada, all from British Columbia (15) and Ontario (3) (Stone and Miles 1990; Frame 2010). In the U.S., a total of 26 cases of prehistoric trepanation have been reported, the occurrences of which are equally divided between east of the Mississippi and the western U.S. States where evidence of trepanation has been reported include Connecticut, Maryland, Georgia, Michigan, Wisconsin, Illinois – east of the Mississippi; Arkansas, South Dakota, New Mexico, California, Washington and Alaska – west of the Mississippi (Gillman 1885; Greenman 1926; Shapiro 1927; Cosgrove 1929; Moodie 1930; Hinsdale and Greenman 1936; Stewart 1940; McGregor and Wadlow 1951; Powell 1970; Romero 1970; Neiburger 1978; Ortner and Putschar 1981; Gregg and Bass 1984; Richards 1995; Frame 2010).

In the Americas, most cases of trepanation occur after about 400 B.C. up through first European contact (Stone and Miles 1990; Andrushko and Verano 2008). In the U.S., the oldest verifiable case of trepanation comes from a skull found in Alameda County, California, that has been dated at ca. A.D. 300-500 (Richards 1995). Most examples of trepanation in the U.S. are associated either with the Woodland Period, the mound-building culture of the Mississippi Valley or with the Puebloan southwest (Stone and Miles 1990; Frame 2010).

In all the known cases of prehistoric trepanation, the procedure appears to have been performed primarily on adults; 53 percent of the surgeries were on males, 20 percent on females, with the remainder on skeletal remains of undetermined sex (Frame 2010). Other studies, especially from Europe, have noted an even higher percentage skewed to males for two reasons: (1) trepanation was a difficult procedure and thus was reserved for the most high status members of society, and (2) males were more likely to have suffered severe injuries due to hunting and battle, resulting in subdural hematomas and thus needing the trepanation procedure for survival.

The majority of the surgeries were performed on the lower part of the parietal bone (just above the squamous suture), followed in order of occurrence by the occipital bone and then the frontal bone. Very few cases of perforating the temporal bone are known and most show no evidence for osteoclastic activity suggesting these patients did not outlive the surgery. This is not surprising as the temporal area of the skull is too fragile and the underlying structures too vascularized and delicate for the patient to survive the operation. The Roman physician Galen knew this and specifically warned against performing trepanation in the temporal region of the skull (Missios 2007). In global prehistoric trepanations, diameter of the cranial perforation ranges from as small as 0.2 cm to almost half the cranium, with most burr holes ranging from 1-9 cm in diameter (Oakley et al. 1959; England 1962; Verano 2003; Andrushko and Verano 2008; Frame 2010). Almost all the surgical openings are circular to oval; square openings with cut marks into the skull are rare and most commonly show no post-surgical regrowth of the bone tissue (Frame 2010). Scraping with an obsidian or flint blade appears to have had the highest survival rate, although circular grooving, drilling (boring) and linear cutting have also been observed (Oakley et al. 1959; Andrushko and Verano 2008; Frame 2010).

Despite the crude nature of the surgery, survival rates, as evidenced by remodeling of the cancellous bone, appear to have been surprisingly high. Stone and Miles (1990) reported a survival rate of about 90 percent on the 20 cases of trepanation they studied in Canada and the U.S. Similarly, Andrusko and Verano (2008) studied 109 surgeries on 66 individuals from burials in the Cuzco region of Peru and concluded that there was a survival rate (at least short-term) of 83 percent. Similar high rates of operation survivability are reported from elsewhere around the globe (Oakley et al. 1959; Weber and Wahl 2006). The degree of healing (and thus survival) appears to relate to the location of the surgery in that trepanation in regions of cranial musculature more often resulted in death of the patient (Andrushko and Verano 2008). Also, the high survival rate indicates that ancient surgeons were able to prevent consistently penetration of the dura matter, thus avoiding high risk of infection and physical damage to the underlying blood vessels, meninges and brain (Petrone et. al. 2015). Sutural (wormian bone) involvement in the surgery does not appear to have influenced survival (Verano 2003; Weber and Wahl 2006; Andrushko and Verano 2008).

The French surgeon and anthropologist, Paul Broca, is credited with the earliest study of trepanation on prehistoric skulls from Europe (Clower and Finger 2001). As part of his studies, Broca attempted to replicate trepanation on both adolescent and adult cadavers. Using both stone and glass cutting implements, Broca found that he could successfully scrape a burr hole in an adolescent's skull in about four minutes; however, the same operation on a fully calcified adult skull took 50-60 minutes (Clower and Finger 2001; Verano 2003). Based on this unique experimental evidence, later researchers have assumed that a single trepanation surgery would take approximately one hour to complete (Verano 2003, Andrushko and Verano 2008).

The Wood Springs Site

The Wood Springs site is located approximately 3 km northwest of Liberty, Texas, on the west side of a small stream known as Wood Springs Creek or Atascosito Springs. This stream is fed by several perennial springs and is a minor tributary of the Trinity River 0.8 km to the west. The site is near Sandune Road on a sandy terrace on the northwest side of the creek where its location was originally described and registered by Elton R. Prewitt in 1973 as part of the Louisiana Loop Survey. Wood Springs was subsequently investigated by Sheldon Kindall and other members of the HAS during their research on the Andy Kyle Archeological Collection during the mid-1980s. The site was one of many from which Mr. Andy Kyle collected artifacts between 1946-1986.

Figure 2. View looking southwest across the main part of the Wood Springs site (41LB15) as it appears today.

Occupational material at Wood Springs covers at least 0.5 acres and possibly as much as 5 acres (Sheldon Kindall, personal communication, 2017). While Mr. Kyle only collected artifacts on the surface, several shovel tests were conducted by the HAS in 1986 as well as recently by the author. The artifact-bearing horizon is a pale brown (Munsell 10YR 7/3) to light gray (Munsell 10YR 7/2) sand that extends to a depth of at least 1 m. Based on artifacts collected by Mr. Kyle, the Wood Springs site represents a long-term occupation that extends from the earliest Paleoindian period (Clovis) through the Late Prehistoric. Construction of a natural gas pipeline has disturbed much of the site such that Paleoindian, Archaic, Woodland and Late Prehistoric materials are found alongside each other on the surface.

Cranial Fragment Displaying Trepanation

The cranial fragment containing the burr hole was found in a box containing ceramic sherds, arrow points and miscellaneous lithic debitage from the Wood Springs site. Due to the acidic nature of the soils coupled with high rainfall rates, bone preservation in southeast Texas prehistoric sites is rare. What examples of worked and unworked bone are present in the Andy Kyle Archeological Collection are exclusively associated with the Late Prehistoric occupation. This level is characterized by Alba, Catahoula, Perdiz and Friley arrow points as well as locally produced (Goose Creek Plain, Goose Creek Incised, Baytown Plain, San Jacinto Incised) and imported Caddo ceramics. The majority of these artifacts date from ca. A.D. 1000-1600 and while it cannot be absolutely ascertained that the skull fragment is from this period, its preservation and association with arrow points and ceramics suggests it is likely.

The cranial fragment measures 62.5 mm by 44.9 mm in its maximum dimensions. Thickness varies across the specimen from 4.5 to 6.0 mm with the average being close to 5.0 mm. A few weathered suture lines appear to demark the edges of the specimen suggesting that it likely comes from the lower parietal area just above the squamous suture. A single perforation is near the center of the fragment. Dimensions of the perforation are nearly circular, varying from 5.5 mm (sinister-to-dexter) by 6.0 mm (superior-to-inferior). The fragment is shown in Figure 3.

Figure 3. Cranial fragment containing burr hole from the Wood Springs site (41LB15), Liberty County, Texas.

The Wood Springs cranial fragment was observed under both a regular binocular microscope (American Optical, 7-20x) and under high power (20-220x) using a Dino-Lite AM4111-T digital microscope. The latter had the capability to take high resolution photomicrographs, two of which are illustrated in Figures 4 and 5. The perforation clearly shows the remains of rotary drilling on at least part of the burr hole. Given the relatively small size of the perforation (0.24 cm) as compared to other recorded prehistoric trepanations, coupled with its near perfectly circular nature, it is almost certain that the surgery was performed by either a hand-held or a hafted lithic drill. Such drills, made from either heat-treated chert or petrified wood, are a common constituent of the Late Prehistoric component at the Wood Springs site (Crook et al. 2017). Examination of the outer surface of the skull table (*lamina exterior cranii*) shows no markings other than those associated with the perforation. However, examination of the interior table (*lamina interior ossium cranii*) shows extensive scaling in the area of the perforation (Figure 4). The interior or vitreous table of the skull is relatively thin, dense and brittle. As a result, it would not be unexpected to see such scaling especially as the result of perforating the skull tissue with a rotary motion lithic drill. In the interior of the perforation, dark brown osteoclastic activity can clearly be seen on one margin (Figure 5). This new bone growth is located on the intervening cancellous bone tissue (diploë) between the two harder surfaces of the skull creating a beveled appearance (White and Folkens 2005). While the extent of new growth is minimal, it is clearly evidence of post-surgical growth indicating that the patient survived the surgery.

Conclusions and Discussion

In their detailed study of trepanation in the Cuzco region of Peru, Andrushko and Verano (2008) noted that prehistoric surgeries resulted in one of three scenarios: (1) no healing around the margins of the burr hole probably indicating that the patient did not survive the operation; (2) short-term healing in which there was a small amount of osteoclastic activity surrounding the areas of necrotic bone; or (3) long-term healing with extensive remodeling and rounding of the hole margins. It is significant to note that almost none of the observed trepanned holes ever completely healed over in terms of new bone growth. This is true for modern craniotomies as well. Burr holes heal very poorly which is the reason surgeons use bone grafts today. However, the trepanned hole would have been covered by scalp and hair regrowth. The high rate of success in such operations is noted not only by

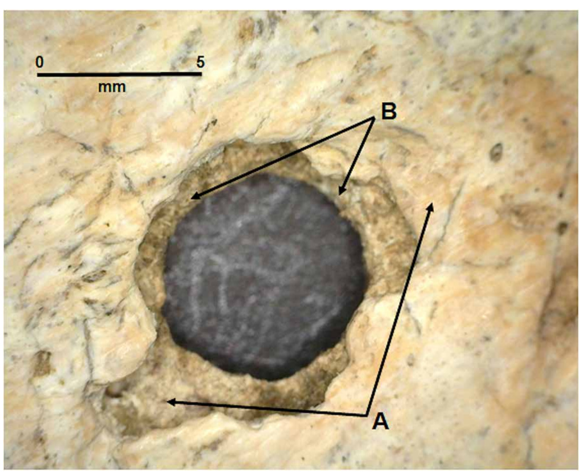

Figure 4. Photomicrograph of trepanned perforation from the Wood Springs Site (41LB15). Note (A) scaling from the surface of the vitreous table as a result of trepanation, and (B) osteoclastic activity (dark brown) on the surface of the cancellous bone (diploë) demonstrating bone remodeling post-surgery.

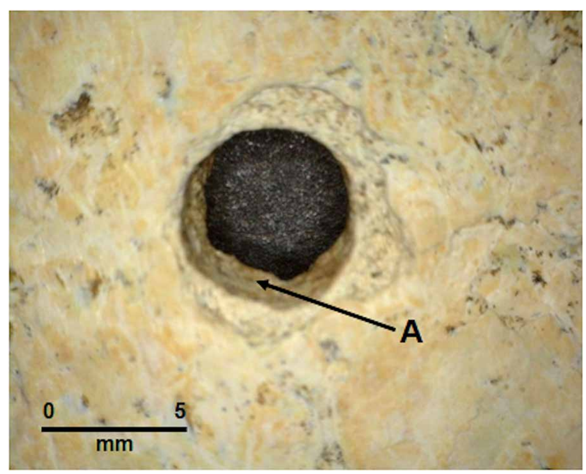

Figure 5. Photomicrograph of the skull perforation showing dark brown-colored osteoclastic activity within the burr hole (A).

the presence of bone tissue regrowth but also by the fact that a large number of skulls worldwide show multiple operations, indicating the patient survived the initial surgical procedure.

The perforated cranial fragment from the Wood Springs site shows clearly the marks of rotary drilling, so the perforation was not made by animal activity but was intentionally made by human processes. The rotary marks on the interior of the perforation coupled with the scaling on the interior table supports the observation that the burr hole was produced by a rotary stone drill. The burr hole is relatively small (approximately 6 mm) but very precise. There are no stress lines, stellate fractures or other signs of tension/force being applied indicating that the force was intentionally concentrated on a small area with precision and with great control. Moreover, there is no evidence of green bone impact fractures that implies that high-energy impacts with a hard object did not occur. Such a hole would be almost impossible to replicate by a chance injury but is strongly consistent with the use of a small stone drill. Paddle drills recovered from the site have maximum diameters of 8 mm or less, consistent with their possible use in the surgery.

Minor osteoclastic activity (remodeling) is also present on the cancellous bone (diploë) on the margin of the perforation. The dark brown area within the burr hole indicates two possibilities: (1) necrosis or lack of blood flow to the tissue and thus the death of the bone, or (2) hyperemia – increased blood flow to the bone tissue *ante mortem* which would then appear as brown-colored tissue *post mortem*. The presence of the dark brown material is only on one side of the burr hole, which makes it less likely that it is due to necrosis of the bone. Given the small size of the hole, any necrosis would likely have impacted the entire area and not just on one side. The presence of the dark color on the exact area where there is visible remodeling indicates that the coloration is due to hyperemia, evidence for increased blood flow to the perforation site. This conclusively shows that the perforation was made *ante mortem* and that the patient survived the operation. The rate of bone remodeling is a function of age, with younger individuals healing significantly quicker than older adults. Bone healing progresses through four stages: inflammation, soft callus formation, hard callus formation and remodeling. Bone remodeling on a normal break typically occurs in six to eight weeks. However, burr holes are not simple bone fractures. The human body is designed to heal linear fractures but it is a different story for healing circular to oval holes. In a study conducted by Nerlich et al. (2003) looking at modern cases of dry bone healing in an attempt to determine the healing time for archeological discoveries, they observed that there was little to no bone healing of cranial burr holes prior to 70 days after the operation. The rate at which a burr hole heals in surviving humans is highly variable but is on the order of months to years before appreciable remodeling occurs. This is the reason that modern craniotomies use bone grafts, mesh or plates because otherwise the skull would remain open well beyond recovery time and the patient's return to normal activities. Thus, based on the remodeling seen on the Wood Springs cranial fragment, it can be assumed that the patient survived the operation for at least a minimum of three months. Given this and the absence of any further trauma to the area, the scalp would have healed over the wound and the patient would have survived the trepanation procedure completely.

To date, there have been no reported cases of prehistoric trepanation, successful or otherwise, from any archeological context in Texas. Thus, the Wood Springs cranial fragment marks the first reported example of this type of primitive surgery in the state.

Acknowledgements. We are grateful to Ms. Alana Inman, Manager of the Sam Houston Regional Library and Research Center in Liberty, Texas, for inviting the Houston Archeological Society to participate in the development of the new prehistory exhibit at the library and thus affording me the opportunity to study in detail all the artifacts contained in the Andy Kyle Archeological Collection. Alana not only provided open access to study the collection but also allowed for the study of artifacts outside the library using high power microscopic analysis. In this regard, we are also grateful to the Houston Archeological Society for use of their Dino-Lite AM4111-T microscope and for Bob Sewell's assistance in taking the photomicrographs that appear in this paper.

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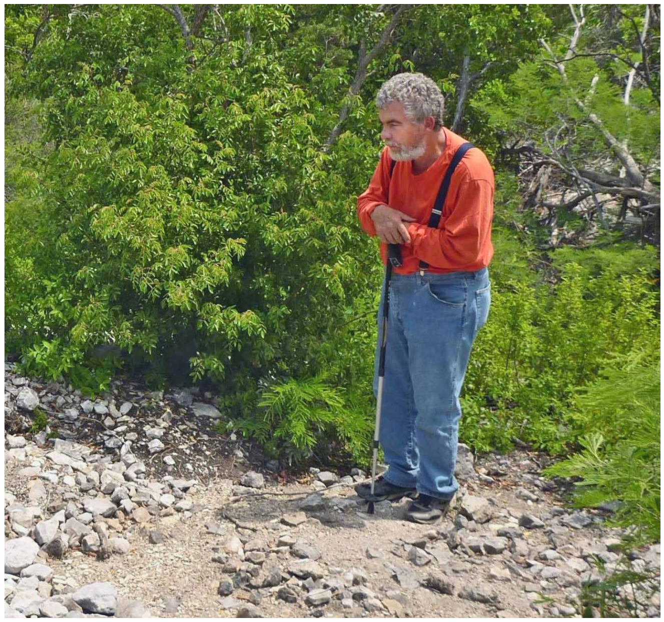

Joseph (Joe) Wilmoth Saunders

Obituary

Joseph (Joe) Wilmoth Saunders
June 25, 1948–September 4, 2017

I met Joe over 40 years ago excavating sites at Fort Sill working for Reid Ferring at the Museum of the Great Plains. A couple of years later we worked together again at Candy Creek Reservoir near Tulsa for Archaeological Research Associates and then later that year on the Zeekoe Valley Survey in South Africa. We were both in graduate school together at SMU, when he lived with Bill Westbury and his family.

Joe had an engaging mind and a sharp, often rapier, wit. In 1979, he used to talk politics with the South African farmers and sometimes that could get pretty heated. He didn't give them much maneuvering room, but everyone always liked him and still remember him.

In the mid-1980s, Joe began working in the Lower Pecos region for his PhD dissertation. He analyzed materials from Hinds Cave but more importantly, he conducted a survey around Hinds Cave and also in the Blue Hills area. That was the earliest upland systematic archeological survey in the Lower Pecos region and it gave us our first view of how the people who occupied all those famous shelters exploited the areas away from the canyons. After finishing his PhD dissertation, he dug sites in Egypt with Fred Wendorf and worked for a short while at Prewitt and Associates digging sites at Jewett Mine. Afterwards, he began working at TAMU where he initiated the Applewhite project in Bexar County.

Just as Applewhite was gearing up, he was offered a regional archeologist position in northeast Louisiana, based at the University of Louisiana, Monroe. Obviously, he took it, and that was the smartest move of his career. He linked up with avocational archeologist, Recca Jones, and the rest is history. He worked tirelessly to document the oldest mounds constructed in North America at Watsons Break, Frenchman's Bend, Hedgpeth Mound, and many others. This research has changed the way North American archeologists view the development of cultural complexity among Native Americans.

Joe always made an impression on everyone he met. He had a remarkably clever mind. In a conversation, he constantly was evaluating every point you would make, often pointing out the inconsistencies, but graciously would end a conversation with a good joke and a laugh. He will be remembered and missed.

– Britt Bousman

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